African Crop Science Conference Proceedings Vol. 8. pp. 185-188
Printed in El-Minia, Egypt
ISSN 1023-070X/2007$ 4.00

Production, characterization and nutritional quality of Napier grass [*Pennisetum Purpureum* (Schum)] cultivars in western Kenya

E.M. NYAMBATI, F.N. MUYEKHO, C.M. LUSWETI & E. ONGINJO
Kenya Agricultural Research Institute (KARI), National Agricultural Research Center, P.O. Box 450, Kitale, Kenya.
Tel: 254-020-2029637, Fax: 254-054-31126, Email: elkananyambati@yahoo.co.uk

Abstract: Productivity and morphological characterization of 8 new Napier grass [*Pennisetum purpureum* (Schum.) cultivars were assessed as alternatives to current recommended ones in the sub-humid highlands of northwestern Kenya for two growing seasons. Nutritional quality of 3 most promising cultivars in terms of dry matter (DM) yields (Kakamega 1, Kakamega 3 and Machakos hairless) was determined. Agronomic measurements were made on DM yield, tiller number, length, diameter and angle, and on leaf length, width, hairiness and colour and on disease incidence. Nutritional measurements were made on leaf to stem ratio, intake, milk yields and body condition. DM yields across the two seasons showed that Kakamega 1, Kakamega 3, Uganda L 14 and Machakos hairless were yielding more than 15 t ha^{-1}. The tallest cultivars were Kakamega 1, Clone 13, and Kakamega 3 with 70, 69 and 61 cm, respectively. There was positive correlation ($r = 0.65$; $P < 0.001$) between tiller thickness and tiller length. The most resistant species to leaf rust and fungal snow mould diseases (*Beniowiskia sphaeroidea*) were Kakamega 3 and Bana. There were no differences ($P > 0.05$) in Napier grass DM intake by dairy Friesian cows. Cows feeding on Kakamega 3 and Kakamega 1 Napier grass cultivars yielded similar ($P > 0.05$) milk as those consuming bana. Cows that were fed Machackos hairless yielded less ($P < 0.05$) milk than the rest of the cultivars. The results provide farmers with a wide option of cultivars to choose from. Kakamega 3 which is resistant to Napier stunting disease could be an alternative to bana in western Kenya.
Key words: Napier grass, cultivars, production, characterization and quality

Introduction

Napier grass [*Pennisetum purpureum* (Schum.) is the most popular perennial fodder recommended for intensively managed smallholder crop-livestock farming systems and is well suited for the "cut and carry" feeding system. This is because it produces greater dry matter (DM) yields than other tropical grasses (Boonman, 1997), and is of high nutritive value for dairy animals particularly when supplemented with high quality feeds such as legumes (Mukisira *et al*., 1995; Nyambati *et al*., 2003). In Kenya, the common cultivars that have been selected and tested over a wide range of environments are Bana, French Cameroon, Clone 13 and Pakistan hybrid (Goldson, 1977). Although Napier grass is known to have high susceptibility to the fungal snow mold disease (*Cowdria sphaenoides)* caused by *Beniowskia sphaeroides*, (Boonman, 1997), it has not been of major concern until recently when new diseases started emerging. The emergence of diseases such as head smut in central Kenya caused by a fungus *Ustilago kamerunensis* (Farrell *et al*., 2001) and stunting disease in western Kenya caused by *Phytoplasma (*Jones *et al*., 2004*)* result in severe biomass losses (Farrel *et al*., 2001; Lusweti *et al*., 2004; Jones *et al*., 2004). This signals the need to develop other alternative Napier grass cultivars that are resistant to diseases. The performance of 57 cultivars at NARC-Kitale in northwestern Kenya and their morphological characteristics and fodder quality were evaluated to identify the most promising cultivars that could be adapted for the smallholder dairy farming system in the region. The specific objectives of the study were to 1) to determine herbage DM yields of the most promising cultivars, 2) identify characteristics that could be used to identify differences between the cultivars and 3) determine the fodder quality of the high yielding new cultivars in terms of leaf: stem ratio, CP, intake, digestibility, and milk yields compared to the current recommended Napier varieties.

Materials and Methods

Agronomic experiment

The experiment was conducted in western Kenya at KARI Kitale Centre (1^0 N and 35^0 E, altitude 1860 m), during the 2000 and 2001 growing seasons. The mean rainfall during the experimental period was 1100 mm while the mean monthly minimum and maximum temperatures were 12 and 24^0C, respectively. The soils are classified as humic Ferrolsols based on the FAO/UNESCO system (FAO – UNESCO, 1994).

Fifty seven accessions of Napier grass consisting of local collections, and introductions from various sites in sub-Saharan Africa held by International Livestock Research Institute (ILRI) and International Crops Research Institute for Semi-arid Tropics (ICRISAT) were planted in a randomized complete block design replicated three times. The cultivars included three currently recommended ones namely Bana, French Cameroon and Clone 13. Experimental plots were 2 x 3 m with a 1-m border between plots and 2-m path between replicates. They were planted using recommended fertilizer rate (26 kg P ha^{-1} yr^{-1} at planting and 60 kg N ha^{-1} as annual top-dress) and without any fertilizer. The split-plot design was used with cultivar (sub-plot) nested within fertilization. Fertilization was considered as the fixed effect factor while cultivar was considered the random effect factor.

The inter- and intra-row spacing was 100 and 100 cm respectively. Measurements of DM yields were taken from whole plots. Morphological characterization was determined by measuring plant growth habit and leaf characteristics from representative stools/tillers. Plant growth habit was determined by measuring tiller number/stool, tiller length and thickness and from average angle of growth. Leaf length and width were determined from three representative plants in each plot. Leaf colour, hairiness and roughness were also assessed using scores from the same plants. The scores for hairiness were 0 = no hair, 1 = sparse and 2 = dense and those for roughness were 0 = smooth, 1 = rough and 2 = very rough. The general colour of the plant was assessed using visual scores as 0 = yellow, 1 = pale green, 2 = green and 3 = dark green. The disease resistance was assessed using the scores; 0 = resistant, 1 = susceptible and 2 = very susceptible. The pest resistance scores were 0 = not attacked, 1 = mildly attacked and 2 = very susceptible. Herbage dry matter yields and morphological characteristics of only the most promising elite cultivars are reported.

Feeding experiment

Three of the most promising cultivars in terms of DM yields (Kakamega 1, Kakamega 3 and Machakos hairless) were compared to cultivar Bana that is popularly grown by farmers. The cultivars were established at KARI Kitale. After establishment they were cut back in sequential blocks to enable uniformity of the forage during the feeding experiment. Eight dairy cows selected from a dairy herd at KARI Kitale were used in a 4 x 4 latin square change over design replicated twice. The adjustment and collection periods lasted 14 and 7 days, respectively. The cows were fed the Napier grass *ad libitum*. Feed intake and milk yield were measured for each cow. Leaf: stem ratio of the feeds were determined on representative samples taken from the bulked fodders. The data was analyzed using the GLM of SAS (SAS, 2001).

Results and Discussion

Dry matter yields

The DM yields during the first growing season of establishment were lower ($P < 0.001$) than the second season (Table 1). The interaction of cultivar by year was significant ($P < 0.001$); therefore the means are presented by year. During the 2001 season, three new cultivars (Kakamega 1, Kakamega 3 and Uganda L 14 in addition to the currently grown French Cameroon and Clone 13 were the five best yielding cultivars that yielded more than 12 t ha^{-1}. In the second season, Kakamega 1, Kakamega 3, and the three recommended cultivars were the five best performing with more than 19 t ha^{-1}. Mean DM yields across the two years showed that the most promising new cultivars were Kakamega 1, Kakamega 3, Uganda L 14 and Machakos hairless. The dry matter yields of the most promising cultivars are within the range (15 to 22 t ha^{-1}) reported for Napier grass in eastern Africa (Mugerwa and Ogwang, 1976; Muia *et al*., 2001). Clone 13 which yielded the highest mean DM was developed from French Cameroon and is resistant to fungal mould disease, *(Beniowiskia sphaeroidea)* (Goldson, 1977).

Morphological characteristics

Fertilization regime increased tiller number ($P = 0.05$), tiller length ($P = 0.001$), tiller diameter ($P = 0.01$) and leaf length ($P = 0.01$). But the fertilization by cultivar interaction was only significant for tiller length ($P = 0.04$). Since Napier grass performance of each cultivar is affected by more than one factor, data was analyzed across the two fertilization regimes.

a) Plant growth habit

There was little variation in tiller number between cultivars except for Soghor Nandi L13 which had higher ($P < 0.05$) tiller number than Pakistan hybrid, Uganda L14, Machakos hairless and Ex-Mariakani (Table 2). There was wide variation in tiller length (Table 2). The tallest cultivars were Kakamega 1, Clone 13, and Kakamega 3 with 70, 69 and 61 cm, respectively which were comparable to those of French Cameroon, Machakos hairless, Kitui L 7 and Bana.

The cultivars with the greatest tiller thickness were Machakos hairless, Kitui L7, Kakamega 1, Soghor Nandi L 13 and Kakamega 3 with a diameter ranging from 6.0 to 6.8cm. There was positive correlation ($r = 0.65$; $P < 0.001$) between tiller thickness and tiller length. The growth form of the new cultivars assessed using the average angle of the tiller stems to the ground from 0 – 90^0 showed that the average angle of the stem to the ground was upright (60 – 90^0) and was similar ($P > 0.05$) to the recommended cultivars.

Table 1 Mean Dry Matter (DM) Yields (t ha^{-1}) ‡ of Napier grass cultivars at Kitale, Kenya

Cultivar	Growing Season		
	2001	2002	Mean
Clone 13	12.2	25.0	18.6
Kakamega 1	13.2	23.5	18.3
French Cameroon	12.4	20.0	16.2
Bana	10.3	22.1	16.2
Kakamega 3	12.5	19.4	16.0
Uganda L 14	11.8	16.8	14.7
Machakos hairless	8.6	17.4	14.6
Soghor Nandi L 13	8.6	16.6	12.6
Kitui L 7	6.9	13.9	10.4
Ex-Mariakani	8.2	11.9	10.0
Kakamega 8	7.7	8.0	7.5
Pakistan hybrid	7.1	7.5	7.5
Mean	10.0	16.8	13.5
LSD	4.31	7.33	3.25
CV	24.8	25.7	20.1

‡ Yields are means of three cuts for 2001 season and 6 cuts for 2002.

c) Disease and Pest Resistance

The most common diseases were leaf rust and fungal snow mould disease, *Beniowiskia sphaeroidea*) which is in agreement with Goldson (1977). The fungal disease attacks leaves of the fodder turning them purple with white spores at the base of the leaves, thus reducing both the quantity and quality of the fodder. Most of the cultivars were susceptible (score = 1) to diseases except Kakamega 3 and Bana that were more resistant (score = 0.4). Based on field observations, the major pest was cereal stem borer, but its infestation was mild only affecting Clone 13 and Machackos hairless.

Table 2 Plant growth habit characteristics of Napier grass cultivars at Kitale, Kenya

Cultivar	Characteristic			
	Tiller number	Tiller length (cm)	Tiller diameter (cm)	Tiller angle
Clone 13	61	68.9	5.29	82.5
Kakamega 1	63	69.8	5.98	82.5
French Cameroon	60	58.4	5.07	75.0
Bana	63	55.3	5.52	80.0
Kakamega 3	63	60.8	5.96	82.5
Uganda L 14	49	48.4	4.82	75.0
Machakos hairless	49	57.4	6.84	90.0
Soghor Nandi L 13	82	49.8	5.97	82.5
Kitui L 7	63	57.2	6.23	75.0
Ex-Mariakani	48	38.5	5.12	75.0
Kakamega 8	61	51.4	4.00	82.5
Pakistan hybrid	59	41.6	4.54	67.5
LSD	18.6	15.2	0.98	15.7
CV	24.1	22.0	14.1	13.9

Nutritional quality

There was no difference ($P > 0.05$) in leaf: stem ratio and DM intake of Napier grass (Table 4). The cows consumed on average 9.0 kg DM (109.4 g kg^{-1} $BW^{0.75}$) day^{-1}. Cows feeding on Kakamega 3 and Kakamega 1 Napier grass cultivars yielded similar ($P > 0.05$) milk as those consuming bana (Table 4). Cows that were fed Machackos hairless yielded less ($P < 0.05$) milk than the rest of the cultivars. However, there was no cultivar effect ($P > 0.05$) on cow body condition The similarity in fodder quality of Kakamega 3, Kakamega 1 and Bana cultivars are in agreement with Gwayumba *et a.,l* (2002) who found no differences between Bana and French Cameroon grass cultivars in terms of DM intake and milk yields

Table 3 Leaf characteristics and disease incidence of Napier grass cultivars at Kitale, Kenya

Cultivar	Characteristic									
	Leaf length	Leaf width	Top leaf Hair[1]	Bottom Leaf hair[1]	Sheath hair[1]	Top leaf roughness[1]	Bottom Leaf roughness[1]	Leaf colour[1]	Sheath colour[1]	Disease
Clone 13	67.8	2.27	0.8	0.2	1.0	0.8	1.2	2.2	0.8	0.8
Kakamega 1	59.8	1.85	1.4	0.8	2.0	0.2	0.6	1.8	0	1.0
French Cameroon	61.8	1.91	1.4	0.8	1.2	0.8	1.2	1.8	0.2	1.0
Bana	71.5	2.71	1.6	1.0	1.4	0.4	0.8	2.0	0	0.4
Kakamega 3	74.5	2.28	1.8	1.0	1.0	0.8	0.8	2.0	0	0.4
Uganda L 14	54.0	1.90	1.0	0.4	1.4	0.6	0.8	2.0	0.2	1.0
Machakos hairless	70.2	2.72	2.0	1.6	1.2	0.6	1.2	1.2	0	0.8
Soghor Nandi L 13	67.0	1.89	2.0	1.3	1.0	0.7	1.0	2.7	0.5	0.8
Kitui L 7	67.9	2.08	2.0	1.0	1.2	0.8	1.2	1.8	0.8	1.2
Ex-Mariakani	51.5	1.65	0.4	0.2	1.0	0.4	0.4	2.6	0.2	0.8
Kakamega 8	42.8	1.49	1.6	0.8	1.4	0.4	1.2	2.6	0.4	1.2
Pakstan hybrid	45.3	1.51	0.2	0.2	0.8	0.2	0	2.4	0.2	1.0
LSD	11.1	0.48	0.7	0.6	0.7	0.7	0.7	0.6	0.7	0.6
CV	14.4	18.8	42.5	64.2	45.7	95.0	63.1	20.9	20.2	51.0

Scores were: Leaf hairiness 0 = no hair, 1 = sparse and 2 = dense; roughness 0 = smooth, 1 = rough and 2 = very rough; colour 0 = yellow, 1 = pale green, 2 = green and 3 = dark green and disease resistance 0 = resistant, 1 = susceptible and 2 = very susceptible. The pest resistance scores were 0 = not attacked, 1 = mildly attacked and 2 = very susceptible.

Table 4 Intake and milk yield of Friesian cows fed various Napier grass cultivars

CONSTITUENTS†	CULTIVAR				
	A-Bana	B-MH	C-KK3	D-KK1	CV
Leaf: stem ratio	3.1 [a]	2.6 [a]	2.4 [a]	1.7 [a]	37.5
NDMI (Kg)	8.9[a]	8.7 [a]	9.3 [a]	9.0 [a]	18.8
NDMI (g kg^{-1} $BW^{0.75}$)	108.6 [a]	106.1 [a]	113.6 [a]	109.7 [a]	18.9
Milk (Kg)	6.2[a]	5.8[b]	6.3[a]	6.1[a]	11.4
Mean BCS	5.4 [a]	5.2 [a]	5.4 [a]	5.7 [a]	6.8

† NDMI = Napier grass dry matter intake; BW = body weight, MH = Machakos hairless, KK3 = Kakamega 3, KK1 = Kakamega 1

ab Treatment means followed by the same letter superscript in the same row do not differ significantly ($P < 0.05$)

Conclusion

This study demonstrates that Kakamega 1, Kakamega 3, Uganda L14 and Machakos hairless are high yielding and can be used as alternatives to commonly planted Bana grass, French cameroon and clone 13. Tiller thickness, leaf length, leaf width, hairiness and roughness are some of the morphological characters that could be used to identify some of the cultivars. Kakamega 3 and Bana grass were the most resistant cultivars to leaf rust and snow mould fungal disease. These cultivars were also less hairy suggesting that they could be more comfortably handled by women and children who do most farm work. Milk yields of cows feed on Kakamega 3 and Kakamega 1 Napier grass cultivars were similar to those given bana, suggesting that they have similar nutritional quality. Future research should focus on screening the performance and the optimal stages of feeding of the high yielding cultivars in different agro-ecological zones.

Acknowledgements

We highly appreciate the assistance provided by the Center Director, staff, and colleagues at KARI-Kitale, Kenya and in particular, Mr. Patrick Imbali, David Asena and Ms Akinyi for assisting in the data collection.

References

Boonman, J.G. 1997. Farmers' success with tropical grasses: Crop/pastures rotation in mixed farming in East Africa. Ministry of Foreign Affairs, The Hague, Netherlands.

Farrell, G., Simmons, S.A. & Hilllocks, R.J. 2001. Aspects off the biology of *Ustilago kamerunensis*, a Smut pathogen of napiergrass (*Pennisetum purpureum*). Journal of Phytopathology **149**,739-744.

FAO-UNESCO. 1994. Soil map of the world. Revised legend. Tech. Paper No. 20. FAO/Rome and ISRIC/Wageningen, the Netherlands.

Goldson, J.R. 1977. Napier grass (*Pennisetum purpureum* K. Schum) in East Africa: A review. Pasture Research Project Technical Report No. 24. National Agricultural Research Station, Kitale, Kenya.

Gwayumba, W., Christensen, D.A., McKinnon, J.J. & Yu, P. 2002. Dry matter intake, digestibility and milk yield by Friesian cows fed two Napier grass varieties. *Asian-Australian* Journal of Animal Sciences, **15(4)**, 516-521.

Jones P., Devonshire, B.J., Holman, T.J. & Ajanga, S. 2004. Napier grass stunt: a new disease associated with a 16Srx1 group phytoplasma in Kenya. New Disease Reports [http://www.bspp.org.uk/ndr/]volume **9**.

Lusweti C.M., Nandasaba, J., Ongijo, E. & Asena, D. 2004. Preliminary results of disease survey on Napier grass in selected sites of West Kenya. In pasture/fodder research Annual Report 2004. National Agricultural Research Centre, Kitale. Kenya Agricultural Research Institute 15p.

Mugerwa, J.S. & Ogwang, B.H. 1976. Dry matter production and chemical composition of elephant grass hybrids. East African Agriculture and Forestry Journal **42**, 60-65.

Muia, J.M.K., Taminga, S., Mbugua, P.N. & Kariuki, J.N. 2001. Effect of supplementing Napier grass (*Pennisetum purpureum*) with poultry litter and sunflower meal based concentrates on feed intake and rumen fermentation in Friesian steers. Animal Feed Science and Technology **92**, 113-126.

Mukisira, E.A., Phillip, L.E. & Mitaru, B.N. 1995. The effect of feeding diets containing intact or partially detoxified lupin on voluntary intake and milk production by Friesian dairy cows. Animal Science **60**, 69-175.

Nyambati, E.M., Sollenberger, L.E. & Kunkle, W.E. 2003. Feed intake and lactation performance of dairy cows offered Napier grass supplemented with legume hay. Livestock Production Science **83**, 179-189.

SAS (Statistical Analysis Systems Institute). 2001. SAS system for windows. Release 8.12, SAS Inst., Cary, NC, USA.