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Regional Evaluation of Agronomic Performance and Nutritive Quality of Accessions of *Pennisetum purpureum* and its Hybrids with *Pennisetum typhoides* in sub Saharan Africa.

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Introduction

An integrated crop and animal farming systems approach is appropriate for improved human nutritive requirements, especially protein, whose supply is notably inadequate in most of Africa. Animal feed resources has been identified to be one major factor limiting production of the important protein sources; milk and meat. One angle for alleviating the problem is the identification and development of fodder crops sustainable on small-holder farms. Furthermore, due to the diverse rainfall occasion and distribution, perennial fodder crops with high re-growth rates that are also drought tolerant may be more appropriate for the region.

Nine promising *Pennisetum purpureum* and *Pennisetum purpureum* X *Pennisetum typhoides* hybrid accessions were identified for testing at ten locations throughout sub-Saharan Africa alongside the best local napier grass varieties between 1993 and 1995. Accessions with outstanding performance at each location underwent further *in vitro* and *in vivo* nutritive value studies to assess their potential for improving livestock productivity.

Materials and Methods

Accessions of napier grass evaluated for yield and nutritive quality as well as ruminant intake and digestibility at ten locations in Cote d'Ivoire, Ghana, Tanzania, Kenya, Ethiopia, Uganda, Zimbabwe and Malawi are listed in Table 1 below.

Table 1: Pennisetum accessions evaluated at various experimental sites

Variable	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Yield and nutritive quality	H34	H34	H34	H34	H34	H34	H37	H34	H35	H34
	H35	H35	H35	H35	H35	H35	C86	H35	H37	H35
	H37	H37	H37	H37	H37	H37	C91	H37	H38	H37
	C86	H38	H38	H38	H38	H38	C98	H38	H40	H38
	C91	H40	C86	H40	H40	C86		C86	C98	H40
	C98	C86	C91	C86	C86	C91		C91	C43	C86
		C91	C98	C91	C91	C98		C98		C91
		C98		C98	C98	C43		C43		C98
		C43		C43	C43					C43
Intake and Digestibility	H37	H34	C86	H37	C86		H37	H34	H35	H38
	C86	H35	C91	C86	C91		C86	H35	H37	C86
	C98	H37	C98	C91	C98		C91	C86	H38	C98
		H38		C98			C98		H40	C43
		H40							C98	
		C86								
		C91								
		C98								
		C43								

Code	Location	Code	Accession No.
L1	Bouake, Cote d'Ivoire	H34	16834
L2	Kumasi, Ghana	H35	16835
L3	Tanga, Tanzania	H37	16837
L4	Morogoro, Tanzania	H38	16838
L5	Kakamega, Kenya	H40	16840
L6	Debre Zeit, Ethiopia	C86	16786
L7	Kampala, Uganda	C91	16791
L8	Holetta, Ethiopia	C98	16798
L9	Marondera, Zimbabwe	C43	15743
L10	Bunda, Malawi		

A summary of climatic data for the test sites is provides in Table2. Two of the ten testing sites, are located in the sub-humid/humid lowlands of West Africa. Bouake, Cote d'Ivoire (L1) has monomodal rainfall with a distinct dry season and steady temperatures during the year. Kumasi-Ghana (L2) has 60% of its rain from May to July and 30% from September to November with a short dry spell between July and September. There is little or no rain in January and February and temperatures are steady throughout the year. Soils are sandy, slightly acidic and of low fertility.

Excepting a weakly bimodal rainfall distribution, peaking in January - February and June - August, Tanga (L3) on the coastal belt of Tanzania has climate similar to the West Africa locations. Morogoro (L4), located further inland at a higher elevation has much lower rainfall with a long dry season and lower mean temperature. Soils are sandy, slightly acidic and of low fertility. Kakamega (L5) and Kampala (L7) are both located in the great lakes basin, the former at a higher altitude. Rainfall is more or less all year-round with a peak between March and June.

Table 2: Climatic characteristics of experimental sites for the Pennisetum evaluation Trial.

Location	Altitude (metres)	Annual rainfall (mm)	Mean annual temperature (°C)	Most humid month*	Most dry month*	Rainfall mode
1. Bouake Ivory Coast	450	1170	26.3	August	April	Monomode
2. Kumasi Ghana	200	1250	25.6	October	February	Weak Bimode
3. Tanga Tanzania	66	1320	26.3	October	February	Bimode
4. Morogoro Tanzania	550	860	24.3	July	May	Bimode
5. Kakamega Kenya	1558	1960	20.5	October	February	Monomode
6. Debre Zeit Ethiopia	1850	850	18.6	June	June	Bimode
7. Kampala Uganda	1200	1180	22.0	December	-	Monomode
8. Holetta Ethiopia	2400	1050	15.4	August	April	Bimode
9. Marondera Zimbabwe	1600	900	18.6	June	June	Monomode
10. Bunda Malawi	1150	810	19.6	May	July	Monomode

*Potential evapotranspiration, PET > 0.35 for humid and < 0.35 for dry

Debre Zeit (L6) and Holetta (L8) in the Ethiopian highlands (1850m and 2400m respectively) have distinctly bimodal rainfall with the rainy season from June to September (70%) and the short season between February and April. Mean temperatures are low, (16-19°C) giving rise to frost in Holetta.

The Southern Africa sites, Marondera, Zimbabwe (L9) and Bunda, Malawi (L10) are characterised by 5-6 month seasons of erratic rainfall with false starts and prolonged dry spells. Mean temperatures are high in September to November and occassionally below freezing point between May and June. Total annual rainfall, length of growing season and severity of the dry season, in terms of relative humidity and temperature are the major climatic factors for rating site potential with respect to fodder growth and persistence.

Accessions were planted in single rows 6m long at the recommended inter-row spacing of 0.75m and 0.4m intra-row, to give a plant density of 33,000 plants per hectare at L2, L4, L5, L8 and L10. The same density was obtained at L6, Debre Zeit, Ethiopia using a spacing of 0.5 X 0.6m. Different plant densities were obtained at L1 (31,000), L3 (29,600) and L9 (18,500). A spacing of 0.5 X 0.5m was used at L7 to attain a density of 40,000 plants per hectare.

Fertiliser application varied across locations with 40 Kg/ha N and P being applied during planting at L1, L3, L5, L6, L8 and L10. Subsequent applications were different, depending on soil type and texture. At L9, lime was applied before planting and 50 Kg N and P per hectare top dressed every 6 weeks and 50 Kg K every 12 weeks. Substantial amounts of manure were applied at L3. Details of agronomic practices are provided in Appendix B.

Dry matter yield, various nutritive quality values as well as ruminant intake and various digestibility characteristics of the forages were measured. We focus on the more important dry matter yield, forage leaf fraction, dry matter content, crude protein content, intake and digestibilty. Data obtained at each location were subjected to analysis of variance. Growth curves were fitted to plant heights obtained at two locations L2 and L3 to obtain and compare accession growth rates. Proportional deviations of accession yield from local cultivar yield values were calculated from the means reported for each location and subjected to analysis of variance to obtain a measure of overall performance of accessions across locations. This non-standard analysis was done considering the varying accessions tested as well as agronomic and harvesting practices among test locations.

Results

Characterization of accessions

Van der Wouw *et al* studied agronomic and phenotypic characteristics of nine accessions at Debre Zeit , Ethiopia (Table 3). Seven of the observed variables describe hairiness of leaves and sheaths on an ascending scale of 0-5. All accessions had hairy sheaths except the completely glabrous Hybrid 16834. A part from this hybrid and cultivars C97 and C43 all other accessions had hairy leaves.

They used the leaf, stem and flower variables to characterise and group the nine accessions using hierarchical cluster analysis. The groups of accessions identified were:

1.	Internodes shorter than 5 cm	C3
	Internodes longer than 5 cm	H34, H35, H38, C86, C98, C91, C97, H37
2.	First flower appears early, small leaves, thin stems	H34, H35, H38
	First flower appears late or not at all, robust plants	C86, C98, C91, C97, H37
3.	Leaf blade and sheath glabrous	H34
	Leaf blade and sheath hairy	H35, H38
4.	Dense hair on nodes	C86, C98
	Sparse hair on nodes	H37
	No hair on nodes	C91, C97

Table 3. **Agronomic and leaf-stem characteristics of Pennisetum accessions grown at Holetta, Ethiopia.**

	Accession									
	C43	**C86**	**C91**	**C97**	**C98**	**H34**	**H35**	**H37**	**H38**	**LSD(p=.05)**
Agronomic Characters										
DM t/ha at 10 weeks	2.3	11.2	9.8	7.3	11.1	4.3	5.8	15.4	5.8	8.5
Leaf fraction (%)	95	79	68	74	72	86	80	74	75	13.8
Height (m)	1.2	2.6	2.9	2.4	2.7	2	1.5	3.2	2.3	0.47
DM t/ha at 15 weeks	6.8	24.1	22	20.8	28.7	6.9	5.6	32.5	18.2	16.9
Leaf fraction (%)	89	53	42	53	44	58	58	47	45	14.7
Stool diameter (cm)	38	32	41	38	34	24	38	46	32	13
Rhizome number	0.0	0.7	2.0	1.0	0.0	0.0	0.0	1.0	0.0	1.5
Weeks to flowering	-	-	-	-	-	8	-	16	-	11
Leaf stem Characters										
Leaf length (cm)	76	130	103	104	130	88	77	129	88	15.4
Leaf width (cm)	2.7	3.4	3.4	3.4	3.7	2.6	2.9	3.0	2.8	0.6
Ligule length (mm)	3.9	5.2	4.5	4.4	4.1	5.5	4.6	5.1	4.7	0.6
Leaf Serrateness (0-5)	2.3	2.0	2.0	1.3	2.0	1.0	2.3	1.3	2.7	0.8
Leaf hair (adaxial)										
density (0-5)	0.0	2.7	1.7	0.0	5.0	0.0	4.0	3.7	4.0	0.98
length (mm)	0.0	1.7	0.7	0.0	2.4	0	1.3	2.3	1.3	1.08
roughness (0-5)	2.7	2.7	2.0	2.7	0.0	1.7	0.0	0.7	0.0	1.08
Leaf hair (abaxial)										
density (0-5)	0.0	0.0	0.0	0.0	2.7	0.0	2.7	0.7	2.7	0.93
length (mm)	0.0	0.0	0.0	0.0	1.7	0.0	1.3	0.3	1.0	0.53
roughness (0-5)	2.0	2.3	2.7	3.3	1.7	2.0	1.7	1.7	2.3	1.17
Leaf sheath hair										
density (0-5)	4.0	4.7	4.7	2.7	5.0	0.0	3.7	3.7	3.7	1.44
length (mm)	2.7	2.3	1.3	2.0	2.0	0.0	1.7	2.7	1.0	0.86
Node hair										
density (0-5)	3.3	5.0	1.0	1.7	5.0	0.0	1.0	0.0	1.7	2.98
length (mm)	0.7	2.7	0.7	1.3	3.7	0.0	0.3	0.0	0.3	1.73
Stem thickness (cm)	1.5	2.2	2.3	1.7	2.4	1.3	1.3	1.9	1.2	0.26
Internode length (cm)	2	14	19	17	19	21	17	18	21	6.10

Three main groupings or families emerged from this scenario:

Group 1: dwarf variety Mott (C43)

Group 2: hybrid varieties H34, H35 and H38

Group 3: napier varieties C86, C91, C97, C98
and hybrid variety H37.

Group 3 consisted of robust, tall plants with thick stems, large long leaves and high yield, the latter being usually highly correlated with plant height, and leaf length.

A similar study was done by Boonman (1992, p 225-6) for napier varieties tested at Kakamega (L5) but invoking additional variables such as aerial tillering from the nodes and palatability.

Yield and nutritive quality

Average dry matter yield per harvest, crude protein content, leaf fraction and dry matter content values for each testing site are provided in Tables 4 and 5. There was wide variability among test sites in agronomic and harvest practices (see Appendix B).

Accession C86 was outstanding for dry matter yield at Bouake Ivory Coast (L1) during the first season performing significantly better than the best local cultivar which was in turn matched by C98. Re-growth of C86 in the second year did not however match that of the best local cultivar, C98, C91 nor H37. Local materials performed better than the introduced hybrids and cultivars. Whereas H37 had higher leaf fraction overall, accessions C86, H34 and C98 had values comparable to those of the best local varieties.

During the second season, yield of the best local variety was higher but not significantly different from that of C98, C91, H37 and C86. These best four introductions overall together with H34 had leaf fractions above 70%. The positive correlation between yield and leaf fraction is a desirable additive association between key quantitative traits.

At Cattle Research Station, Kumasi, Ghana (L2a) accessions H35 and H34 were outstanding for yield and dry matter content while C86, H40 and C98 were comparable to the best local variety for these traits. These five accessions also performed well at Livestock farm, Kumasi, Ghana (L2b) alongside H38. All of these promising accessions plus C43 and H37 gave higher than or comparable leaf fractions to the best local variety except H34 and H35 at location L2a and C98 at L2b.

Although a local variety was best overall for yield at Tanga, Tanzania (L3), C91, C86, C98, H38 and H35 were the promising new accessions for this site. Accession H35 was outstanding in DM content whereas H38 and H34 also gave values above the 15% for the best local variety TAI 124. Accession C91 had a relatively lower DM content rating.

Accessions C98, H37, C86 and C91 performed well in terms of yield and leaf fraction at Morogoro, Tanzania (L4). The low yielding C43 had the highest leaf fraction and crude protein content. No significant difference in crude protein content was detected although the local variety had a slightly higher value than all accessions except C43. Hybrids H40, H34 and H35 had DM content higher than the best local variety.

Only accession C91 had yield high enough to match that of the best local variety Clone 13 at Kakamega – Kenya (L5). However, H37, H35 and C98 were the other more promising introduced accessions.

At Addis Ababa, Ethiopia (L6) accessions H37, C98, C86 and C91 performed well with mean dry matter yield per harvest of 16 to 24 tons per hectare compared to 4.6 tons for the lowest yielding C43. Leaf stem ratios declined considerably at 15 weeks growth compared to 10 weeks except for C43 which retained a high leaf fraction. However, C43, H34, H35 and C86 had significantly higher mean leaf fractions (Table 5). The highest yielders were tall robust plants, with thick stems and large leaves. High correlations were observed between plant height, leaf length and yield.

At Kampala, Uganda (L7), there was little variability in DM yield among accessions but C86 recorded slightly higher levels of DM content.

Table 4. Dry matter yield (t/ha) of Pennisetum accessions grown at various locations in the sub-Saharan region of Africa

Accession	L1Y1	L1Y2	L2A	L2B	L3	L4	L5	L6	L7	L8	L9Y1	L9Y2	L10
H16834	1.20	5.00	8.09	9.07	4.27	1.78	3.61	5.60	.	4.99	.	.	7.94
H16835	3.80	4.40	8.21	13.73	7.63	3.30	4.49	5.70	.	6.50	4.02	8.22	14.29
H16837	3.70	6.75	3.76	7.10	5.43	7.47	4.68	23.95	18.47	6.04	4.74	5.80	5.28
H16838	.	.	4.14	11.82	8.53	4.14	3.90	12.00	.	3.92	4.50	7.36	16.78
H16840	.	.	5.77	15.98	.	1.50	2.45	.	.	.	4.00	5.92	6.18
C16786	14.30	5.80	5.79	12.86	8.73	6.94	4.08	17.65	23.80	5.76	.	.	8.41
C16791	5.00	7.43	1.92	7.87	9.50	6.90	5.35	15.90	21.93	6.43	.	.	10.23
C16798	9.20	7.80	5.67	10.37	8.53	7.83	4.48	19.90	23.47	5.58	3.62	5.68	9.72
C15743	.	.	2.27	4.51	.	1.43	2.01	4.55	.	1.63	2.50	5.38	7.30
Best local variety	10.80	10.60	5.26	11.40	11.60	7.15	5.53	-	24.13	3.88	4.28	8.30	5.67
SED	-	2.52	0.92	1.01	0.99	2.69	0.41	5.40	-	1.85	0.42	0.71	-
No. Of harvests	3*	3*	2	1	3	4	5	2	3	3	5*	5*	1

Note: see appendix B for varying harvesting practices
* Not repeated harvests

Location Key:

L1Y1 - Bouake, Cote d'Ivoire (Year 1)
L1Y2 - Bouake, Cote d'Ivoire (Year 2)
L2 - Kumasi, Ghana
L3 - Tanga, Tanzania
L4 - Morogoro, Tanzania
L5 - Kakamega, Kenya
L6 - Debre Zeit, Ethiopia
L7: Kampala, Uganda
L8 - Holetta, Ethiopia
L9 - Marondera, Zimbabwe
L10 - Bunda, Malawi

Table 5. **Mean Crude protein content , Leaf fraction and Dry matter content of various napier grass accessions grown at various locations**

	Crude protein (%)					*Leaf fraction (%)*						*Dry matter content (%)*				
Accession	**L4**	**L7**	**L8**	**L9Y1**	**L9Y2**	**L1Y1**	**L1Y2**	**L2A**	**L2B**	**L4**	**L6**	**L2A**	**L2B**	**L3**	**L4**	**L7**
H16834	7.07	.	15.07	.	.	75.0	71.0	39.0	66.6	42.6	72.0	37.5	35.1	15.5	27.2	.
H16835	6.93	.	15.04	13.94	11.84	57.9	65.0	34.6	73.8	30.3	69.0	30.8	32.9	16.9	26.9	.
H16837	6.80	9.6	15.51	12.80	11.72	81.1	72.3	51.0	61.1	54.6	60.5	19.3	28.3	13.7	23.3	29.1
H16838	6.47	.	12.88	12.24	11.48	.	.	46.2	63.0	30.1	60.0	19.2	35.4	15.7	22.7	.
H16840	7.43	.	.	13.06	12.12	.	.	43.5	70.2	46.2	.	21.7	31.2	.	32.9	.
C16786	6.60	8.1	13.29	.	.	76.9	77.6	46.8	58.3	60.3	66.0	22.3	33.5	14.0	22.0	36.0
C16791	6.83	10.5	14.22	.	.	60.0	70.5	29.6	57.8	55.0	55.0	18.7	43.1	13.7	18.7	33.5
C16798	6.00	9.7	13.79	13.40	12.30	71.7	78.9	48.5	55.2	58.3	58.0	19.9	29.5	14.1	19.9	29.7
C15743	8.77	.	17.04	15.40	13.80	.	.	61.4	61.1	68.0	92.0	13.4	29.5	.	24.0	.
Best local variety	8.20	8.5	13.69	12.16	11.50	74.2	73.7	50.7	63.6	57.4	.	20.7	28.2	15.1	21.4	32.0
SED	1.12		0.21	0.65	0.46	-	3.0	2.4	2.5	8.1	4.2	-	2.4	1.2	2.9	-

Legend:

L1 - Bouake, Cote d'Ivoire L2 - Kumasi, Ghana L3 - Tanga, Tanzania L4 - Morogoro, Tanzania L5 - Kakamega, Kenya

L6 - Debre Zeit, Ethiopia L7: Kampala, Uganda L8 - Holetta, Ethiopia L9 - Marondera, Zimbabwe L 10 - Bunda, Malawi

Holetta, Ethiopia (L8), at the highest elevation of all testing sites was favourable to the newly introduced napiers . Only C43 fell below the local variety in yield. Accessions H35 and C91 were outstanding followed by H37, C86 and C98. Whereas C35, C98 and H38 were susceptible to frost damage, accessions C86, C43, H35 and the local check had intermediate tolerance while H34 and H37 were highly tolerant. All accessions had significantly higher crude protein content than the local check except H38, C86 and C98.

Separate plots were established to cater for cutting frequencies of 2, 4, 6, 8 and 10 weeks at Marondera, Zimbabwe (L9). Best overall for yield, during the establishment year were H37 and H38 followed by H35 and H40 that were comparable to the best local variety SDPP19. During the subsequent year, the local cultivars Bana and SDPP19 and H35 emerged leaders for DM yield closely followed by H38. No significnt difference in CP content levels was detected among accessions except C43 that was outstanding during the first season.

Accessions H38 and H35 were outstanding for yield at Lilongwe, Malawi (10) followed by C91, C98 and C86. Hybrid H34 and C98 were intermediate while hybrids H40 and H37 matched the local variety on the lower side.

Across Region Yield Performance

Means of proportional deviations of accession dry matter yield from corresponding local cultivar yield across all locations for each accession and over all accessions at each location are presented in Table 6. Location L6 was left out of this analysis since no local cultivar was tested alongside the others at that site. Accessions C86 and H35 emerged the highest ranked introduced accessions followed by H38. Nevertheless, their average performance was above (positive mean deviation) but not significantly different from that of adapted local varieties. These then, are the top three accessions for forage yield production across the region.

Table 6. Means of proportional deviations* of accession dry matter yield from corresponding best local cultivar yield.

Rank	Accession	Mean
1	C16786	0.05
2	H16835	0.05
3	H16838	0.01
4	C16798	-0.01
5	C16791	-0.07
6	H16837	-0.19
7	H16840	-0.23
8	H16834	-0.24
9	C15743	-0.57
	Location	
1	L10	0.62
2	L8	0.27
3	L2A	-0.03
4	L9Y1	-0.06
5	L2B	-0.08
6	L7	-0.15
7	L9Y2	-0.18
8	L5	-0.27
9	L4	-0.32
10	L3	-0.38
11	L1Y2	-0.42
12	L1Y1	-0.43

*Proportional deviation = (Y – X) / X
Y= Accession mean yield at a location
X= Best local cultivar mean yield at the location

Overall, the performance of all introduced accessions was not significantly different (P>0.05) from that of the best local cultivars except for the dwarf variety C43 (57% below local varieties). Introduced accessions performed better at Bunda, Malawi (L10) and Holetta, Ethiopia (L8) compared to all other locations. Their performance was poorest at Bouake, Cote d'Ivoire (L1) and Tanga, Tanzania (L3) (38 - 43% below local varieties).

Rates of growth

Crude protein content generally followed the same trend over time as leaf fraction at Morogoro, Tanzania (L4). This seems logical given that protein content of leaves is

higher than that of stems. Favourable weather may cause plants to grow rapidly, thus causing a faster reduction in leaf fraction and consequently CP content levels.
It is also well known that fodder dry matter yield is directly related to amount of rainfall at a given phase lag, provided other growth factors remain favourable. Perennial fodder crop genotypes with high growth rates are more likely to withstand a high frequency of harvesting at optimum stages of growth, thereby efficiently utilising high precipitation while it lasts. Therein lies the latent contribution of growth rate to both quantity and quality of forage yield.

The rate of growth or regrowth of fodder crops is not a linear function of time, rather, growth follows the exponential law. A simple exponential curve,

$$\boldsymbol{h = a e^{b t} + e}$$

where h is plant height at time t after establishment or cut-back, a a constant , b the coefficient of growth and e a random error term, satisfactorily models growth of perennial fodder crops (Kamidi and Wanjala 1988). Height data taken at locations L2b and L4 were used to fit the curve.

Fitted parameters, p -values for the hypothesis $Ho : b = 0$, coefficients of determination and resulting rates of regrowth in centimetres per day at 1 metre plant height are presented in Table 7. There was a conspicuous accession X location interaction for growth rates, a pointer to genotypic adaptation to specific environments. The consistent, relatively high growth rates for local varieties is further testimony in support of growth rate as a measure of adaptation. H38 had a distinctly high growth rate at Kumasi, Ghana (L2b), but ranked 6th at Morogoro, Tanzania (L4). Accessions C91 and H40 performed equally well at Morogoro, the latter growing at a relatively lower rate at Kumasi. The dwarf variety C43 grew at a fairly fast rate at Morogoro where most accessions performed well. It however grew at lowest rate of 1.5 cm/day at Kumasi. Growth rates were generally lower at Kumasi possibly due to off season establishment and irrigation in early growth. Incidentally, Kumasi is a high potential site (1250 mm rainfall) compared to the marginal Morogoro (860 mm). However, a matrix of factors including soils, altitude, humidity, temperature, rainfall etc. interact to provide the sum total environment for growth.

Table 7. **Growth curve parameters and derived growth rates (cm/ day) for various Napier grass accessions grown at two locations in sub- Saharan Africa**

	Location 2b - Kumasi, Ghana						*Location 4 - Morogoro, Tanzania*					
Accession	**a**	**b**	**SEb**	**R^2**	**p**	**Rate**	**a**	**b**	**SEb**	**R^2**	**p**	**Rate**
H16834	39.88	0.0236	0.0026	0.98	0.0121	2.36	17.7	0.0288	0.0013	0.99	0.0019	2.88
H16835	50.6	0.0213	0.0035	0.95	0.0255	2.13	15.59	0.0322	0.0067	0.92	0.0403	3.22
H16837	37.87	0.0217	0.0046	0.92	0.0414	2.17	11.57	0.0323	0.0027	0.98	0.0070	3.23
H16838	27.29	0.0265	0.0043	0.95	0.0252	2.65	14.47	0.0315	0.0054	0.94	0.0281	3.15
H16840	63.64	0.0181	0.0032	0.94	0.0296	1.81	15.16	0.0336	0.0064	0.93	0.0344	3.36
C16786	39.9	0.0206	0.0037	0.94	0.0315	2.06	20.29	0.0222	0.0003	0.99	0.0002	2.22
C16791	54.65	0.0209	0.004	0.93	0.0356	2.09	12.04	0.0337	0.0012	0.99	0.0013	3.37
C16798	38.89	0.0209	0.0021	0.98	0.0104	2.09	5.98	0.0268	0.0056	0.92	0.0415	2.68
C15743	29.22	0.0152	0.002	0.97	0.0169	1.52	8.16	0.0292	0.0026	0.98	0.0076	2.92
Local variety	32.71	0.0237	0.0024	0.98	0.0098	2.37	10.14	0.0400	0.0061	0.96	0.0224	4.00

Dry matter Intake and Digestibility

To improve livestock production, a sustainable solution to seasonal deficiencies in feed availability and quality is required. Range-land pastures and crop residues are the main feed resources for the greater part of this region but they fail to meet nutritional requirements of livestock in both quantity and quality. Intake of forage ultimately determines animal performance. It is however influenced by factors such as capacity of the digestive tract, palatability and digestibility of the feed, microbial activity and rate of passage of residues through the alimentary canal (Van soest 1975, Poppi *et al* 1981). The nutritive value of napier grass accessions was therefore assessed using *in vivo* DM digestibility, *in sacco* DM degradability and intake *per se*. Dry matter intake (DMI) and digestibility (DMD) values obtained from studies carried out at various test locations are presented in Table 8.

At Bouake, Cote d'Ivoire (L1), the nutritive value of three accessed cultivars, one hybrid and a local cultivar was assessed in a feeding study involving growing bucks. The forages were fed after 9-11 weeks regrowth. Data were collected for 7 days following an adaptation period of 14 days. Dry matter digestibility for the local cultivar was slightly higher than that of C86 and H37 with C98 having a considerably lower value. In contrast, intake was significantly lower for the local cultivar.

At Kumasi, Ghana (L2), intake studies were carried out using 40 West African dwarf sheep randomly allocated ten treatments (fodder accessions) in groups of similar weight and sex. After eight weeks of re-growth, fodder grasses were harvested every morning, chopped to 5-10 cm pieces, weighed and fed in adequate quantities. Intake was determined from refusals weighed the following morning. Data collection for 22 days was preceded by an adaptation period of 14 days. DM intake values indicated that H38, and C86 were more preferable to animals whereas H35 and C91 were less preferred. Apparent digestibility was slightly higher for H38, C43, C98 and C86.

Table 8. Dry matter Intake and Digestibility valuessof various napier grass accessions obtained at several experimental locations

	DMI (*G*m/W$^{.75}$/day)							*DMD (%)*							
Accession	**L1**	**L2**	**L4****	**L5***	**L7***	**L9**	**L10***	**L1**	**L2**	**L3**	**L4**	**L5**	**L7**	**L8**	**L9**
H16834	.	67.9	.	.	.	.	.	.	70	.	.	.	.	68.4	.
H16835	.	56.2	.	.	.	86.9	.	.	68	.	.	.	.	73.1	72.5
H16837	66	70.3	6.25	.	0.51	85.8	.	66.2	70	.	53.5	.	59.1	.	75.6
H16838	.	80.4	.	.	.	68.0	0.78	.	76 .	.	.	.	.	.	67.4
H16840	.	73.2	.	.	.	71.0	.	.	69	.	.	.	.	.	67.4
C16786	67	79.7	6.33	0.72	0.58	.	0.76	66.7	74	60.4	53.3	48.9	62.3	68.2	.
C16791	.	62.8	6.39	0.67	0.58	.	.	.	70	63.6	50.1	48.8	62.0	.	.
C16798	60	72.0	6.52	0.66	0.55	81.1	0.66	62.1	75	63.7	58.3	48.3	63.7	.	69.9
C15743	.	69.6	.	.	.	.	0.82	.	75	.	.	.	.	.	.
Local variety	47	73.0	6.32	0.73	0.59	78.2	.	71.2	71	64.2	48.0	50.6	62.8	.	72.7

*DMI in *Kg/day* for sheep
** DMI in *Kg/day* for heifers

Legend:

L1 - Cote d'Ivoire
L2 - Kumasi, Ghana
L3 - Tanga, Tanzania
L4 - Morogoro, Tanzania
L5 - Kakamega, Kenya
L6 - Debre Zeit, Ethiopia
L7: Kampala, Uganda
L8 - Holetta, Ethiopia
L9a - Marondera, Zimbabwe (sheep)
L10 - Bunda, Malawi

At Tanga, Tanzania (L3), digestibility *(in vitro*) was determined using the method of Tilley and Terry (1963) and degradability by incubation of samples in the rumen of fistulated steers. No feed intake studies were carried out. However, the digestibility results reported indicated no significant difference in DM digestibility of three accessions C86, C91, C98 and the local variety TAI 124. The values were sufficiently high to indicate their suitability for use as quality forage feed.

Three mature rumen fistulated Friesian X Boran heifers were used in the determination of DM degradability using the nylon bag technique at Morogoro, Tanzania (L4). Accession C98 had a higher DM degradability value than H37, C86, C91, C98 and local Bana.

Ruminant nutrition studies at Kakamega, Kenya indicated no significant differences in digestibility among the four napier varieties C86, C98, C91 and local cultivar Bana fed to growing sheep.

At Kampala, Uganda, five Pennisetum forages were fed to Sheep after 8 weeks re-growth in a digestibility trial. C98 had slightly higher DM digestibility than the local forage KW4, C86 and C91 while H37 had a lower value overall.

Degradability characteristics were evaluated in the rumen of three fistulated crossbred steers at Holetta, Ethiopia by the method described by Orskov *et al* (1980). The degradability values obtained were sufficiently high but not significantly different among the three accessions H34, H35 and C86.

Fresh forage was offered to cross bred (Dorper x Sabi) male lambs twice daily at Marondera, Zimbabwe. An adaptation period of 21 days was allowed before data collection for 7 days. Hybrids 16835 and 16837 had significantly higher DM intake compared to C98, local Sdpn1 , H40 and H38. Hybrid H37 had a significantly higher DM digestibility value but C98, H38 and H40 had lower values than H35 and local SDPN1.

At Bunda, Malawi, crossbred sheep were offered 1kg of forage for 21 days subsequent to an adaptation period of 7 days. Accession C43 had significantly higher DM intake than H38 and C86 which were in turn more preferable than C98.

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Appendix A : Authors of original reports and sources of primary data for the regional Pennisetum evaluation trials

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Appendix B : Experimental sites and corresponding agronomic practices for the regional Pennisetum evaluation trials

1. Bouake, Cote d'Ivore

First year : Planted July 1993, Spacing 80 x 40 cm . Fertiliser 40 kg/ha P_2O_5, 40 kg/ha N. Harvested at 1m height 11 weeks after planting.

Second year : Cut back to 30 cm stubble July 1994. Fertiliser 40 kg/ha P_2O_5, 40 kg/ha N. Harvested once at 3, 6, 9 and 12 weeks regrowth.

2a. Kumasi, Ghana (Research station)

Planted December 14, 1994, Spacing 75 x 40 cm. Irrigated till March 1995. Harvested 28 weeks after planting and at 56 days regrowth.

2b. Kumasi, Ghana (Livestock farm)

Planted May 1995. Harvested once 14 weeks after planting leaving 15 cm stubble.

3. Tanga, Tanzania

Planted May 1994, Spacing 75 x 45 cm. Fertiliser 40 kg/ha P_2O_5, 40 kg/ha N, 40 kg/ha K at planting applied as, TSP, Sulphate of Ammonia, and Sulphate of Potash respectively. Harvested repeatedly at 1.5 m, 1 m and 1.5 m height 9, 15 and 24 weeks after planting respectively.

4. Morogoro, Tanzania

Planted April 1994, Spacing 75 x 40 cm. Manure applied at planting. Harvested repeatedly at 1.5 m height 13, 29, 39 and 54 weeks after planting .

5. Kakamega, Kenya

Planted June 1993, Spacing 75 x 40 cm. Fertiliser 40 kg/ha P_2O_5 at planting, 60 kg/ha N top dressed during the season. Harvested repeatedly at 1 m height 20, 32, 40, 56, and 68 weeks after planting .

6. Debre Zeit, Ethiopia

Planted June 1994, Spacing 60 x 50 cm. Irrigated first year. Fertiliser 100 kg/ha Urea. Cut back to 20 cm stubble beginning of rains 1995. Harvested repeatedly at 10 and 15 weeks regrowth .

7. Kampala, Uganda

Planted May 24, 1993, Spacing 50 x 50 cm. Cut back after 16 weeks. Harvested repeatedly at 2 m, 0.5 m and 1.5 m height 32, 48, and 64 weeks after planting.

8. Holetta, Ethiopia

Planted June 1994, Spacing 75 x 40 cm. Fertiliser 46 kg/ha P_2O_5 applied at planting, 23 kg/ha N top dressed. Harvested repeatedly 16, 24 and 54 weeks after planting .

9. Marondera, Zimbabwe

Planted November 1993, Spacing 90 x 60 cm. Fertiliser 500 kg/ha lime, 400 kg/ha SSP and 40 kg/ha Ammonium Nitrate at planting, 60 kg/ha Ammonium Nitrate every 6weeks during rains and 100 kg/ha Muriate of Potash every 12 weeks. Cut back at 1.5 m height. Harvested once at 2, 4,6,8 and 10 weeks regrowth.

10 Bunda Malawi

Planted December 1992, Spacing 75 x 40 cm. Fertiliser 40 kg/ha P_2O_5, 40 kg/ha N, applied as NPK 23:21:0 at planting and 40 kg/ha N topdressed 4 weeks after planting as CAN. Harvested once at 20 weeks growth.

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