NAPIER GRASS (*Pennisetum purpereum*): A RESILIENT AND HIGH-QUALITY FORAGE FOR SUSTAINABLE RUMINANT PRODUCTION IN SEMI-ARID REGIONS – A REVIEW

[1]Hyelda, A.J., [2]Ahmed, A.,[*] [3]Abdullahi, S., [1]Muazu, A. and [2]Tuwanga, J.V.
[1]Animal Quarantine Department, Nigeria Agricultural Quarantine Service
[2]Department of Animal Science and Range Management, Modibbo Adama University, Yola
[3]Federal University of Agriculture, Mubi
Corresponding Author: aaa2daware@gmail.com ; +2347069306448

Abstract
Napier grass (*Pennisetum purpureum*), also known as elephant grass, is a perennial tropical forage crop recognized for its exceptional biomass production, adaptability, and nutritive value. It is widely cultivated in tropical and subtropical regions, particularly in Africa, as a primary feed resource for ruminants. In semi-arid zones of Nigeria, where seasonal feed scarcity constrains livestock productivity, Napier grass offers a sustainable solution due to its drought tolerance, rapid regrowth, and compatibility with various conservation methods such as silage and haymaking. This review synthesizes available literature on the agronomic characteristics, nutritional composition, adaptability, and management strategies for optimizing Napier grass production under semi-arid conditions. Emphasis is placed on its role in improving feed availability during dry seasons, potential for integration into cut-and-carry feeding systems, and compatibility with smallholder farming systems. Given its high crude protein content, digestibility, and energy value, Napier grass stands out as a pivotal forage for enhancing cattle performance, milk yield, and overall farm profitability. The review concludes that targeted research, farmer training, and policy support are essential to fully harness the potential of Napier grass as a dependable forage in semi-arid livestock systems.

Keywords: Napier grass, forage, biomass, ruminant

Description of Problem

Napier/Elephant grass (*Pennisetum purpureum* Schumach.) is one of the most important forage species in the world. It has been grown in almost all tropical and subtropical regions of the globe due to its high potential for forage accumulation, nutritive value, acceptability by different animal species, vigor and persistence [22]. It is also called merker grass, Napier grass, Uganda grass and by several other names in different parts of the world. It carries the name "Napier grass" to recognize the contribution of Colonel Napier of Rhodesia who first wrote to the Rhodesian Agricultural Department to make them aware of the value of this plant [28].

Origin and Distribution

Napier grass is native to Sub-Saharan Africa from where it is believed to have been distributed to other tropical and subtropical regions around the world [19]. [28] also noted the origin of Napier grass to be from the humid tropical, making it a tropical grass. Being a perennial grass possessing underground stems or rhizomes and thereby having its growth nodes protected by the soil during a ground fire, Napier grass in its native range developed as a fire sub-climax to broadleaf tropical forests [28]. It has been naturalized to Central and South America, tropical parts of Asia, Australia, the Middle East and Pacific islands for use as animal fodder [28]. Once the fast-growing habit and potential for fodder especially for dairy cows became known outside Africa, spread of Napier grass to other continents was expeditious and in some of the countries it became an important animal fodder [28].

Propagation of Napier Grass

Napier grass is not propagated by seeds for several reasons. First, due to cross-pollination, the seeds are a mixed lot, thus the plants produced from them will not be uniform and their performance not predictable. The seeds often germinate poorly and seedlings are weak. Moreover, poor seed-setting and shattering makes seed availability problematic. Thus, vegetative propagation of Napier grass is a routine practice [17, 28]. The propagation of Napier grass is by stem cuttings (setts), rooted stems or splitting of rhizomes [28]. The difficulties involved in obtaining rhizomes contribute to its little usage compared to the use of stem cuttings [22] The most common way of planting is using setts. The mature stems in the

basal 2/3 zone with well-developed leaf buds are utilized [28].

Methods of Planting Napier Grass

Conventional method

Stem cuttings consisting of at least three nodes, two of which are buried are used. This can be done by hand or with a sugarcane planter. Row width ranges from 50 to 200cm, the greater distances being preferred in drier regions. Distance within rows varies from 50 to 100cm [17]. The stems are planted in holes 15 to 30cm deep [15] and at an angle of 30 to 45° [25].

Tumbukiza method

'Tumbukiza' a Kiswahili word meaning 'placing in a hole', is a new planting method started by farmers to increase productivity per unit of land. The method, which involves planting cuttings or root splits in well-manured holes, produces more herbage yields than the conventional method [15].

Management and Harvest of Napier Grass

For high yields and persistence, Napier grass planted as a crop requires a regular water supply and a rich supply of nutrients. The latter applies particularly when the crop is cut frequently. Nutrient removal per dry matter ton is: nitrogen 10 to 30kg, phosphorus 2 to 3kg, potassium 30 to 50kg, calcium 3 to 6 kg, magnesium and sulphur 2 to 3kg. With annual dry yields between 20 to 40 tons/ha, very large quantities are thus extracted from the soil [17]. If they are not replenished, yield drops and weeds will invade. Forage legumes like silverleaf (*Desmodium uncinatum*), greenleaf (*Desmodium intortum*) and stylo (*Stylosanthes guianensis*) can be intercropped with Napier grass to improve the quality of the feed and reduce the cost of nitrogen fertilizer [15]. Intercropping with cassava and banana is often practiced in home gardens [17]. The rate of fertilization varies with the soil and is dependent on the existing fertility level [28]. [30] applied both inorganic and organic fertilizer at the rate of 625 kg/ha (nitrogen: phosphorus: potassium 15-15-15) and 6.25 ton/ha of manure respectively. [20] applied 26 kg phosphorus/ha/year at planting and 60 kg nitrogen/ha as annual top-dress. [25] applied a basal fertilizer 2:3:2 (nitrogen: phosphorus: potassium) at the rate of 250 kg/ha, plus superphosphate at the rate of 300 kg/ha. [13] applied a blanket basal phosphorus fertilizer in the form of diammonium phosphate at the rate of 100 kg/ha and 50 kg/ha urea was applied after every harvest. [10] applied nitrogen phosphate sulfate at the rate of 100 kg/ha 50kg urea/ha after every harvest. [15] recommended any of (at planting): 50 to 100kg/ha diammonium phosphate; 10 ton/ha of farmyard manure; 25 to 50kg/ha diammonium phosphate and 5 ton/ha farmyard manure. Weeding should be done when and where necessary. [11] carried out weeding 40 days after planting and Lukuyu *et al*. [15] recommended weeding to be done after each harvest to maintain high productivity.

Napier grass can be harvested year-round. The ideal harvest regime depends on the cultivar, weather conditions, soil fertility, management practices and livestock needs. When Napier grass is intended for hay, it should be cut at an early stage of maturity as the stems become too coarse when the plant ages [7]. [21] suggested leaving 10 to 15cm high stubble when harvesting so as to provide sufficient carbohydrate reserves for subsequent regrowth.

Agronomic Parameters of Napier Grass

In their various studies, [5], [8] and [10] reported 90.67%, 84.37% and 88.80% respectively as the average germination percentages of some Napier grass cultivars. [24] reported 87.75 to 100% as germination percentage for different varieties of Napier grass cultivated on different soil types. [6] reported a mean of 18.51 for tiller number per plant of different Napier grass accessions under rain fed, harvested after five months of planting when fertilizer was used. [26] reported 184.4cm as plant height for Napier grass hybrid harvested after 80 days. [27] observed taller plants with narrower spacing because of higher competition for sunlight but [18] noted that wider spacing resulted in the tallest plant height and was due to lesser competition for nutrients, moisture, and carbon dioxide among the roots of the plants.

[16] reported a leaf length range of 84.74 to 89.48cm for four Napier grass varieties, [24] reported a range of 2.80 to 4.20cm as leaf width for different varieties of Napier grass harvested after 120 days and [16] recorded 3.69cm as the broadest width for four Napier grass varieties harvested after four months. [5] reported a range of 10.07 m to 14.00 as number of leaves of six Napier grass cultivars at forage harvesting stage whileb[10] and [16] recorded

15.17 and 11.17 to 13.50 respectively in their various studies on Napier grass production.

Yields of Napier Grass

The yield estimates vary depending on the climate, soil, cultivar and cultural practices [28]. [29] noted an increase in dry matter yield with corresponding increase in Napier grass population per hectre and [27] observed that fresh forage yield has positive correlation with plant height, tiller number, leaf number and leaf width. In their study on different varieties of Napier grass cultivated on different soil types, [23] observed a higher dry matter yield on plots cultivated using organic fertilizer than on plots cultivated using inorganic fertilizer.

[30] reported a dry matter yield of 6.59 to 8.59 ton/ha for Napier grass under different planting densities, harvested after 70 days. [25] and [10] obtained a dry matter yield of 6.08 ton/ha and 7.70 to 12.11 ton/ha in their studies on the performance of Napier grass.

Chemical and Mineral Compositions of Napier Grass

[11] observed a progressive increase in dry matter content of Napier grass with increase in the time of harvest. [23] reported a dry matter average of 15.8 to 16.3% after five harvests of 60 days interval each and [25] reported a dry matter content of 24.40%, 27.79% and 33.05% harvested at 4 weeks after planting (WAP), 8 WAP and 12 WAP respectively. [2], [31], [25] and [11] observed and reported a reduction in crude protein content with prolonged stage of harvest. [23] reported that inorganic fertilizer produced Napier grass with higher crude protein content than organic fertilizer in four of five harvesting stages. [23] and [12] reported a crude protein content of 7.6 to 8.1% and 5.41 to 5.73% respectively, in their various studies on Napier grass production.

[13] and [11] observed that ash content reduced with increased stage of maturity. The high ash content in forage could be an indication of high mineral concentration [12] and if the ash content of a forage is abnormally high, there is a very good chance the forage is contaminated with soil which is not desirable [9]. In their studies, [25] and [11] observed that that ether extract content decreased with maturity of Napier grass. [7] reported 1.0 to 3.8% as ether extract content range of Napier grass and [16] obtained 1.90 to 2.05% ether extract content in Napier grass after four months of cultivation. Organic matter contents of 92.1% and 92.5% were reported by [23] after five harvests for organic and inorganic fertilizer respectively.

In their studies, [2] and [31] reported a progressive increase in cell wall constituents with increase in maturity. [2] reported a neutral detergent fibre, acid detergent fibre and acid detergent lignin 68.3 to 73.6%, 42.1 to 44.1% and 4.6% to 6.3% respectively while [26] reported a neutral detergent fibre and acid detergent fibre of 86.45 to 88.06% and 56.09 to 61.89% respectively. Neutral detergent fibre, acid detergent fibre and acid detergent lignin contents of 54.1 to 79.9%, 29.5 to 52.9% and 2.7 to 9.1% respectively were reported by [7]. For non-fibre carbohydrate of Napier grass, [14] obtained 3.02%. [11] and [2] observed that both macro and micro nutrients decrease with maturity of Napier grass. [3] stated that the application of organic manures including farmyard manure, compost or liquid slurry from animal farms can improve the macro and micro mineral content of soil in which it is applied and the mineral content in these farm wastes may be adequate to meet the growth and production of crops.

Napier Grass as Feed for Ruminants

Napier grass is a very important forage in the tropics due to its high productivity [7] It is particularly suited to feed cattle [7] Napier grass is mainly used in cut-and-carry systems ("zero grazing") and fed in stalls, or made into silage or hay [7]. The grass can be grazed, provided it can be kept at the lush vegetative stage: livestock tend to feed only the younger leaves [4]. With about 70 to 80% of Napier grass yield concentrated in the rainy season, it is important to consider both volume of precipitation and distribution of rainfall throughout the year [22] to enable for enough fodder cultivation and preservation that will be fed to animals during the dry season.

Conclusion and Application

Napier grass is a versatile, high-yielding, and nutritious forage crop with proven adaptability to semi-arid environments. Its potential to bridge feed gaps, support sustainable livestock production, and improve smallholder livelihoods is well established. However, maximizing its benefits requires improved agronomic practices, efficient conservation methods, and the adoption of improved

cultivars. Strengthening extension services, promoting farmer education, and supporting research into pest management and soil fertility will further enhance productivity. With strategic investment and policy backing, Napier grass can play a central role in ensuring year-round forage availability and boosting livestock productivity in Nigeria's semi-arid regions.

References

1. Aganga, A.A., Omphile, U.J., Thema, T. and Baitshotlhi, J.C. (2005). Chemical composition of Napier grass (*Pennisetum purpureum*) at different stages of growth and Napier grass silages with different additives. *Journal of Biological Sciences*, 5(4): 493-496.
2. Bayble, T., Melaku, S. and Prasad, N.K. (2007). Effects of cutting dates on nutritive value of Napier (*Pennisetum purpureum*) grass planted sole and in association with Desmodium (*Desmodium intortum*) or Lablab (*Lablab purpureus*). *Livestock Research for Rural Development*, 19(1): 1-11.
3. Davis, J., Anil, K.S., Joseph, M., Suraj, P.T., Ally, K. and Ramnath, V. (2017). Mineral profile of Hybrid Napier grass under slurry irrigation. *International Journal of Advanced Research in Biological Science*, 4(3): 119-126.
4. Food and Agriculture Organization [FAO]. (2015). Grassland Index. A searchable catalogue of grass and forage legumes. FAO, Rome, Italy. http://www.fao.org/ag/AGP/AGPC/doc/GBASE/default.htm
5. Gadisa, B., Dinkale, T. and Debela, M. (2021). Agronomic performance and evaluation of Elephant (*Pennisetum purpureum*) grass cultivars for fodder production at Mechara research station, Eastern Oromia, Ethiopia. *World Journal of Agricultural Sciences*, 17 (3): 169-176.
6. Getiso, A. and Mijena, D. (2021). Performance evaluation of Napier grass accessions under rain fed and irrigation system at Wondo Genet. *Global Journal of Ecology*, 6(1): 028-033.
7. Heuze, V., Tran, G., Giger-Reverdin, S. and Lebas, F. (2020). Elephant grass (*Pennisetum purpureum*). Feedipedia, a programme by INRAE, CIRAD, AFZ and FAO.
8. Hidosa, D., Zeleke, B. and Nahom, F. (2022). Evaluation of Elephant (*Pennisetum perpureum*) grass variety for agronomic parameters and biomass yields under rain fed condition to improve feed availability in South Omo, Southwestern Ethiopia. *Journal of Veterinary Medicine and Animal Sciences*, 5(1): 1107.
9. Hoffman, P.C. (2005). Ash contents of forages. *Focus on Forage*. Adapted from: Hoffman, P.C. and Taysom, D. How much ash are you feeding your cows? *Hoards Dairyman*, 7(1): 1-2.
10. Jabessa, T., Bekele, K., Tesfaye, G. and Amare, Z. (2022). Evaluation of Elephant grass (*Pennisetum purpureum* L.) accessions for their agronomic performances in lowland areas of Guji Zone, Southern Oromia, Ethiopia. *American Journal of Biological and Environmental Statistics*, 8(1): 31-35.
11. Kamaruddin, N.A., Zulkifli, A.N., Ahmad, N. and Zakaria, J. (2018). Effects of different harvesting ages on chemical composition of five Napier grass (*Pennisetum Purpureum)* varieties. *International Journal of Engineering & Technology*, 7(4.43): 46-49.
12. Kebede, G., Feyissa, F., Assefa, G., Alemayehu, M., Mengistu, A., Kehaliew, A. … Abera, M. (2016). Chemical composition and In-vitro organic matter digestibility of Napier grass accessions in the Mid and Highland areas of Ethiopia. I*nternational Journal of Livestock Research*, 6(4): 41-59.
13. Kebede, G., Feyissa, F., Assefa, G., Alemayehu, M., Mengistu, A., Kehaliew, A. … Abera, M. (2017). Agronomic performance, dry matter yield stability and herbage quality of Napier grass accessions in different agro-ecological zones of Ethiopia. *Journal of Agricultural and Crop Research*, 5(4): 49-65.
14. Khaleduzzaman, A.B.M., AL-Mamun, M. A., Kabir, M.A., Bilkis, T. and Hazary, M.E.H. (2016). Low-cost forage preservation and evaluation in relation to nutrient intake, digestibility and rumen fermentation characteristics of indigenous cross bred cattle. *International Journal of Recent Scientific Research*, 7(6): 12220-12226.
15. Lukuyu, B., Gachuiri, C.K., Lukuyu, M.N., Lusweti, C. and Mwendia, S. (eds). (2012). Feeding dairy cattle in East Africa. *East Africa Dairy Development Project*, Nairobi, Kenya.
16. Maleko, D., Mwilawa, A., Msalya, G., Liliane, P. and Mtei, K. (2019). Forage growth, yield and nutritional characteristics of four varieties of Napier grass (*Pennisetum purpureum* Schumach) in the West

Usambara highlands, Tanzania. *Scientific African*, 6: 1-9.
17. Mannetje, L.'t. (1992). *Pennisetum purpureum* Schumach. [Internet] record from Proseabase. Mannetje, L.'t and Jones, R.M. (Editors). PROSEA (Plant Resources of South-East Asia) Foundation, Bogor, Indonesia. http://www.proseanet.org.
18. Mujeeb-ur-Rahman., Iqbal, M., Jilani, M.S. and Waseen, K. (2007). Effect of different plant spacing on the production of cauliflower (*Brassica oleracae*) under agro climatic conditions of DI Khan. *Pakistan Journal of Biological Sciences*, 10: 4531-4534.
19. Negawo, A.T., Teshome, A., Kumar A, Hanson, J. and Jones, C.S. (2017). Opportunities for Napier grass improvement using molecular genetics. *Agronomy*, 7(2): 1-21.
20. Nyambati, E.M., Muyekho, F.N., Onginjo, E. and Lusweti, C.M. (2010). Production, characterization and nutritional quality of Napier grass [*Pennisetum purpureum* (Schum.)] cultivars in Western Kenya. *African Journal of Plant Science*, 4(12): 496-502.
21. Orodho, A.B. (2006). The role and importance of Napier grass in the smallholder dairy industry in Kenya. FAO, Rome, Italy. https://www.fao.org/ag/agp/agpc/doc/newpub/napier/
22. Pereira, A.V., Lira, M.A., Machado, J.C., Gomide, C.A.M., Martins, C.E., Ledo, F.J.S. and Daher, R.F. (2021). Elephant grass, a tropical grass for cutting and grazing. *Revista Brasileira de Ciencias Agrarias*, 16(3): 1-13.
23. Rahman, M.M., Wan Khadijah, W.E. and Abdullah, R.B. (2016). Comparison between urea and goat manure as sources of nitrogen for Napier grass grown on terraced hill. *Malaysian Journal of Animal Science*, 19(2): 83-93.
24. Rahman, R.A., Manikandan, K., Shenbagavalli, S. and Prabhakaran, J. (2022). Assessment of germination percentage and growth parameters of different varieties of Napier grass (*Pennisetum purpureum*) on sodic soil of Thoothukudi district, Tamil Nadu, India. *Journal of Applied and Natural Science*, 14(1): 45-50.
25. Rambau, M.D., Fushai, F. and Baloyi, J.J. (2016). Productivity, chemical composition and ruminal degradability of irrigated Napier grass leaves harvested at three stages of maturity. *South African Journal of Animal Science*, 46(4): 398-408.
26. Sarker, N.R., Yeasmin, D., Tabassum, F., Amin, M.R. and Habib, M.A. (2019). Comparative study on biomass yield, morphology, silage quality of hybrid Napier and Pakchong and their utilization in bull calves. *Journal of Agricultural Science and Technology*, 9: 166-176.
27. Sathees, D. and Santhiralingam, S. (2022) Evaluation of growth and yield performances of Napier grass cultivar Pakchong-1 under different spacial patterns in the Kilinochchi district, Sri Lanka. *Journal of Agro-Technology and Rural Sciences*, 1(2): 1-5.
28. Singh, B.P., Singh, H.P. and Obeng, E. (2013). Elephant grass. In: Bharat P. Singh (Editor), *Biofuel Crops: Production, Physiology and Genetics*, Publisher: CAB International. 13: 271-291.
29. Tessema, Z. (2008). Effect of plant density on morphological characteristics, yield and chemical composition of Napier grass. *East African Journal of Sciences*, 2(1): 55-61.
30. Wijitphan, S., Lorwilai, P. and Arkaseang, C. (2009). Effects of plant spacing on yields and nutritive values of Napier grass (*Pennisetum purpureum*) under intensive management of nitrogen fertilizer and irrigation. *Pakistan Journal of Nutrition*, 8(8): 1240-1243.
31. Zailan, M.Z., Yaakub, H. and Jusoh, S. (2016). Yield and nutritive value of four Napier (*Pennisetum purpureum*) cultivars at different harvesting ages. *Agricultural and Biological Journal of North America*, 7(5): 213-219.