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Nutritive composition of *Eragrostis superba* Peyr and *Cenchrus ciliaris* L. collections from the ASALs of Kenya

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Abstract

A study was conducted in the southern rangelands of Kenya to establish the nutritive value of ecotypes of *Cenchrus ciliaris* and *Eragrostis superba*. A total of eleven ecotypes for *C. ciliaris* and nine for *E. superba* collected from sites representative of medium to low potential agro-ecological zones (III to VI) were established at KALRO Kiboko research centre in a randomized complete block design. Plant samples collected were analysed for *in vitro* dry matter digestibility (INVDMD), crude protein (CP), Crude fibre (CF), ash content and percent dry matter yield (%DM).

Significant variations were observed among *C. ciliaris* ecotypes. KBK2 and KLF2 collections had higher ash content than the rest of the ecotypes at $p \leq 0.05$. Also, KBK2 had higher values ($p \leq 0.05$) than TVT1 in INVDMD with no variation between the rest of the ecotypes. Positive correlations ($p \leq 0.05$) were recorded between INVDMD with stem thickness and leaf breadth and CP with leaf length, plant height, heading time and stem thickness. Late flowering and robust ecotypes of *C. ciliaris* were higher in CP while CF negatively correlated ($p \leq 0.05$) with plant height and leaf length. Significant variations between *E. superba* ecotypes resulted in 3 major clusters that combined ecotypes from different sites. Kiboko (KBK2) and Kilifi (KLF1) collections clustered together with high CF, CP and INVDMD while TVT3 was grouped alone with higher CP and low CF at $p \leq 0.05$. Mean ash content for *C. ciliaris* (13.6%) was higher than *E. superba* mean (8.6). The two species had no difference in the other four nutritive value components. Significant variations existed among the study collections that could potentially be exploited to meet different feed requirements. Morphological traits could be used to select for high INVDMD or CP levels among and within *C. ciliaris* ecotypes. Selection for low CF should target shorter ecotypes of *C. ciliaris* with shorter leaves.

Key words: *crude protein, ecotype, grasses, in-vitro digestibility, nutrient content*

Introduction

Feed inadequacy in terms of quality and quantity is the major constraint to livestock production in the Arid and Semi-arid Lands (ASALs) of Kenya (Gitunu et al 2003, Kibet et al 2006; Mnene 2006). Reseeding with range grass species as an option to address the problem has been promoted with some success (Nyariki et al 2008; Manyeki et al 2011). *Eragrostis superba* and *Cenchrus ciliaris* grass species are drought tolerant and are among the species being used in the reseeding. They are among the most preferred grasses by farmers in the ASALs (Mnene 2006) with preference shifting from *E. superba* to *C. ciliaris* with increase in aridity (Ndathi et al 2012).

Despite having been the most studied species in the genus *Cenchrus,* Goel et al (2011) notes that *C. ciliaris* has not gone through the bottleneck of domestication and is still open for exploitation by using naturally occurring variation in the species. Variation in its natural collections have been observed in agro-morphological attributes and chemical composition (Pengelly et al 1992; Hacker and Waite 2001; Mnif et al 2005; Jorge et al 2008 and Ashraf 2013). The species has been associated with loss of native plant species due to its invasive nature and has been declared a noxious weed in some areas (Cook et al 2005; Franklin et al 2006). *Eragrostis superba* has high tolerance to drought,salinity and alkalinity and it is also used for erosion control. It is fairly palatable and readily grazed but it gets stemmy and unpalatable at near maturity when its nutritive value drops (FAO 2012).

The amount of nutrients in the forage determines the quality of livestock production. Knowledge of forage quality is necessary in planning and proper utilization of the pastures for optimum livestock performance (Amiri and Shariff 2012). This study was therefore aimed at establishing the nutritional value of the ecotypes of the two grass species with the aim of exploiting the potential in their natural variation for development of better varieties.

Materials and methods

The study involved 11 ecotypes of *Cenchrus ciliaris* and 9 of *Eragrostis superba* that were collections from Kilifi (KLF), Taveta (TVT), Kiboko (KBK), and

Magadi (MGD) in the semi-arid lands of Kenya. The collection sites are representative of agro-ecological zone 3, 4, 5 and 6, respectively. The ecotypes were established at KALRO Kiboko research centre in October 2012 in plots measuring 4 m x 4 m, planted to single spaced plants at 1 m between rows and 0.5 m within rows. The design was a randomized complete block with 3 replicates. Full plot establishment was achieved in the long rains of April 2013. The data reported here were collected during the short rains of October – December 2013. All the plots were clipped to 5 cm level above the ground at the beginning of the rains. At six weeks post clipping, twelve plants were randomly sampled from the 3 replicates of each ecotypes and clipped to 5 cm level. The samples were bulked into 1 sample per ecotype and dried in the oven for 24hours at 60^{o}C. The dried samples were sub-sampled to 2 units and used in the analysis of ash content, crude protein (CP), Crude fibre (CF), percent dry matter yield (%DM) and in-vitro digestibility at the animal production laboratory, University of Nairobi.

The ash, crude protein, crude fibre, and dry matter yield of individual grass ecotypes were analyzed using the standard procedures of AOAC (2005). Nitrogen content was determined by the Kjeldahl method, while percent crude protein (CP) was calculated by multiplying the nitrogen content in the sample with a factor of 6.25. The in-vitro digestibility of dry matter (IVDMD) was done through the Tilley and Terry procedure (1963). The data on herbage related traits, which were used in correlation, was collected at full plot heading or flowering during the same season.

The data were analysed for correlation, analysis of variance (ANOVA), and mean separation using the Tukey in Genstat 15th edition analysis tools (Payne et al 2012). Further analysis for Hierarchical clustering was performed for *E. superba.*

Results and discussion

Comparison by site for *C. ciliaris*

There was variation in crude protein between sites (Table 1). Kiboko ecotypes were higher than Kilifi collections at $p \leq 0.05$. This could be due to the very low levels recorded by KLF3 collection. Actually only Kiboko collection recorded above 10% CP (Table 3). The variation though, could be attributed to differences in flowering time between Kiboko and Kilifi collections. The Kiboko collections flowered much later than Kilifi collections. Also, all Kiboko collections were previously clustered as robust ecotypes that were tall with wider stems and long, wider leaves compared to all Kilifi ecotypes, which were clustered as none robust.

Table 1. Nutritive value contents of C. ciliaris ecotypes based on site of collection

Site	N	**CF**	**CP**	**IVDMD**	**Ash**	**%DM**

Kiboko	6	35.2^{a}	10.5^{a}	51.6^{a}	14.3^{a}	91.3^{a}
Kilifi	6	36.7^{a}	7.96^{b}	49.5^{a}	13.0^{a}	91.9^{a}
Magadi	4	34.7^{a}	9.06^{ab}	50.9a^{b}	13.9^{a}	91.4^{a}
Taveta	6	36.7^{a}	9.10^{ab}	48.6^{a}	14.4^{a}	91.5^{a}
CV (%)		5.82	14.6	5.05	9.37	1.32
LSD$^{(0.05)}$		2.68	1.72	3.25	1.64	1.28
P-value		0.31	0.03	0.219	0.308	0.811

Mean values in the same column without common letter differ at $p \leq 0.05$

Comparison by site for *E. superba*

There was no variation between the sites in all measured attributes at $p \leq 0.05$ (Table 2). This could be attributed to the significant variations among ecotypes within a site (Table 5). Kiboko collections had higher but insignificant INVDMD and percent dry matter.

Table 2. Proximate composition of *Eragrostis superba* ecotypes based on site of collection

Site	n	CF	CP	IVDMD	Ash	%DM
Kiboko	4	40.1	10.1	54.1	8.89	92.3
Kilifi	6	40.0	9.94	50.1	8.53	91.5
Magadi	2	38.8	9.39	49.2	8.07	91.4
Taveta	6	38.2	9.09	48.7	8.83	91.6
LSD$^{(0.05)}$		2.03	2.04	4.74	0.873	2.02
CV (%)		3.31	13.5	6.02	6.46	1.41
P-value		0.102	0.585	0.083	0.320	0.749

Comparison between ecotypes of *C. ciliaris*

There was significant variation in all measured nutritive content attributes except CP (Table 3). Significant variation was observed in Kiboko collections in percent DM yield where KBK1 was higher than KBK2 and KBK3. The overall mean of 91.5 for all the ecotypes is lower than 92.1 recorded by Ndathi et al (2012) with *C. ciliaris* grass samples from farmers' fields. The variation could be as a result of variation in stage of plant growth or management of the crop.

Table 3. Mean values for nutritive contents of *C. ciliaris* ecotypes

Ecotype	%DM	Ash	IVDMD	CP	CF
KBK1	93.1^{a}	14.0^{bc}	48.2^{ab}	10.5^{a}	38.4^{a}
KBK2	90.5^{b}	15.2^{a}	55.0^{a}	10.2^{a}	35.0^{c}
KBK3	90.4^{b}	13.9^{cd}	51.7^{ab}	10.9^{a}	32.4^{d}
KLF1	92.4^{ab}	12.5^{e}	48.7^{ab}	8.89^{a}	37.5^{a}
KLF2	91.7^{ab}	15.3^{a}	50.0^{ab}	8.34^{a}	34.9^{c}
KLF3	91.5^{ab}	11.2^{f}	49.9^{ab}	6.64^{a}	38.0^{a}
MGD1	91.7^{ab}	13.2^{d}	50.8^{ab}	8.36^{a}	37.1^{ab}

MGD3	91.2^{ab}	14.6^{ab}	51.1^{ab}	9.75^{a}	32.4^{d}
TVT1	90.6^{ab}	14.2^{bc}	45.6^{b}	9.64^{a}	37.3^{ab}
TVT2	92.1^{ab}	11.9^{e}	49.5^{ab}	8.19^{a}	37.8^{a}
TVT3	91.8^{ab}	14.2^{bc}	50.9^{ab}	9.48^{a}	35.3^{bc}
Total mean	91.5	13.7	50.1	9.17	36.0
CV (%)	0.7	2.2	3.6	15.4	1.4
SEM	0.464	0.212	1.28	0.996	0.364
P-value	0.032	<.001	0.03	0.247	<.001

Mean values in the same column without common letter differ at p<0.05

Despite lack of variation between sites in ash content, variation between ecotypes resulted in various groups. KBK2 and KLF 2 were higher ($p \leq 0.05$) than all except MGD3. The lack of variation in the 3 ecotypes, all representing different sites of origin could have led to the similarity in site results. Ash represents the total mineral content in the sample. However, this includes both endogenous and exogenous mineral content. The endogenous content includes calcium, magnesium, potassium and phosphorus, which is valuable to livestock and is about 6% in grasses. Thus, the extra ash represents contamination with soil contents among others, which may not be valuable to the animal by reducing total digestible nutrients in the feed. The ash content results were higher than Onyeonagu and Eze's (2013) who recorded 6.21 and 5.77 for rainy and dry seasons with selected grass species. However, Onyeonagu and Eze's grass species were robust grasses, mainly fodder, with higher stem content which could explain the difference. Higher stem content has been noted to result in low ash content in plants (Roger and Bano 1998). The ash content in these *C. ciliaris* ecotypes was higher than recommended levels (6%) for grasses.

Only KBK2 had higher values ($p \leq 0.05$) than TVT1 in INVDMD with no variation between the rest of the ecotypes. This attribute had positive correlation ($p \leq 0.05$) with stem thickness and leaf breadth. These results indicates that ecotypes with thicker stems and wider leaves have higher INVDMD which probably gives them a higher intake. Thus selection within an ecotypes for improved INVDMD is possible.

The highest CP content among the ecotypes was for KBK3 at 10.9% and lowest was KLF3 with 6.6%. This range was below the minimum recorded by Ashraf (2013) at 13.1, which could be due to variation in the time of sampling, ecotypic variation or environmental factors. All the Kiboko collections (KBK1, 2 and 3) higher crude protein levels though not significantly different from the rest. However, variation in CP content among grass cultivars have previously been recorded by Saini et al (2007) and Ashraf (2013). There was a positive correlation ($p \leq 0.05$) between CP and six of selected herbage related traits as well as ash content (Table 4). Tall, long leaved and thick stemmed ecotypes have higher CP. Thus these traits should be targeted in selection for higher CP among and within the ecotypes. Also, robust and late flowering ecotypes have potentially higher CP than small and early flowering ecotypes at six weeks post harvesting. Probably the CP levels were already on the downfall in the small ecotypes since full plot heading had been achieved by end of the fourth week. Full plot heading among the robust group was achieved by end of fifth week. Thus heading or flowering time can be used to estimate the period for obtaining optimum CP for different ecotypes of this species. However, further studies are necessary ascertain the optimum levels for individual ecotypes.

Table 4. Pearson correlation results between nutritive content and selected herbage related traits in *C. ciliaris* ecotypes

Attribute	%DM	Ash	INVDMD	CP	CF
%DM	1	-.343	-.375	-.232	**.654***
Ash	-.343	1	.279	**.661***	-.156
INVDMD	-.375	.279	1	.162	-.526
CP	-.232	**.661***	.162	1	-.291
CF	**.654***	-.156	-.526	-.291	1
Robust group[1]	-.131	.473	.550	**.652***	-.476
Flowering group[2]	-.167	.538	.492	**.770****	-.575
Heading date	-.268	.397	.446	**.634***	-.521
Plant height	-.480	.509	.551	**.719***	**-.650***
No of nodes	-.083	.242	.340	.226	-.028
Stem thickness	-.371	.438	**.608***	**.712***	-.505
Leaf length	-.578	.482	.560	**.675***	**-.720***
Leaf breadth	-.247	.487	**.684***	.571	-.357
Tiller numbers	-.455	-.031	-.274	-.260	-.256

**. *Correlation is significant at the 0.01 level and* *. *Correlation is significant at the 0.05 level (2-tailed).* [1] *1 small and 2 robust;* [2]*1 early and 2 late*

Crude fiber levels ranged from 38.4 to 32.4% for KBK1 and KBK3 or MGD3, respectively. The highest CF of compared well with Ashraf (2013) with 39.48g/100g. All ecotypes were higher than the lowest, KBK3 and MGD3 at $p\leq0.05$. KBK1 had the highest level of CF probably because the ecotype, which is blue in color, has tough stems and rough leaves. This was corroborated during an evaluation of the farmer knowledge and perception on the ecotypes. Farmers indicated that the blue-colored ecotypes were least preferred by animals because of rough leaves and tough stems. Crude fibre was negatively correlated with all the traits and to significant levels ($p\leq0.05$) with plant height and leaf length. This indicates that tall and long leaved ecotypes had lower Crude fibre. These are KBK2, KBK3 and MGD3 that essentially had longer leaves than the rest ($p\leq0.05$). Thus selection for lower CF should target the taller ecotypes with longer leaves. There was also a positive correlation ($p\leq0.05$) between % DM and CF.

Some of the ecotypes in the collection that have promising results include KBK2, KBK3 and MGD3 which recorded high CP and lowe CF. KBK2 also had higher IVDMD but was lower in dry matter yield probably due to high moisture content. The ecotype was clustered in the robust group during characterization using morphological traits. It is significantly tall with long and wide leaves. Bulkiness is misinterpreted to mean high yield in forage production (Boonman 1993).

Despite being bulky, Elephant grasses have the lowest % DM yield of all cultivated East African grasses such as Guineagrass and Rhodesgrass.

Comparison among *E. superba* ecotypes

There was significant variation in all the measured attributes resulting to several groups within a component (Table 5). The Kilifi collection, KLF1, had the highest ($p \leq 0.05$) crude fiber (41.6%) than all other ecotypes except KBK2 and KLF2. The lowest CF was recorded by TVT3 at 37%, which was lower than all except KLF3and TVT2 at $p \leq 0.05$. TVT3 and KBK2 had the highest CP ($p \leq 0.05$) than all except for KLF1 and KLF2. The two ecotypes were on extreme end in CF content. Despite recording the highest levels of CF, KLF 1, KBK2 and KLF2 are also among the highest in CP. Positive correlation between CF and CP have previously been recorded by Ashraf (2013) while working on *C. ciliaris* collections from Pakistan.

Table 5. Mean nutritive contents of E. superba ecotypes

Ecotype	CF	CP	IVDMD	Ash	%DM
KBK1	39.8^{bcd}	9.04^{cd}	56.1^{a}	9.25^{ab}	92.7^{a}
KBK2	40.4^{abc}	11.2^{a}	52.1^{abc}	8.53^{bc}	91.9^{bc}
TVT1	39.2^{cd}	8.36^{cd}	48.9^{bcd}	8.92^{bc}	90.8^{d}
TVT2	38.5^{def}	7.68^{d}	47.5^{cd}	8.13^{c}	91.9^{bc}
TVT3	37.0^{f}	11.2^{a}	49.7^{bcd}	9.45^{a}	91.9^{bc}
KLF1	41.6^{a}	10.8^{ab}	54.7^{ab}	8.18^{c}	93.1^{a}
KLF2	40.7^{ab}	9.68^{abc}	50.4^{abcd}	9.32^{ab}	92.5^{ab}
KLF3	37.7^{ef}	9.27^{bcd}	45.4^{d}	8.08^{c}	88.9^{e}
GBK	38.8^{cde}	9.39^{bcd}	49.2^{bcd}	8.07^{c}	91.4^{cd}
Total mean	39.3	9.64	50.4	8.66	91.9
SEM	1.286	0338	1.09	0.103	0.138
CV (%)	1.0	5.0	3.0	1.7	0.2
P-value	<.001	<.001	0.001	<.001	<.001

Mean values in the same column without common letter differ at $p<0.05$

The recorded INVDMD ranged from 45.4 to 56.1%. This range is higher than that recorded by Ndathi et al (2012) on *E. superba* grass growing in farmers' fields. His CP was also much lower at 4.88%. The variation could be attributed to the difference in the time of harvesting in the two studies. KBK1 had higher INVDMD than all except KBK2 and KLF1 at $p \leq 0.05$. There was a positive correlation ($p \leq 0.05$) between INVDMD and CF with a coefficient of 0.7. Dugmore et al (1986) also found a positive correlation between fibre components and digestible Organic matter (DOM) while working with Kikuyu grass. TVT3 was higher in ash content than all except KBK1 and KLF2 while KBK1 and KLF1 were higher than all except KLF2 in %DM yield except KLF2 ($p \leq 0.05$).

Except in Ash content, KLF1 and KBK2 featured highly in all the measured attributes and were grouped together in cluster analysis using all the nutritive value components. (Figure 1). The ecotypes had high CP, CF and INVDMD. The KBK2 ecotype was taller (96.1 cm) with longer leaves ($p \leq 0.05$) than KLF1 (66.6 cm) and against an overall mean height of 80.8cm. The later was clustered as a robust ecotype while the former was in the smaller group that was shorter with thinner stems and fewer spikelets per inflorescence (unpublished data). TVT3 ecotype was distant from the rest due to its significantly high CP but low CF. Despite being similar in nutritive value KLF1 and KBK2, from different collection sites, should be evaluated for potential variation in environmental adaptation given their distant relationship in morphological characteristics. This also indicates that the environments of collection did not influence the nutritive values of the ecotypes. The significant variation among the ecotypes provides an opportunity for selection targeting specific nutritive value components.

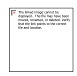

Figure 1 : Dendogram of 9 ecotypes of *E. superba* based on 5 nutritive value components

Comparison between *E. superba* and *C. ciliaris* in nutritive value components

There was no variation in all attributes except with ash content where *C. ciliaris* had 13.6 against *E. superba* at 8.6% at $p \leq 0.05$. Similar results were recorded by Rasool (2013) where *Cenchrus ciliaris* (10.4%) had higher levels in ash content than *E. superba* (8.5%) at $p \leq 0.05$. Ndathi et al (2012) however, found variation in INVDMD between the two species where *Eragrostis superba* (44.9%) had higher levels than *C. ciliaris* (36.9) at $p \leq 0.05$. There was also variations among the ecotypes of the two species in CP and % DM. TVT3 and KBK2 ecotypes of *E. superba* were higher ($p \leq 0.05$) than KLF3 of *C. ciliaris* in CP. In addition, *C. ciliaris* KBK1 ecotype recorded higher % DM (93.1%) ($p \leq 0.05$) than *E. superba* KLF3 (88.9%). Thus it is possible to select either of the species or their ecotypes for a specific nutritive value component.

Conclusions

- The positive correlations between INVDMD and stem thickness and leaf breadth or CP and plant height, leaf length and stem thickness offers an opportunity for selection for higher CP or INVDMD using these traits within *C. ciliaris* ecotypes.

- Crude fibre was negatively correlated with plant height and leaf length in *C. ciliaris*, thus selection for lower CF should target shorter ecotypes with shorter leaves.

- Late flowering and robust ecotypes of *C. ciliaris* were significantly higher in CP. However, further studies should be carried out to identify and compare the CP levels at different flowering stages of each ecotype.
- Variation in nutritive values in *E. superba* ecotypes resulted in distinct clusters from which selection for targeted nutritive value component could be done.
- KBK2 and KLF 1 could be targeted for higher levels of ash, CP and INVDMD and TVT3 higher levels of only CP but lower CF.
- Thus, significant variation in nutritive value components that existed among the ecotypes of *C. ciliaris* and *E. superba* provides an opportunity for further of exploitation of the ecotypes to meet the different feed requirements including using their mixtures.

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