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Research Paper

Dry matter yields and quality parameters of ten Napier grass (*Cenchrus purpureus*) genotypes at three locations in western Oromia, Ethiopia

Producción de materia seca y calidad nutritiva de diez genotipos de Cenchrus purpureus *en tres localidades en Oromia occidental, Etiopía*

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Abstract

Ten Napier grass genotypes (accessions) were assessed across 3 locations, Bako, Boneya Boshe and Gute, for forage dry matter (DM) yield, crude protein (CP) concentration, leaf:stem ratio, nutrient composition and digestibility characteristics during 2016 and 2017. The genotypes were evaluated in a randomized complete block design with 3 replications. Mean DM yield was higher for accession ILRI 16804 across all locations followed by ILRI 16801 and ILRI 16800. Leaf:stem ratio, CP concentration and CP and digestible organic matter (OM) yields also varied significantly among genotypes with the highest values obtained for accession ILRI 16804 across all locations, followed by ILRI 16800 and ILRI 16801. Yields of DM, CP and digestible OM and leaf:stem ratio were higher at Boneya Boshe and Gute than at Bako and higher during 2017 than during 2016. The consistently superior performance of ILRI 16804, ILRI 16801 and ILRI 16800 in both years across the 3 sites suggests that these genotypes should be studied further on farms and in differing environments before being recommended for general cultivation in this area. Examining performance with more frequent harvests and feeding studies with livestock would confirm the benefits to be obtained from planting these new accessions.

Keywords: Digestibility, diversity, quality traits, tropical grass.

Resumen

Durante 2016 y 2017 se evaluaron diez genotipos (accesiones) del pasto Napier (*Cenchrus purpureus*) en las localidades Bako, Boneya Boshe y Gute, en el occidente de la región Oromia, Etiopía, por rendimiento de materia seca (MS), relación hoja:tallo, concentración de proteína cruda (PC), digestibilidad y composición nutricional. Se empleó un diseño experimental de bloques completos al azar con tres repeticiones. El rendimiento promedio de MS fue mayor para la accesión ILRI 16804 en todas las localidades, seguido por ILRI 16801 e ILRI 16800. La relación hoja:tallo, la concentración de PC y los rendimientos de PC y materia orgánica (MO) digestible, igualmente variaron significativamente entre genotipos; los valores más altos de estas características se obtuvieron para la accesión ILRI 16804 en todas las localidades, seguido por ILRI 16800 e ILRI 16801. Los rendimientos de MS, PC y MO digestible y la relación hoja:tallo fueron más altos en Boneya Boshe y Gute que en Bako y en 2017 que en 2016. El desempeño consistentemente superior de las accesiones ILRI 16804, ILRI 16801 e ILRI 16800 en ambos años y en los tres sitios sugiere que estos genotipos deben ser evaluados a nivel de productor y en diferentes ambientes, antes de ser recomendados para cultivo en esta región. Además se recomiendan estudios con cosechas más frecuentes y mediciones de producción animal.

Palabras clave: Digestibilidad, diversidad, gramíneas tropicales, pasto Napier, valor nutritivo.

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Introduction

A major problem facing livestock producers in tropical countries is how to provide adequate nutrition for their animals (Muhammad 2016). In Ethiopia, like other tropical countries, poor nutrition is a major constraint to livestock production in small-holder crop-livestock farming, especially during the dry season, when pastures and cereal residues are both limited in quantity and of low nutritional value (Tolera et al. 2000). Rangeland pastures (54.6%) and crop residues (31.4%) are the main feed resources for the greater part of the country, but they fail to meet nutritional requirements of livestock (McDonald et al. 2002; CSA 2017). To improve livestock production, a sustainable solution to seasonal deficiencies in feed availability and quality is required.

Napier grass (*Cenchrus purpureus* syn. *Pennisetum purpureum*) shows great potential to alleviate the problem because it is adaptable, vigorous and drought-tolerant and can produce high dry matter yields (Alemayehu 2002). It is a tall perennial grass, which is well adapted to elevations from sea level up to 2,000 m. It is reported to be tolerant of drought and will grow in areas where the rainfall range is from 200 to 4,000 mm (FAO 2016). It is also palatable and can be fed fresh as cut-and-carry forage and as hay or silage or directly grazed in the field (Alemayehu 2002; Getnet 2003). According to Boonman (1993), forage yields of 85.4 t DM/ha without fertilizer and a record of 130 t DM/ha with 1,320 kg N/ha have been recorded. However, forage yields vary significantly depending on variety, season, location, soil fertility and management practices (Ogoshi et al. 2010; Rengsirikul et al. 2011). Testing of Napier grass genotypes for both qualitative and quantitative attributes under diverse environmental conditions in order to select superior genotypes for particular environments seems warranted.

The Napier grass variety, accession ILRI 16792, which was introduced in 1998 from International Livestock Research Institute (ILRI), is well adapted to the area and the most commonly grown local variety. However, it is now considered to have limited capacity to produce high forage yields. Therefore, the current study was undertaken to identify Napier grass genotypes superior to the local variety in terms of forage yield, nutritive value and digestibility at 3 locations in western Oromia, Ethiopia.

Materials and Methods

Locations

The experiment was conducted at 3 locations (Bako Agricultural Research Center, Bonaya Boshe and Gute subsites), located in the western part of Oromia regional state, Ethiopia, which represent the subhumid mid-altitude maize-growing area of western Oromia. Specific locations were: Bako (9°06' N, 37°09' E; 1,650 masl; 2,285 mm mean annual rainfall); Bonaya Boshe (9°54' N, 37°00' E; 1,645 masl; 1,295 mm); and Gute (9°01' N, 36°40' E; 1,880 masl; 1,586 mm) (Figure 1). Monthly rainfall means and maximum and minimum temperatures at the 3 sites are shown in Figures 2a, 2b and 2c. The soil type at Bako location is classified as a Nitosol with 2.5% organic carbon, 10 ppm available P, 0.22% total N and pH (H_2O) 5.18, while that at Bonaya Boshe is a clay loam with 1.86% organic carbon, 12 ppm available P, 0.16% total N and pH (H_2O) 4.6; soil at Gute has 60% silt, 35% sand and 5% clay with 1.98% organic carbon, 6.2 ppm available P, 0.17% total N and pH (H_2O) 4.43. Farming systems in the study area are mixed crop-livestock systems, in which production of maize (*Zea mays*), teff (*Eragrostis tef*), noug (*Guizotia abyssinica*), sorghum (*Sorghum* spp.), hot pepper (*Capsicum annuum*) and sugar cane (*Saccharum officinarum*) are the major crops, and cattle, small ruminants and poultry are the most important livestock species.

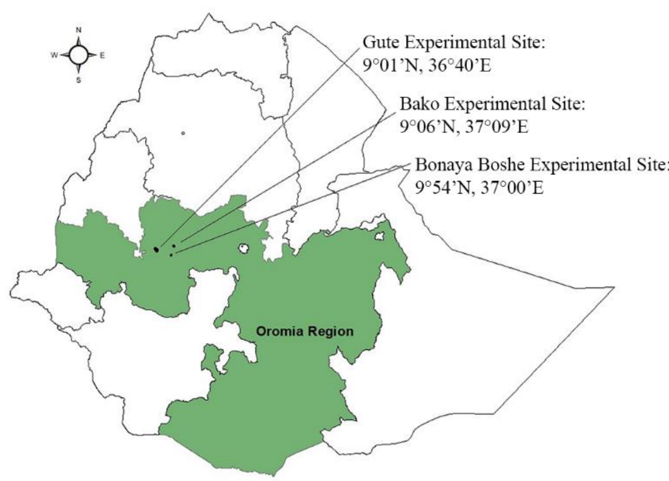

Figure 1. Map of the study area.

Experimental land preparation and planting

Thirty 6 m^2 plots (2 × 3 m) were established on 1 June 2016 at each location. Cuttings of 10 Napier grass genotypes with 3 nodes were planted into a well-prepared seedbed, 2 nodes deep, at an angle of about 45°, with a row spacing of 60 cm and 50 cm between cuttings within rows. Fertilizer was applied according to the recommendation of Tessema et al. (2003), i.e. diammonium phosphate (DAP) at 100 kg/ha at planting, plus urea at 50 kg/ha close to the root slips a month after planting when the Napier grass was well established. In the second year, experimental plots were top-dressed with 50 kg urea/ha, of which one-third was applied immediately after cutting and the remaining two-thirds 2 weeks later.

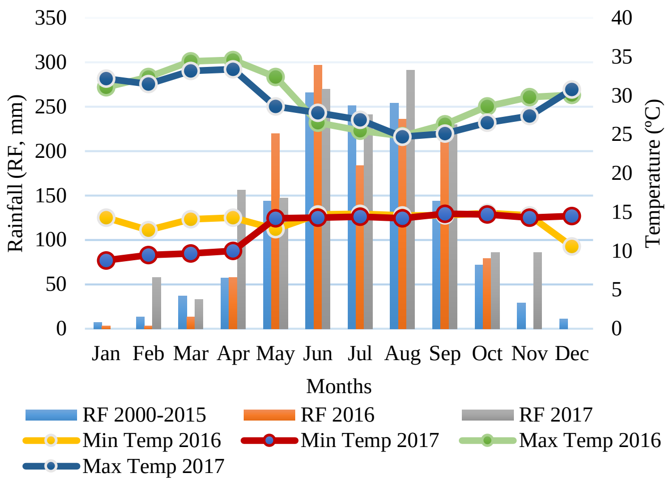

Figure 2a. Mean monthly rainfall and minimum and maximum temperatures at Bako.

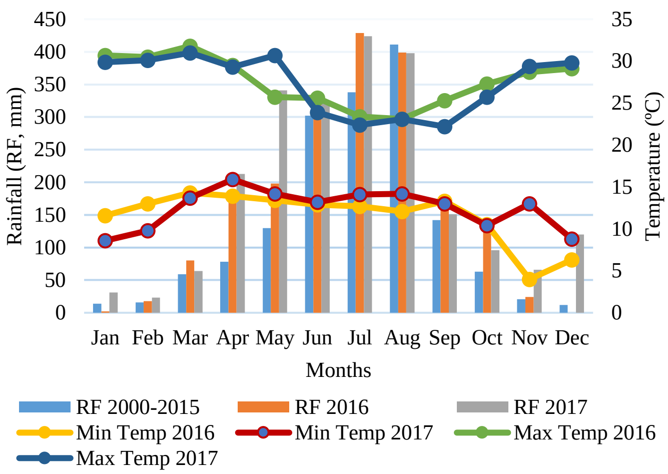

Figure 2b. Mean monthly rainfall and minimum and maximum temperatures at Gute.

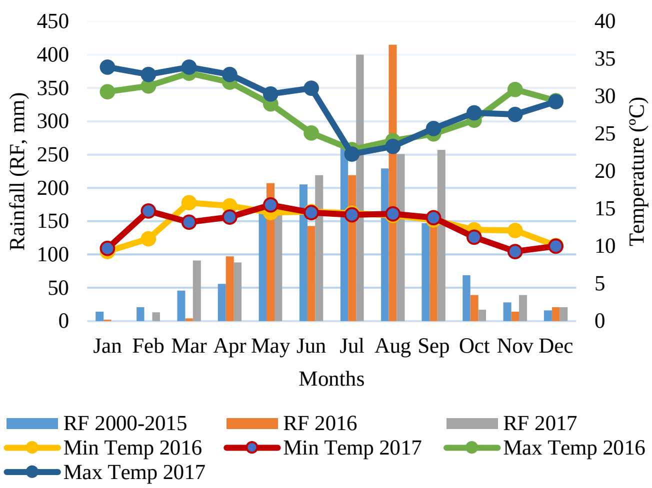

Figure 2c. Mean monthly rainfall and minimum and maximum temperatures at Bonaya Boshe.

Experimental design and treatments

The design was a complete randomized block design with 10 genotypes, 3 locations and 3 replications, giving a total of 30 observations per location. The genotypes tested were: accessions ILRI 14389, ILRI 15473, ILRI 16785, ILRI 16787, ILRI 16798, ILRI 16800, ILRI 16801, ILRI 16804, ILRI 16840 and ILRI 16792. Accession ILRI 16792, the local variety, was included as the standard/check variety for comparison (Control).

Source of planting materials

The 10 genotypes evaluated were selected from a previous screening and preliminary variety trial conducted at Bako Agricultural Research Center on the basis of their yield performance and adaptation to the subhumid climatic conditions of Bako. Cuttings for planting were obtained from International Livestock Centre for Africa (ILCA), now International Livestock Research Institute (ILRI).

Forage yield and calculated yield measurements

Harvesting of forage for data collection was done only once during the first year, while during the second year harvesting was done twice and yields from the 2 harvests combined to provide the total dry matter (DM) yield. Harvesting was done when Napier grass reached about 1.5 m tall, which is the recommended height for harvesting at the Bako Agricultural Research Center. For herbage yield measurements, forage in the middle row of each plot was harvested manually with a sickle at 20 cm above ground level. The fresh forage was weighed with a suspended field balance just after mowing. Then subsamples of 300 g were taken from each replication of each treatment at each location and oven-dried at 65 °C for 72 hours until constant weight to determine forage DM yields. After measuring the fresh forage mass, 5 plants were selected at random from each plot, sorted into leaf and stem and oven-dried to constant weight at 65 °C for 72 hours for estimating leaf:stem ratio on a DM basis. Yields of crude protein (CP) and digestible forage were estimated as a product of total dry forage yield and CP% and in vitro organic matter digestibility, respectively (Schroeder 2013).

Chemical composition and in vitro digestibility analyses

For herbage chemical composition analysis, chopped herbage from the 3 replications was pooled, thoroughly mixed and 1 representative subsample was taken for each accession at each site. The samples were dried in an oven at 65 °C for 72 h and ground to pass through a 1 mm sieve. Then, DM, nitrogen (N) and ash concentrations were determined according to AOAC (1990), and organic matter (OM) percentage was calculated by deducting the ash concentration from 100. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) concentrations were determined using the procedures of Van Soest et al. (1991). In vitro organic matter digestibility (IVOMD) was determined using the Tilley and Terry (1963) method. Metabolizable energy (ME) values were estimated from IVOMD using the equation of Saha et al. (2010): ME (MJ/kg DM) = 0.15 × IVOMD.

Data analyses

Statistical analyses were done using analysis of variance (ANOVA) following the General Linear Model (GLM) procedure of SAS, Version 9.3 (SAS 2007), and significantly different means were separated using the least significant difference (LSD) test at P<0.05. For forage DM, CP and digestible OM yield measurements and leaf:stem ratio, genotypes, year, location and their interactions were considered as independent variables in the model indicated as:

$$Yijkl = \mu + Gi + Ej + Yk + (Gi\times Ej\times Yk) + Bl(j) + eijkl,$$

where:
Yijkl = response variable;
μ = overall mean;
Gi = genotypic effect;
Ej = environmental effect;
Yk = year effect;
Gi×Ej×Yk = interaction effect of genotype, environment and year;
Bl(j) = block effect; and
eijkl is the random error.

For quality traits, since only a composite sample per treatment was taken from each location, location was considered as a replicate and hence the data were subjected to the following model:

$$Yij = \mu + Gi + Ej + eij,$$

where:
Yij refers to the response of forage quality traits;
μ = overall mean;
Gi = effect of genotypes I;
Ej = environmental effect (replicate); and
eij is the random error.

Results

Dry matter, crude protein and digestible organic matter yields and leaf:stem ratio

The results from analysis of variance for DM yield, crude protein (CP) yield and digestible OM yield, and leaf:stem ratio of the 10 Napier grass genotypes (accessions) over the 3 sites are shown in Table 1. All yields were significantly (P<0.01) affected by genotype, location and year with significant interactions, so data for individual sites and treatments are presented.

DM yield varied significantly (P<0.001) and ranged among genotypes from 19.2 to 35.2 t DM/ha at Bako, 31.5 to 50.7 t DM/ha at Bonaya Boshe and 30.5 to 50.0 t DM/ha at Gute (Table 1). The highest mean DM yield over the 3 locations was recorded for ILRI 16804 (45.3 t DM/ha) followed by ILRI 16801 (39.5 t DM/ha) and ILRI 16800 (38.3 t DM/ha). Overall yields at Bonaya Boshe and Gute were higher than at Bako. Yields of CP and OM also

Table 1. Cumulative yields of dry matter, crude protein and digestible organic matter (DOM) and leaf:stem ratios of 10 Napier grass accessions at 3 locations over 2 years (2016 and 2017) in western Oromia, Ethiopia.

Accession	Dry matter yield (t/ha)			Crude protein yield (t/ha)			DOM yield (t/ha)			Leaf:stem ratio		
	Bako	Bonaya	Gute	Bako	Bonaya	Gute	Bako	Bonaya	Gute	Bako	Bonaya	Gute
ILRI 14389	25.6c[1]	40.4c	41.8b	1.76c	3.07c	2.97b	13.6d	20.9c	20.3cd	1.73cd	1.67d	1.81c
ILRI 15743	21.3e	33.8de	36.9c	1.28e	1.99e	2.25c	11.6ef	16.0e	19.2def	1.70cd	1.88bcd	1.86c
ILRI 16785	21.3e	31.5e	36.8c	1.22e	1.86ef	2.25c	9.1g	14.0f	16.9fgh	1.75cd	1.85cd	1.97bc
ILRI 16787	21.4e	32.2de	35.8cd	1.54d	2.22d	2.39c	11.3ef	17.6de	20.1cde	1.88bc	1.86bcd	1.76c
ILRI 16798	19.2f	33.0de	30.5e	1.23e	1.92ef	1.86e	10.8f	16.8de	14.6h	1.76bcd	1.92bc	1.79c
ILRI 16800	28.9b	43.1bc	42.8b	2.08b	2.89c	3.13b	16.3c	21.3c	21.8c	1.98ab	2.09b	2.18ab
ILRI 16801	30.1b	44.6b	43.7b	2.17b	3.57b	3.10b	18.0b	25.9b	26.6b	1.88bc	2.04bc	2.20ab
ILRI 16804	35.2a	50.7a	50.0a	2.78a	4.10a	4.50a	21.5a	30.9a	29.9a	2.17a	2.33a	2.36a
ILRI 16840	22.6de	34.3d	34.3cd	1.22e	2.02de	2.20cd	10.8f	17.1de	16.6gh	1.74cd	1.92bc	1.75c
Control[2]	23.7d	33.5de	33.8d	1.25e	1.71f	1.97de	12.3e	18.0d	17.8efg	1.56d	1.81cd	1.72c
Overall mean	25.0	37.7	38.6	1.65	2.54	2.66	13.5	19.8	20.4	1.82	1.94	1.94
$LSD_{0.05}$	1.54	1.96	2.15	0.11	0.12	0.14	0.87	1.02	1.99	0.22	0.24	0.29
P-level	***	***	***	***	***	***	***	***	***	**	**	***
CV (%)	5.3	4.4	4.8	5.5	4.3	4.6	5.5	4.4	8.4	10.6	10.5	13.0

[1]Means within columns followed by different letters differ significantly (P<0.05). [2]ILRI 16792.

varied significantly (P<0.001) among the tested genotypes as well as between locations (Table 1). CP yields ranged from 1.22 to 2.78 t/ha at Bako, 1.71 to 4.1 t/ha at Bonaya Boshe and 1.86 to 4.5 t/ha at Gute, with the highest values recorded for ILRI 16804 at all locations followed by ILRI 16801 and ILRI 16800. Similarly, digestible OM yield also ranged among genotypes from 9.1 to 21.5 t/ha at Bako, 14.0 to 30.9 t/ha at Bonaya Boshe and 14.6 to 29.9 t/ha at Gute, with the highest values again recorded for ILRI 16804 at all locations followed by ILRI 16801 and ILRI 16800.

As shown in Table 1, the value for leaf:stem ratio ranged among genotypes from 1.56 to 2.17 at Bako (mean 1.82), 1.67 to 2.33 at Bonaya Boshe (mean 1.94) and 1.72 to 2.36 at Gute site (mean 1.94) with the highest value recorded for genotype ILRI 16804 followed by ILRI 16800 and ILRI 16801 across locations (Table 2).

Significant variation in DM (P<0.001), CP (P<0.001) and digestible OM yields (P<0.001) and leaf:stem ratios (P<0.001) were observed among the tested genotypes across locations (Table 2). DM yield ranged from 22.3 to 38.1 t/ha in 2016 and 32.8 to 52.4 t/ha in 2017 with the highest value recorded for genotype ILRI 16804 in both years followed by ILRI 16801 and ILRI 16800. CP yield ranged from 1.35 to 3.19 t/ha in 2016 and 1.91 to 4.39 t/ha in 2017, whereas digestible OM yield ranged from 10.9 to 23.1 t/ha in 2016 and 15.8 to 31.8 t/ha in 2017. Values for leaf:stem ratio ranged among the tested genotypes from 1.57 to 2.27 (mean 1.78) in 2016 and 1.79 to 2.31 (mean 2.01) in 2017. As for DM yield in both years, accession ILRI 16804 gave the highest CP and digestible OM yields plus leaf:stem ratio, followed by accession ILRI 16801 and ILRI 16800. Overall mean DM, CP and digestible OM yields and leaf:stem ratio were higher in 2017 than in 2016 (P<0.0001).

Nutrient composition

Mean nutrient composition of the 10 Napier grass genotypes across the 3 sites is shown in Table 3. Concentrations of CP, OM and ash differed between genotypes (P<0.001). The highest CP concentration (83.3 g/kg DM) occurred in ILRI 16804, followed by ILRI 16801, ILRI 16800, ILRI 16787 and ILRI 14389 (mean 71.6 g/kg DM), while the lowest was recorded for ILRI 16792 (Control), ILRI 16840, ILRI 16798, ILRI 16785 and ILRI 15743 (mean 58.6 g/kg DM). Ash and OM concentrations in the 10 genotypes ranged from 65.7 to 94.3 g/kg DM and 906 to 934 g/kg DM, respectively. Differences in fiber and lignin concentrations were generally non-existent.

In vitro digestibility

Table 4 shows the mean in vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) values for the 10 Napier grass genotypes over the 3 locations. Both quality traits showed marked variation (P<0.001) among genotypes. The highest IVOMD values occurred in accessions ILRI 16804 and 16801 (mean 60.1%) and the lowest in ILRI 16785 (44.3%). ME values were highest in ILRI 16804 and 16801 (mean 9.0 MJ/kg DM).

Table 2. Dry matter (DM), crude protein (CP) and digestible organic matter (DOM) yields and leaf:stem ratios of 10 Napier grass accessions in 2 years across 3 locations in western Oromia, Ethiopia.

Accession	DM yield (t/ha)		CP yield (t/ha)		DOM yield (t/ha)		Leaf:stem ratio	
	2016	2017	2016	2017	2016	2017	2016	2017
ILRI 14389	30.1c[1]	41.9c	2.18c	3.03d	14.6d	21.9d	1.57c	1.91c
ILRI 15743	25.2d	36.2d	1.51de	2.17f	12.8e	18.4f	1.69c	1.93c
ILRI 16785	24.4de	35.4d	1.45ef	2.10f	10.9g	15.8h	1.73c	1.99bc
ILRI 16787	22.9ef	36.6d	1.58d	2.52e	12.6ef	20.2e	1.68c	1.98bc
ILRI 16798	22.3f	32.8e	1.35f	1.99g	11.4fg	16.7g	1.73c	1.92c
ILRI 16800	31.8b	44.7b	2.24c	3.16c	16.4c	23.1c	1.93b	2.24a
ILRI 16801	32.8b	46.1b	2.46b	3.43b	19.5b	27.5b	1.94b	2.14ab
ILRI 16804	38.1a	52.4a	3.19a	4.39a	23.1a	31.8a	2.27a	2.31a
ILRI 16840	25.4d	35.4d	1.51de	2.11f	12.4ef	17.3g	1.68c	1.92c
Control[2]	25.5d	35.1d	1.38f	1.91g	13.5de	18.6f	1.59c	1.79c
Mean	27.9	39.7	1.9	2.7	14.7	21.1	1.78	2.01
$LSD_{0.05}$	1.52	1.56	0.1	0.1	1.35	0.84	0.17	0.20
P-level	***	***	***	***	***	***	***	***
CV (%)	5. 8	4.2	5.7	4.1	9.7	4.2	10.4	10.8

[1]Means within columns followed by different letters differ significantly (P<0.05). [2]ILRI 16792.

Table 3. Chemical composition of 10 Napier grass accessions across 3 locations in western Oromia, Ethiopia.

Accession	Parameter (g/kg DM)					
	Ash	CP	OM	NDF	ADF	ADL
ILRI 14389	80.0bc[1]	72.0b	920bc	640	398b	75.8
ILRI 15743	94.3a	60.0cd	906d	647	437a	73.0
ILRI 16785	87.0ab	59.0cd	913cd	656	432a	78.5
ILRI 16787	79.3c	69.3b	921b	639	436a	77.7
ILRI 16798	87.7a	61.0c	912d	646	443a	75.8
ILRI 16800	68.6d	70.7b	931a	644	432a	79.0
ILRI 16801	77.4c	74.3b	923b	635	433a	75.0
ILRI 16804	65.7d	83.3a	934a	631	432a	73.3
ILRI 16840	78.3c	59.0cd	922b	655	432a	78.5
Control[2]	78.0c	54.0d	922b	655	433a	80.4
Overall mean	79.6	66.3	920	645	431	7.67
$LSD_{0.05}$	0.75	0.64	0.75	2.49	1.54	0.8
CV (%)	5.5	5.6	0.48	2.3	2.1	6.1
P-level	***	***	***	NS	**	NS

[1]Means within columns followed by different letters differ significantly (P<0.05). [2]ILRI 16792. CP = crude protein; OM = organic matter; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin.

Table 4. In vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) concentration of 10 Napier grass accessions across 3 locations in western Oromia, Ethiopia.

Accession	IVOMD (% DM)	ME (MJ/kg DM)
ILRI 14389	52.5b[1]	7.9b
ILRI 15743	51.2bc	7.7bc
ILRI 16785	44.3d	6.7d
ILRI 16787	54.5b	8.2b
ILRI 16798	51.5bc	7.7bc
ILRI 16800	52.1bc	7.8bc
ILRI 16801	59.6a	8.9a
ILRI 16804	60.7a	9.1a
ILRI 16840	48.6c	7.3c
Control[2]	52.7b	7.9b
Overall mean	52.8	7.9
$LSD_{0.05}$	3.87	0.58
CV (%)	4.3	4.3
P-level	***	***

[1]Means within columns followed by different letters differ significantly (P<0.05). [2]ILRI 16792.

Discussion

The present study has provided useful information to assess the relative performance in terms of both quality and quantity of the 10 Napier grass genotypes under the different environmental conditions tested. While there was significant variation in biomass yield, CP concentration and yield, leaf:stem ratio and in vitro digestibility among genotypes over the 3 locations, ranking of genotypes remained remarkably consistent across the 3 locations. Results obtained in a single environment would give a good indication of how a particular genotype would perform relative to another but absolute yields etc. at a given site could be misleading if applied to a different environment. Significant differences in DM yield have been observed previously among 20 oat varieties and 14 grass pea lines tested across various locations in Ethiopia (Fekede 2004) and Iran (Ahmadi et al. 2012), respectively. In the current study, environmental effects were highlighted by the marked differences in overall yields of DM and CP at Bonaya Boshe and Gute compared with Bako (approximately 50% greater). In a similar fashion, mean DM yields recorded for the genotypes tested, particularly for ILRI 16804, ILRI 16801 and ILRI 16800, were higher than the values reported by Tessema (2005), who studied 10 Napier grass accessions (labeled as ILRI 14983, ILRI 14984, ILRI 15743, ILRI 16834, ILRI 16835, ILRI 16786, ILRI 16791, ILRI 16798, ILRI 16836 and local check) at Adet Agricultural Research Center, Ethiopia. As reported by Boonman (1997), agro-meteorological variables such as rainfall, soil fertility, air temperature and wind have major impacts on crop growth and development.

In evaluating forage crops, it is well accepted that DM yield should not be considered as the sole parameter for evaluating a species. Quality of the forage produced must be considered along with DM yields to give nutrient yields, as the optimal time to utilize a forage is always a compromise between DM yield and CP concentration plus digestibility. Including CP% and DM digestibility with DM yield in determining the overall value of a forage provides an overall picture of the nutritional value of a crop. In the current study, despite variation between sites, there was surprising consistency across the 3 different locations in terms of the genotypes which performed at the highest level. Not only did ILRI 16804 produce the highest DM yields at all sites, but also it had the highest CP% and equal highest in vitro digestibility. ILRI 16804, ILRI 16801 and ILRI 16800 consistently outperformed the local Control variety (accession ILRI 16792), indicating that local farmers could improve production by changing the genotype they are growing.

The higher leaf:stem ratio recorded for accessions ILRI 16804, ILRI 16800 and ILRI 16801 reinforced their superiority over other genotypes in terms of DM yield, given that leaf is generally of higher nutritive value than stem (Islam et al. 2003). The overall mean leaf:stem ratio recorded across locations in the current study (1.82–1.94) was lower than the 1.7–3.1 reported by Nyambati et al. (2010). This difference might be attributed to environmental variation where the studies were carried out as well as genetic variability among the tested genotypes and stage at which they were harvested.

The higher yields of DM, CP and digestible OM, and higher leaf:stem ratio observed during the second production year might be attributed predominantly to the perennial nature of Napier grass, which produces more tillers and higher vegetative growth as the pasture develops following planting. Fekede et al. (2005) and Tessema and Alemayehu (2010) reported that tiller production by Napier grass increases with time after planting and density of vegetative growth increases as the pasture consolidates due to the perennial nature of the grass. In addition to stand development, the higher and better distributed rainfall received during the second production year across the 3 locations could be expected to produce growth superior to that recorded in the establishment year.

Forage quality is highly variable among and within forage types with forage species, variety and stage of maturity at harvest all contributing to this variation (NRC 2000). CP concentrations obtained (54–83.3 g/kg DM) in the current study span the minimum level of CP required for effective rumen function reported in the literature. Van Soest (1982) reported that, at CP concentrations less than 70 g CP/kg DM, rumen function suffers and feed intake in ruminants can be depressed. While most genotypes studied either failed to reach this level or barely did so, ruminants fed on this forage as cut-and-carry would require protein supplements, particularly so lactating animals. However, stage of maturity at which the forage is harvested plus soil fertility have a marked influence on CP%. Harvesting more frequently would provide forage with higher CP%. Only ILRI 16804 in this study produced forage with CP% considered acceptable for providing a diet above a maintenance level (Norton 1982). Even though NDF concentrations did not vary significantly among genotypes, the range (631–656 g/kg DM) was slightly below the average value of 662 g/kg DM reported for tropical grasses (Barton et al. 1976). The overall mean of ADF recorded in the current study was 431 g/kg DM which is comparable with the findings reported by Keba et al. (2013) who studied the nutritive value of common grass species in the semi-arid rangelands of Borana, southern Ethiopia.

Digestibility of a forage is important because of its influence on energy and protein extracted by animals and feed intake in ruminant production systems. The IVOMD values (44.3–60.7%) obtained in the current study fall within the general range reported for tropical grasses of 50–60% (Owen and Jayasuriya 1989). With the exception of genotypes ILRI 16785 (44.3%) and ILRI 16840 (48.6%), which had relatively low digestibility percentages, all Napier genotypes, especially ILRI 16804 (60.7%) and ILRI 16801 (59.6%), produced forage which would be quite acceptable for ruminant nutrition. The ME values obtained in this study (6.7–9.1 MJ/kg DM) agree with the values reported for other tropical grasses, e.g. 7.1–9.4 MJ/kg DM by Krishnamoorthy et al. (1995) and 5.76–9.12 MJ/kg DM by Nogueira Filho et al. (2000).

The variation in performance of the different genotypes in the 3 locations indicates the potential for selecting superior genotypes in terms of both yield and quality for use in environments suitable to those involved. The consistent high performance of ILRI 16804, ILRI 16800 and ILRI 16801 across the 3 sites relative to the Control accession ILRI 16792 suggests that further studies be carried out with these genotypes in the area as well as similar environments. These studies should examine more frequent harvesting of the forage in an endeavor to improve the quality of forage without significant yield depression. Demonstrations on farms should encourage farmers to replace the existing variety with these apparently superior lines. These future studies should focus not only on performance of the grass but also the performance of ruminants fed on the forage to determine if the apparent better quality of the forage produced by these new genotypes is reflected in superior animal performance.

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