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Adaptation of Napier grass varieties in the highlands of East Gojjam

Mezgebu Getnet[1], Mariye Melkam[1] and Mesfin Dejene[2]

[1]Ethiopian Institute of Agricultural Research, Debre Markos Agricultural Research Center, P.O. Box 357 Debre Markos, Ethiopia;
[2]Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center.
Corresponding author: Mezgebu Getnet E-mail: meget1212@gmail.com

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***Abstract*— *The experiment was conducted in the East Gojjam Zone of the Amhara Regional State to evaluate the varieties of released Napier grass in the study area. The four varieties of Napier grass considered for this research experiment were Maralfalafa, ILRI- 16743, ILRI-14984 and Zehone-03 (Acc. 16819). The varieties were planted in 4 m x 3 m plots using a randomized complete block design (RCBD) with three replications at the beginning of the main rainy season. Root splits at the Debremarkos onstation and Debere Eliyas sites were planted in four rows per plot. The analysis was conducted using R software. Least significance difference (LSD) at the 5% significance level was used for the comparison of means. The combined plant height, number of tillers per plant, total fresh biomass yield per hectare (t/ha), and total dry matter yield (t/ha) did not significantly differ between the varieties. The leaf-to-stem ratios of the Napier grass varieties were significantly different. In the present study, ILRI-14984 was found to be leafier than the other tested varieties. The combined analysis of the second- and third-year data revealed significant differences in plant height, number of tillers and leaf-to-stem ratio among the tested years. The greatest plant height (152.42 cm) at harvest was found in the second year after establishment, which was 2022, whereas the number of tillers per plant was greater in the 2023 harvest season. The testing location did not affect plant height, total fresh biomass yield per hectare, or total dry matter yield per hectare. The number of tillers per plant and the leaf-to-stem ratio significantly differed among the tested locations. A greater number of tillers per plant was recorded at the Debre Eliyas testing site. Similarly, the leaf-to-stem ratio was significantly greater at the same testing site.*

***Keywords*— Debre Eliyas, Aneded, Zehone-03, East Gojjam and Napier Grass**

I. INTRODUCTION

With the world population projected to increase by more than 25% to 9.9 billion people by the year 2050 [1], agriculture is expected to meet proliferating food and agro-pastoral demands [2] from limited land and water resources. Livestock are the key quality food sources for humans worldwide. The ability of livestock to meet this ever-increasing food demand around the world depends on the quality and quantity of livestock feed.

Napier grass (Pennisetum purpureum Schumach) is the key diet of many elephants and, as such, is commonly known as elephant grass [3], but it may also be named elephant grass due to its robust growth as opposed to other grass species. Napier is a C4 perennial grass in the Poaceae family. It can grow up to 7.5 m in height, and its extensive root system can penetrate up to 4.5 m, which makes it a highly drought-tolerant grass native to sub-Saharan Africa (SSA) and an underutilized source of biomass (4, 5, 6, 7] and potentially important in carbon sequestration [8].

Some of Napier's desirable characteristics include high yields per unit harvestable area [9], high photosynthetic and high water use efficiency [10; 11] and adaptability to sporadic drought and a wide range of soil and agro-ecological conditions [12; 13], making it a forage of priority. Napier establishes best in areas where the average annual precipitation is greater than 750 mm. Napier grass is known for its high dry matter (DM) yield potential (up to 78 tons/ha/yr) [14; 15].

Among the promising forage species introduced to Ethiopia, Napier grass is reported to be a popular fodder crop in the Ethiopian highlands, where it has shown considerable potential to alleviate severe shortages of high-quality fodder [16]. Its leafy nature, considerable plant height, high tiller and regrowth ability make it a highly productive feed crop per unit area of land compared to other grass species [17].

The productivity of Napier grass varieties differs depending on environmental conditions, especially rainfall. Yields depend on fertility, moisture, temperature and management. DM yields of 10-30 t/ha/yr are common (and can reach 85 t/ha/yr) if well fertilized and 2-10 t/ha/yr if unfertilized. More frequent cuts (up to 45 days) result in less dry matter but better leaf production than infrequent cuts [18]. Selecting the right variety can greatly increase yield. The yield (t DM/ha) of different varieties under the same management conditions ranged from 2.7 to 68.1 tons in Ethiopia [19]. The yield can be simply multiplied up to 25 times [20] by selecting the right variety. Napier grass varieties differ in plant height, leaf number, tiller number, leaf-to-steam ratio, and leaf area index [20; 21; 22], which impact both yield and nutritive value.

Livestock production is an integral part of the traditional crop-livestock mixed farming system of the East Gojjam Zone, where livestock provide livelihoods for smallholder farmers in terms of cash income, draught power, food, fuel, manure, and hedging against the risk of crop failure. Crop residues were found to be the dominant feed resources available in the zone, followed by communal grazing. Reports have shown that shortages and poor quality of available feed resources, poor adoption of improved breeds, skill and knowledge gaps in the application of improved livestock technologies, emerging diseases and resistance to drugs are the major livestock production constraints in this zone [23]. Therefore, the aim of this study was to identify adaptable and promising Napier grass varieties under East Gojjam agroecological conditions to reduce the feed gap.

II. MATERIALS AND METHODS

2.1. Description of the Testing Site

The experiment was conducted in the East Gojjam Zone of the Amhara Regional State, the Debremarkos Agricultural Research Center onstation and the Debre Eliyas district (Yekegat Kebele).

Table 1. Description of the testing locations for the adaptation of Napier grass varieties

Parameters	Testing locations	
	Aneded On station	Debre Eliyas
Altitude (masl)	2470	2167
Latitude (N)	10° 16' 01''	10° 59' 52''
Longitude (E)	37° 46' 31''	37° 14' 12''
ARF (mm)	1350	1400
Temperature (°c)	7.5 - 27	17 - 27
Soil pH	5.29	4.54
Soil textural class	Clay	Nitosol

2.2. Experimental design and layout:

The four varieties of Napier grass considered for this research experiment were Maralfalafa, ILRI- 16743, ILRI-14984 and Zehone-03 (Acc. 16819). The planting material of the accessions was collected from the Holetta Agricultural Research Center. The varieties were planted in 4 m x 3 m plots using a randomized complete block design (RCBD) with three replications at the beginning of the main rainy season. Root splits at the Debremarkos onstation and Debere Eliyas sites were planted in four rows per plot. A total of 24 root splits were planted per plot with intra- and interrow spacings of 0.5 m and 1 m, respectively, resulting in a density of 20,000 plants/ha. There was a path 2 m wide between blocks and 1 m wide between plots. Basal phosphorus fertilizer was uniformly applied to all plots in the form of nitrogen, phosphorus and sulfur (NPS) at a rate of 100 kg/ha. After every cut, the plots were top dressed with 50 kg/ha urea, one-third of which was applied at the first shower of rain, and the remaining two-thirds was applied during the active growth stage of the plant. All other crop management practices were performed uniformly in all plots as needed.

2.3. Data collection and measurements:

The number of tillers per plant, plant height at the forage harvesting stage, total fresh biomass yield, total dry matter yield and leaf-to-stem ratio were measured before and after harvest. Plant height was based on five culms randomly selected from each plot and measured using timber tape from the ground level to the highest leaf. For determination of biomass yield, varieties were harvested at the forage harvesting stage from the two rows next to the guard rows 5-10 cm above ground level. The total fresh biomass yield was recorded from each plot in the field, and an estimated 500 g sample was taken from each plot. The samples taken from each plot were weighed to determine their fresh weight and oven-dried for 24 hours at 105°C to determine the dry matter yield.

2.4. Statistical analysis:

The analysis was conducted using R software. Least significance difference (LSD) at the 5% significance level was used for comparison of means. The data were analyzed using the following model:

$Y_{ij} = \mu + V_i + B_j + e_{ij}$,

where

Y_{ij}= measured response of variety i in block j;

μ = grand mean; V_i= effect of variety i;

B_j = effect of block j; and

e_{ij} = random error effect of variety i in block j.

III. RESULTS AND DISCUSSION

3.1. Performance of Napier Grass Varieties during Harvesting

The combined performance analysis results for the four Napier grass varieties are presented in Table 1. The combined plant height, number of tillers per plant, total fresh biomass yield per hectare (t/ha) and total dry matter yield (t/ha) did not significantly differ between the two years. The greatest plant height was observed for the Maralfalfa (145.87 cm) Napier grass variety, followed by the ILRIs (1643, 136.93 cm) and Zehone-03 (Acc. 16819, 131.48 cm). A relatively lower plant height was found for ILRI-14984. The current result for Zehone-03 (Acc. 16819) was greater than the study result (126.02 cm) reported by [24] under different environmental conditions in Ethiopia. This variation could be due to differences in the soil fertility conditions of the testing locations. The height at cutting reportedly affects the growth characteristics and productivity of Napier grass [25]. Other results also indicated that plant height at cutting significantly affects the fodder yield of Napier grass in Kenya [26]. Among the major agronomic practices needed, harvesting Napier grass at appropriate cutting heights and defoliation frequencies is very important for improving the DM yield and nutritive value of this plant [27; 28]. A greater cutting height of Napier grass may result in underutilization, and the quality of the forage is reduced by a greater cutting height [27; 28]. The number of tillers per plant was comparable among the Napier grass varieties. In the present study, relatively high (49.55) numbers of tillers per plant were detected for ILRI-14984.

There was no significant difference in the total fresh biomass yield per hectare among the Napier grass varieties. The highest fresh biomass yield was obtained for Maralfalfa, followed by the ILRI-14984 variety. The total dry matter yield per hectare did not differ among the varieties. A numerically higher yield was recorded for ILRI – 16743, followed by Zehone-03 (Acc – 16819). The total dry matter yield in the present study was lower than the forage DM yield, which ranged from 7.97 to 12.57 t/ha, with a mean of 11.04 t/ha reported by [24] for ten accessions tested under different environmental conditions in Ethiopia. This may be due to the frequency of cuts per year during the forage harvesting stage. The herb yield of Napier grass can be affected by the harvesting stage and plant height. [29 and 28] reported that increasing foliage height increased biomass yield. According to [30] and [31], taller varieties have greater dry matter yields than shorter varieties. The DM yield of Napier grass increased as the frequency between cuttings increased, which indicates that a long harvest interval is necessary to achieve high herbage yields [32]. The leaf-to-stem ratios of the Napier grass varieties were significantly different. In the present study, ILRI-14984 was found to be leafier than the other tested varieties. The current combined analysis revealed that the ILRI-16743 variety had a lower leaf than the other tested varieties.

Table 2. Combined analysis of the performance of the tested Napier grass varieties

Tested varieties	PH	NTPP	TFBSth	TDMYth	LSR
Maralfalfa	145.87	42.78	65.52	7.62	1.18bc
ILRI - 16743	136.93	41.01	56.15	8.77	1.00c
Zehone-03 (Acc-16819)	131.48	42.87	51.19	8.40	1.73b
ILRI-14984	128.38	49.55	60.76	7.76	2.45a
P value	0.13	0.37	0.13	0.72	<0.001
CV	13.69	28.46	25.47	31.63	46.37
LSD	15.42	10.39	12.34	2.31	0.59

3.2. The performance of Napier grass varieties by year and location

The combined analysis revealed significant differences in plant height, number of tillers and leaf-to-stem ratio among the tested years. A greater plant height (152.42 cm) at harvest was found in the second year of establishment, that is, in 2022, whereas the number of tillers per plant was greater in the 2023 harvest season. This may be because regrowth can result in more tillers than the first cut. The total fresh biomass yield and total dry matter yield did not significantly differ between the testing years. The Napier grass varieties showed significant differences in the leaf-to-stem ratio between the testing years. The Napier grass varieties were found to be leafier in 2023, the third year after establishment.

The testing location did not affect the plant height, total fresh biomass yield per hectare or total dry matter yield per hectare. The number of tillers per plant and the leaf-to-stem ratio were significantly different among the tested locations. A greater number of tillers per plant was recorded at the Debre Eliyas testing site. Similarly, the leaf-to-stem ratio was significantly greater at the same testing site.

Table 3. Effect of year and testing location on the performance of Napier grass varieties

Parameters		PH	NTPP	TFBSth	TDMYth	LSR
Year	2022	152.42a	40.33b	58.44	7.96	0.72b
	2023	118.92b	47.78a	58.37	8.82	2.45a
	P value	<0.001	0.04	0.98	0.29	<0.001
Location	Onstation	136.98	36.60b	62.58	7.99	1.26b
	Debre Eliyas	134.36	51.51a	54.24	8.78	1.92a
	P value	0.63	<0.001	0.06	0.34	0.003
LSD		10.90	7.35	8.72	2.03	2.03
CV		13.69	28.45	25.47	33.22	46.37

IV. CONCLUSION AND RECOMMENDATION

The measured parameters of the Napier grass varieties were comparable. The plant height, number of tillers per plant, total fresh biomass yield per hectare and total dry matter yield per hectare were comparable across the tested Napier grass varieties. The testing location affected the number of tillers per plant and the leaf-to-stem ratio of the tested varieties. Similarly, plant height, number of tillers per plant and the leaf-to-stem ratio were affected by testing year across locations. Overall, the results of the present study showed that the tested Napier grass varieties were adaptable and performed well. Therefore, the body of interest, such as the extension system, NGOs, universities, and different actors involved in livestock development, should demonstrate and encourage farmers to use these varieties to alleviate chronic livestock feed shortages in the East Gojjam Zone and similar environments.

REFERENCES

[1] United Nations (UN). 2019. World population prospects 2019. In Department of Economic and Social Affairs. World Population Prospects 2019. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12283219.

[2] Food and Agriculture Organization (FAO). 2019. The future of livestock in Uganda. Opportunities and challenges in the face of uncertainty. Rome.

[3] Heuzé, V., Tran, G., Giger-Reverdin, S., and Lebas, F. 2020. Available at: https://www.feedipedia.org/node/395. Hu, J., Richwine, J. D., Keyse

[4] Cook, B. G., Pengelly, B. C., Brown, S. D., Donnelly, J. L., Eagles, D. A., Franco, M. A.,et al. 2005. Tropical forages. CSIRO, DPI&F (Qld), CIAT and ILRI, Brisbane, Australia. https://www.feedipedia.org/node/1689

[5] Mohammed, I.Y., Abakr, Y.A., Kazi, F.K. 2018. In situ upgrading of napier grass pyrolysis vapor over microporous and hierarchical mesoporous zeolites. Waste Biomass-. Valoriz. 9 (8), 1415–1428. https://doi.org/10.1007/s12649-017-9925-x.

[6] Norsuwan, T., Marohn, C., Jintrawet, A. 2014. Effects of irrigation treatments and nitrogen applications on Napier grass planted in dry season as energy crop at Chiang Mai province. Khon Kaen Agr. J. 42 (2), 1–7.

[7] Singh, B.P., Singh, H.P., Obeng, E. 2013. 13 Elephantgrass. In: Singh, B.P., Ed., Biofuel Crops: Production, Physiology and Genetics, CABI, Georgia, USA. (September 2013), 271–291.

[8] Yang, Y., Tilman, D., Furey, G., and Lehman, C. 2019. Soil carbon sequestration accelerated by restoration of grassland biodiversity. Nat. Commun.10, 718. doi:10.1038/s41467-019-08636-w

[9] Sarker, N.R., Habib, M.A., Yeasmin, D., Tabassum, F., Mohammed, R.A. 2021. Studies on biomass yield, morphological characteristics and nutritive quality of napier cultivars under two different geo-topographic conditions of Bangladesh. Am. J. Plant Sci. 12 (06), 914–925. https://doi.org/10.4236/ajps.2021.126061.

[10] Mwendia SW, Wanyoike M, Nguguna JGM, Wahome RG, Mwangi DM. 2006. Evaluation of Napier grass cultivars for resistance to Napier head smut. Proceedings of the 10th KARI Biennial Scientific Conference, KARI, Nairobi, Kenya 85-97. Link:https://bit.ly/3u6xuiY.

[11] Mwendia, S.W., Yunusa, I.A.M., Sindel, B.M., Whalley, R.D.B., Kariuki, I.W. 2017. Assessment of Napier grass accessions in lowland and highland tropical environments of East Africa: water stress indices, water use and water use efficiency. J. Sci. Food Agric. 97 (6), 1953–1961. https://doi.org/10.1002/jsfa.8004.

[12] Kabirizi, J., Muyekho, F., Mulaa, M., Pallangyo, B. 2015. Napier Grass Feed Resource: Production, Constraints and Implications for Smallholder Farmers in East and Central Production, Constraints and Farmers in Eastern and Central.

[13] Rengsirikul, K., Ishii, Y., Kangvansaichol, K., Sripichitt, P., Punsuvon, V., Vaithanomsat, P., Tudsri, S. 2013. Biomass yield, chemical composition and potential ethanol yields of 8 cultivars of napiergrass (<i>Pennisetum purpureum</i>Schumach.) Harvested 3-Monthly in Central Thailand. J. Sustain. Bioenergy Syst. 03 (02), 107–112. https://doi.org/10.4236/jsbs.2013.32015.

[14] Maria, L.F.O., Rogrio, F.D., Geraldo, de, A.G., Vernica, B., da, S., Erina, V.R., Aldo, S., Avelino… dos, S.R. 2014. Prebreeding of elephant grass for energy purposes and biomass analysis in Campos dos Goytacazes- RJ, Brazil. Afr. J. Agric. Res. 9 (36), 2743–2758. https://doi.org/10.5897/ajar2014.8900.

[15] Muktar, M.S., Habte, E., Teshome, A., Assefa, Y., Negawo, A.T., Lee, K.W., Jones, C.S. 2022. Insights Into the Genetic Architecture of Complex Traits in Napier Grass (Cenchrus purpureus) and QTL Regions Governing Forage Biomass Yield, Water Use Efficiency and Feed Quality Traits. Front. Plant Sci. 12 (January) https://doi.org/10.3389/fpls.2021.678862.

[16] Farrell G, Simons SA, Hillocks RJ. 2002. Pests, diseases and weeds of Napier grass, Pennisetum purpureum: a review. J Pest Manage 48: 39-48. Link: ttps://bit.ly/3t3v5V9.

[17] Anderson WF, Dien BS, Brandon SK, Peterson JD. 2008. Assessment of Bermuda grass and bunchgrasses as feed stocks for conversion to ethanol. Appl Biochem Biotechnol 145: 13-21. Link:https://bit.ly/3gJlCQh.

[18] Piccoli, A. P. (2024). Reproductive phenology and environmental temperatures in the Smooth Newt Lissotriton vulgaris meridionalis (Boulenger, 1882), (Amphibia, Urodela) in a Mediterranean habitat. In International Journal of Environment, Agriculture and Biotechnology (Vol. 9, Issue 1, pp. 001–007). https://doi.org/10.22161/ijeab.91.1

[19] Factsheet- Pennisetum purpureum. 2012. http://www. tropicalforages. info/ key/ Forages/ Media/ Html/ Pennisetum_purpureum.htm

[20] Habte, E., Teshome, A., Muktar, M. S., Assefa, Y., Negawo, A. T., MaChado, J. C., et al. 2022. Productivity and feed quality performance of napier grass (Cenchrus purpureus) genotypes growing under different soil moisture levels. Plants11, 2549. doi:10.3390/plants11192549 Halim, R. A., Shampazurain

[21] Ito, K., Takaki, K., and Misumi, M. 1989. Relations between leaf area index and crop growth rate of napiergrasses (Pennisetum purpureumSchumach) under different planting densities.J. Jpn. Grassl. Sci.34, 257–263. doi:10.14941/grass.34.257

[22] Zhang, X., Gu, H., Ding, C., Zhong, X., Zhang, J., and Xu, N. 2010. Path coeffcient and cluster analyses of yield and morphological traits in Pennisetum purpureum.Trop. Grassl.44, 95–102.

[23] Shyamsunder, B., Menon, Dr. S., Walia, Dr. U. S., Prasanna, T., Raju, G. S. K., & Nawabpet, P. (2024). Effect of intercropping wheat (triticum aestivum.L.) with mustard (brassica juncea) on yield and economics under organic system of cultivation. In International Journal of Environment, Agriculture and Biotechnology (Vol. 9, Issue 2, pp. 218–223). https://doi.org/10.22161/ijeab.92.24

[24] Wangchuk, K., Rai, K., Nirola, H., Thukten, Dendup, C., and Mongar, D. 2015. Forage growth, yield and quality responses of Napier hybrid grass cultivars to three cutting intervals in the Himalayan foothills.Trop. Grassl.–Forrajes Tropicales.3, 142– 150. doi:10.17138/TGFT(3)142-150.

[25] Setotaw F., Getachew A., Aemiro K., Tesfahun A., and Chilot Y. 2020. Farming Systems Characterization and Analysis in East Gojjam Zone: Implications for research and development (R&D) interventions. Addis Ababa, Ethiopia. http://www.eiar.gov.et.

[26] Gezahagn Kebede, Fekede Feyissa, Getnet Assefa, Mengistu Alemayehu, Alemayehu Mengistu, Aemiro Kehaliew, Kassahun Melese, Solomon Mengistu, Estifanos Tadesse, Shewangizaw Wolde and Mergia Abera. 2016. Evaluation of Napier Grass (Pennisetum purpureum (L.) Schumach) Accessions for Agronomic Traits Under Different Environmental Conditions of Ethiopia. International Journal of Advanced Research, Vol. 4, 4, 1029-1035.

[27] Mureithi J.G and W. Thorpe. 1996. The effects of herbaceous legume intercropping and mulching on the productivity of Napier grass (Pennisetum purpureum) and total forageyield in coastal lowland Kenya. In: Jean Ndikumana and Peter de Leeuw (eds.) Sustainable Feed Production and Utilization for Smallholder Livestock Enterprises in Sub-Saharan Africa. African Feed Resources Network (AFRNET) Workshop held in Harare, Zimbabwe 6-10 December 1993. AFRNET, Nairobi, Kenya, 45-50.

[28] Muinga, R. W., Thorpe, W. and Topps, J. H. 1992. Voluntary food intake, live-weight change and lactation performance of crossbred dairy cows given ad libitum Pennisetum purpureum(napier grass var. Bana) supplemented with leucaena forage in the lowland semihumid tropics. Anim. Prod., 55 (3): 331-337.

[29] Butt MN, Donart GB, Southward MG, Pieper RD, Mohammad N. 1993. Effect of defoliation on the growth of Napier grass plants. Trop. Sci., 33: 111-120.

[30] Tessema Zewdu, Baars R, Alemu Yami, Dawit N. 2003. Effect of plant height at cutting and fertilizer on growth of Napier grass (Pennisetum purpureum (L.) Schumach.). Tropical science 43: 57-61.

[31] Boonman JG. 1993. East Africa’s grasses and fodders: Their ecology and husbandry. Kluwer Academic Publishers, Dortrecht, Netherlands, p. 341.

[32] Tessema Zewdu. 2005. Variation in growth, yield, chemical composition and in vitro dry matter digestibility of Napier grass varieties (Pennisetum purpureum). Trop. Sci. 45: 67-73.

[33] Ishii, Y., Yamaguchi, N. And Idota, S. 2005. Dry matter production and in vitro dry matter digestibility of tillers among Napier grass (Pennisetum purpureum Schumach) varieties. Grassland Science 51: 153-163.

[34] Tessema Zewdu and Alemayehu Mengistu. 2010. Management of NapierGrass (Pennisetum Purpureum (L.) Schumach) for High Yield and Nutritional Quality in Ethiopia: AReview. Eth. J. Anim. Prod. 10(1) –2010: 73 –94. ©Ethiopian Society of Animal Production (ESAP) EJAP ISSN: 1607-3835 Volume 10, Number 1, 2010.