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Bana Grass Growing in Sub Saharan Africa

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Abstract

The chapter provides a detailed summary on the morphology and physiology of Bana, climatic and soil adaptation, establishment, fertilization, weeding, basic management, and uses of the grass such as hay and silage making in sub-Saharan Africa. A detailed review of pest, disease, and weed control as well as grazing management of the crop is given at the end of the chapter. Bana grass is a very robust improved grass that has vast potential to improve animal production in the tropics. The grass was originally developed in South Africa as a cross between *Pennisetum purpureum* and *Pennisetum americanum* and was widely used as livestock feed. However, the limited use of the grass in some parts of sub-Saharan Africa like Zimbabwe might be attributable to knowledge gap in production and overall importance of the grass. The high cost of commercial supplementations in ruminant animals particularly in sub-Saharan Africa justifies promotion of improved forage production. The author calls upon researchers, government structures responsible for agriculture, and development partners to promote establishment and utilization of the miracle grass in order to improve livestock production and livelihoods and reverse the terrible effects of climate change in sub-Saharan Africa.

Keywords: Bana grass, perennial grass, silage, pasture, dry matter, water-soluble carbohydrates

1. Introduction

Bana grass also known as the miracle grass is natural and invasive to Tropical Africa and the sub-Saharan region. The bunch grass is high yielding and deep rooted. Bana grass is a hybrid derived from the annual Babala (*Pennisetum americanum*) and the perennial Napier grass (*Pennisetum purpureum*) and was developed in South Africa as food for livestock.

The name Bana is derived from the acronym **ba** in Babala and **na** from Napier. However, some authors reiterate that the word Bana is from the word Ghana, the nation where it is abundantly grown. For better and maximum yields, the grass can be grown in warm climates that receive annual rainfall ranging from 750 to 2500 mm. Bana is susceptible to frost and therefore does not perform well in frost-prone regions. In Kenya and other African countries, Bana is the most common fodder crop where it is used to feed smallholder dairy cows and supplement beef animals during the dry winter [2]. With the high cost of commercial supplementation in dairy production, Bana grass provides a cost-effective way of improving milk production [4]. The popularity of Bana grass is associated with its drought-tolerant nature, its low nutrient requirement, and its ability to resist pests and diseases. In the past, Bana has been used chiefly for grazing; lately, however, it has been incorporated into a pest management approach and can also be used as a source of fuel and as wind break in homesteads or banana plantations. The grass has shown potential at attracting stem borer moths away from maize and hence is the “pull” crop [13]. This strategy is much more sustainable, serves more purposes, and is more affordable for farmers than insecticide use. Furthermore, Bana grass improves fertility of the soil especially when reinforced with legumes, and like many other robust grasses, Bana protects soil against erosion. It is also utilized for firebreaks, windbreaks, in paper pulp production, and most recently to produce bio-oil, biogas, and charcoal. The grass resembles sugarcane in appearance. It is characterized by pale green leaves and can grow up to 4 m. Bana grass is tolerant to drought and can be grown even on infertile lands. Bana is mainly propagated vegetatively, that is, through cuttings though some seed producing varieties have been reported but are not very common. Under good management, Bana yields up to 80 tons per hectare, but this can go down to 10 if fertilization and watering regime are poor. Frequent defoliation improves herbage quality but reduces herbage yield [12]. Knowledge gap in production and values of Bana limits Bana production in the subtropical regions. Literature publishing and dissemination will help alleviate this gap.

2. Bana botanical description and genetic variation

Kingdom: Plantae, **Order:** Poales, **Family:** Poaceae, **Genus:** *Pennisetum*, **Species:** *P. Purpureum*

2.1. Reproductive biology

Bana grass is mainly vegetative propagation, though sexual reproduction has been reported in some apomictic species of Bana grass. The apomictic species is an unpredictable seed producer, and in some environments, it seldom develops seeds, probably due to low pollen viability. Produced they are dispersed by wind but viability via this method is often very low.

2.2. Physiology and phenology

P. purpureum is a fast-growing perennial grass that flowers at different times of the year depending on climatic condition, for example, in Florida, the grass flowers between July and February. In Mexico and Central America, flowering occurs all year long with peaks from

December to May. In South Africa, this species flowers from January to June. As many other C4 grasses, *P. purpureum* is well adapted to environments with high daytime temperatures, intense sunlight, drought, and nitrogen and/or CO₂ limitation. Though the grass grows best during the rainy season, its deep root system allows it to survive long drought periods.

2.3. Morphology

Bana grass is a robust, rhizomatous, tufted perennial grass. The root system of Bana grass is vigorous and it develops from the nodes of its creeping stolons. The culms can reach a height of 4–7 m and usually coarse and perennial. The grass forms dense thick clumps, up to 1 m across [6]. The leaves have a blue-green color and are flat, linear, and hairy at the base, with a length of 100–120 cm and a width range of 1–5 cm. The midrib for the Bana grass leaf can be easily seen with naked eyes, and the margins of its leaves are flimsily toothed. Bana produces no seeds at all; if ever seeds are produced, there will be very small seeds (3 million seeds/kg). Bana grass resembles sugarcane in appearance (*Saccharum officinarum*), the reason why some people call it sugarcane grass or elephant grass, but it is easily distinguished from sugarcane because of its leaves that are narrow leaves and the stems that are taller reaching up to a height of 4 m.

3. Uses of Bana

Bana grass is very important forage in the sub-Saharan Africa due to its high productivity. It can be used as silage or hay to feed dairy cows and supplement beef cattle and sometimes goats during the dry winter. Bana grass can be used under cut-and-carry systems (“zero grazing”) or grazed, provided it can be kept at the lush vegetative stage: livestock tend to feed only the fresher leaves.

Bana grass is a multipurpose plant. The young leaves and shoots are edible by humans and can be cooked to make soups and stews. The yellow stem of Bana grass can be used to make fences and thatching houses (whole plant). The section gives a detailed outline of the use of Bana grass in subtropical Africa.

3.1. Silage

Bana grass is known for producing good-quality silage either alone or mixed with other crops. However, ensiling of Bana grass is complicated by the low concentration of water-soluble carbohydrates and its high cell wall content [6, 7]. Studies done in Zimbabwe, concluded that for good quality silage production. The optimal time for harvesting Bana grass should be when the concentration of water-soluble carbohydrates is at their pick point (6–7 weeks), to increase DM content and optimize herbage production without affecting nutritive value. When making Bana grass silage, the high moisture content of the grass when its nutritive value is highest is the main barrier for using Bana grass in silage making, because it results in undesirable fermentation with considerable nutrient losses. It is against this background that the grass is usually ensiled with materials that improve the quality of the silage and its nutritional value (protein or energy) such as cassava, velvet bean, and rice bran.

3.2. Hay and dry grass

When Bana grass is to be used as hay, though it is less common that it should be cut at an early stage of maturity as the stems become too coarse when the plant ages. In some parts of Africa, Bana grass is used for the production of dry grass pellets used as additional stock feed during the dry winter.

3.3. Fresh grass

The best harvesting regime for Bana grass is determined by weather conditions, inherent soil fertility, the levels of management, and physiological needs of animals. The 6- to 8-week harvesting interval can then be adopted. In Eastern African countries like Tanzania and Kenya and even Southern African countries like Zimbabwe, farmers are advised and recommended to harvest Bana grass for the first time when it attains a height of 1–1.2 m, usually 3–4 months after planting [2]. Thereafter, the grass should be harvested at intervals of 6–8 weeks, at the same height. Under excellent management, the grass can be harvested on a monthly basis in hot and wet environments or every 2 months in drier areas. If the grass is harvested at longer intervals, it produces higher DM yields, but the quality of the forage will be low as content of essential nutrients like protein and ash decreases with maturity of the grass. The digestibility of the grass will also go down; this is a direct result of the increase in the ratio stem-to leaf. When harvesting the grass as fresh forage under the cut and carry system, it is important to remember to leave behind the stubble with a height of 10–15 cm. This stubble will provide adequate energy reserves for subsequent regrowth.

Under cut-and-carry systems, Bana grass is often fed fresh to animals. To promote nonselection of leaves and stems and to increase voluntary feed intake, the grass can be chopped and fed to animals. Thus, for efficient forage utilization, the grass needs to be chopped and then sun wilted for several hours. This treatment of Bana decreases moisture, stimulates appetite, and facilitates rumination.

3.4. Pasture

When used for pasture, Bana grass should be heavily grazed so that most of the young leaves and shoots, which have the highest nutritive value, are available to ruminants. For the best utilization, the crop should be grazed at intervals of 6–9 weeks and at a height of about 90 cm. The crop can be top-dressed with nitrogen fertilizers after each grazing or cutting in high-rainfall areas.

3.5. Biological control agent of pests

Studies have shown that Bana grass in conjunction with other grasses and legumes like *Desmodium* spp. effectively controls notorious pests like maize stem borer moth. If planted alongside maize fields, the stem borer moth is pushed out of the field by *Desmodium* and will go and lay eggs on Bana grass [9]. When the larvae start boring Bana grass, the grass emits a sticky chemical that kills almost all larvae while the surviving ones are attacked by *Cotesia sesamiae*.

3.6. Weed and soil erosion control

Bana grass has been used successfully in erosion control, gully reclamation, and mulching of garden and field crops to fight against stem borers in maize crops. The grass is a good weed controller and, in Africa, it has been reported to be used as a trap plant in push-pull management strategies.

3.7. Climate and soil adaptation (ecology)

Bana grass is grown in both the tropical and subtropical regions. Rainfall amounts that range from 750 to 2500 mm per year and temperature range of 25–40°C are ideal for Bana grass production. However, it can be grown even in climates that receive less than 500 mm annual rainfall. Bana grass is prone to frost damage and it is not advised to grow it in frost-prone areas. Generally, the grass grows very well in regions that receive high rainfall, but its deep rooted system adapts it to drought risk areas that receive less rainfall.

Bana grass can be grown on a wide variety of soils that have good drainage, from the infertile sandy soils to the nutrient-rich loam soils. But it is best advised to grow Bana on unutilized soils with good drainage as it does not tolerate waterlogging and prolonged flooding. The grass can be grown on wet lands, flood plains, riverbanks, swamps, forest edges, disturbed sites, and waste ground. The grass grows well in soils with a pH range of 4.5–8.2, and there is no literature on tolerance of Bana to soils with high salinity.

Bana is found on vleis and river banks in the wild, explaining its need for good moisture, though it is not tolerant to prolonged flooding.

3.8. Establishment and yields

Bana grass is best planted in spring in temperate climate to give it the opportunity to grow before frost but throughout the year in sub-Saharan Africa but best planted during the rainy season to reduce irrigation requirements. Land preparation methods for planting Bana grass are the same as for maize. Identified land is plowed, disked, and harrowed before planting the grass [4]. Bana grass is best propagated vegetatively (stem cuttings with two to three nodes). These nodes are pushed into the soil at an angle of 45° with the bottom end down. Two nodes will then be buried into the soil. Bana is planted at an interrow spacing of 0.5–2 m and intrarow spacing of 0.3–1 m. However, when planting Bana grass for soil conservation purposes, close spacing is required. In the subtropical regions, since the annual average rainfall is usually low, it is advisable to increase spacing. The grass needs to be irrigated frequently soon after planting to establish the proper root system. The grass grows rapidly after planting and can grow up to 4 months soon after planting. Due to its fast growing nature, Bana grass has high yield potential that of course is influenced by prevailing climatic conditions. In the sub-Saharan Africa for Bana grass to fully realize its potential (20–80 t DM/ha/year), there is need to regularly irrigate the crop and heavily fertilize it. It is important to note that when management is poor, yields as low as 2–10 t DM/ha/year are realized. When space is limiting air layering or marcotting can be done to propagate Bana grass. Air layering is not different

from the other forms of layering except that roots are induced on the part of the plant while it is still above the ground (air layering). When performing air layering for Bana grass, one node must be under the soil such that roots will develop from the nodes.

Bana grass can also be best planted by digging up a clump and then separating the segments with their roots. The separated segment can then be planted at an interrow spacing of 0.5–2 m and intrarow spacing of 0.3–1 m. The segments will also form clumps.

4. Harvesting of Bana grass (caring and pruning)

Harvesting intervals and technique for Bana depends with intended use. Bana grass can be harvested at intervals of 3–4 months depending on management and climate to pave way for renewed growth when feeding it livestock [1]. This can be done by allowing the animals to graze freely or the common cut-and-carry system. This cut-and-carry system is the best method of harvesting Bana and is normally referred to as the cutting back system. Under dry land or hard to irrigate conditions, Bana is cut back at the end of the rainy season to ground level, and the clumps will shoot up vigorously during the rainy season. It is important to note that under excellent management, harvesting intervals can go up to 6–8 weeks for 5 years [5]. When harvesting Bana under the cut-and-carry system, it is encouraged to leave a stem height of at least 10 cm from the ground to encourage vigorous regrowth. The grass can be fed green or as hay to livestock. When Bana is grown for making fuel, it can be cut every 9–12 months to increase the quantities of fuel obtained. It is important that even under poor management, Bana fares better than most grasses.

5. Intercropping Bana grass

Though Bana grass is mainly grown in pure stands, it can be intercropped with legumes and other shrubs such as *Leucaena leucocephala*, and intercropping Bana grass and leguminous improves the nutritional value of DM yield and soil fertility. Legumes such as *Leucaena*, *Desmodium*, *Sesbania*, and *Mulberry* can be intercropped with Bana. Some authors alluded that *Desmodium intortum* gives the DM content and nutrient value in intercropping regimes when compared to most legumes such as *Sesbania*, *Leucaena*, etc.

6. Nutritional attributes of Bana grass

Bana grass has rather low protein content (about 10% DM), but young grass can be very nutritive. For instance, studies in Venezuela revealed that at 30 days of regrowth, protein values ranged from 21% DM but reduced down to less than 4% DM when Bana was cut at 70 days. Bana grass is reported to be rich in fiber, but the fiber content is dependent on stage of maturity. The Neutral Detergent Fiber for Bana ranges from 55 to 75% depending on stage of maturity.

7. Potential constraints in use of Bana grass

7.1. Nitrate poisoning

When used as a sole component of the diet, Bana grass can cause nitrate poisoning in cattle. In Malaysia, it was reported that some cattle died from nitrate poisoning after they were fed with Bana grass. The levels of nitrate in Bana grass from the toxic area averaged 28.3 mg/g (up to 44 mg in some samples), while the levels of nitrates in Bana grass from nontoxic areas were 3.9 mg/g. When cattle manure was used to fertilize Bana in Brazil, two outbreaks of nitrate poisoning were reported. Some of the notable clinical signs in livestock suffering from nitrate poisoning after consuming Bana grass include uncoordinated gait, extreme salivation, anorexia, discharge from the nose, respiratory distress, grinding of teeth, depression, or abdominal contractions, cyanosis, and finally recumbency. The actual quantities of Bana grass that results in toxicity after ingestion are not yet known.

7.2. Mature leaves

When Bana leaves reach maturity stage, its leaves will be razor sharp and can occasionally hurt foraging animals. This is common in instances where cutting back rate will be low.

8. Animal production and Bana grass

8.1. Ruminants

Bana grass is one of the most vital fodder grasses for feeding ruminant in sub-Saharan Africa, mainly due to its high productivity. The grass can be grazed, fed as hay, cut fresh, and fed to animals or ensiled [13]. Voluntary intake of the grass is affected by variability among cultivars.

8.2. Palatability

Bana grass is very palatable during its early growth stages (young and leafy). However, as it matures, it becomes coarse and unpalatable. In light of this background, fresh elephant grass is often chopped to prevent animals from selecting the best parts.

8.3. Digestibility and intake

The high cell wall content of Bana grass reduces its protein and energy content. In situ digestibility trials revealed that there is a general decrease in crude protein content and an increase in the fiber content as the grass matures. Young Bana grass has a high nutritive value like most grasses [4]. Bana retains a high level of digestibility over a longer period because its cell wall content increases at a lower rate as it approaches maturity when compared to other grasses such as Kikuyu. Studies with steers in Brazil reported a decline in

dry matter intake and organic matter digestibility with days of regrowth. OM digestibility varied from 75% at 33 days to 56% at 93 days. The authors then recommended use of Bana grass between 30 and 35 days of regrowth for effective organic matter digestibility and voluntary feed intake.

Due to a fill intake caused by water intake when Bana grass is very young, voluntary intake will be usually low. Some results suggest that, at restricted level of intake, maturity can result in an increase of metabolizable energy available in the gastrointestinal tract. Studies in Pakistan revealed that the use of N fertilizer increased the protein concentration of the Bana grass, but these fertilizers failed to reverse the adverse effects of maturity on nutrient digestibility in buffaloes. Bana grass can be chopped and roller-milled to increase voluntary feed intake of the grass and overall value of the grass and consequently a reduction in feed costs. This is made possible by the increase in cell wall surface area available for digestion by microbes in the rumen.

9. Some livestock classes and feeding of Bana grass

9.1. Dairy cattle

In most smallholder dairies in sub-Saharan Africa, Bana grass is a popular forage and is used to feed dairy cattle under the cut-and-carry system [2]. The grass is cut at a height of 55–60 cm, that is, 2–3 months after planting and fed to dairy cows [11]. To reduce feed wastage, the grass needs to be chopped into smaller pieces. A mature dairy cow will consume about 10 kg of Bana a day under intensive management. Effective utilization of freshly harvested Bana is affected by its low dry matter content and high fiber content. When supplemented with *Leucaena*, Bana grass will sustain milk yields of 7–8 l/day. For adequate performance of dairy cows, the grass should be supplemented with leguminous forages.

9.2. Sheep and goats

Sheep and goats raised for either mutton/chevron production can be sustained by Bana [8]. However, for lactating goats and sheep, there is need to supplement this class of stock with leguminous forages. Legumes supply protein to animals, which is an important component in milk synthesis.

9.3. Rabbits

In tropical countries such as Vietnam, Nigeria, and Mozambique, Bana grass is commonly used as green forage for feeding rabbits. When fresh, Bana grass is moderately palatable to rabbits and is associated with high productivity. Palatability of Bana grass to rabbits is also affected by factors such as season, with high levels of palatability and crude protein during the rainy season, while low palatability during the dry season. Bana grass needs to be fed together with other legume forages such as Lucerne for effective growth.

10. Diseases and pests

Bana grass just like other grasses and crops can be attacked by various disease-causing agents, but it has shown a greater degree of resistance compared to other forages [10]. In parts of sub-Saharan Africa like Central Kenya, reports of the grass being attacked by head smut caused by *Ustilago camerumensis* were received [3]. However, some varieties of Bana were found to be resistant to the disease. *Helminthosporium* spp. has also been reported in Bana, but a lot of work is being done to look for varieties that are tolerant to this disease-causing agent. During the rainy season, now mold fungal disease is common to most species of Bana grass with the exception of Clone3. Nevertheless, herbage production is not threatened by snow mold fungal disease.

11. Source of planting material

In most sub-Saharan African countries, Bana grass planting material can be obtained from various places and sources such as research institutions, farmers who are into production, ministry of agriculture, agriculture colleges, and universities.

12. Limitations in Bana grass production

Despite its robust growth and the big production potential, Bana has its own limitations. Bana matures rapidly and becomes stemmy, making it highly unpalatable if growth is not controlled [2]. Bana is also propagated vegetatively and rarely from seeds, since most varieties produce seeds that are not viable. In order for Bana to realize its maximum yield, it needs to be established on soils with high inherent fertility or on heavily manured soils.

13. Conclusion

Bana grass has always had a valuable role in the world of agriculture over the years. The potential of the grass for improving agriculture and bringing stability to the ecosystem is enormous in sub-Saharan Africa. Nevertheless, its future use in agriculture is limited by the knowledge gap and poor adoption in general. The current impacts of climate change together with the high cost involved in feeding animals justify the need to improve establishment and utilization of the miracle grass. Bana grass is relatively easy to propagate and can reach up to a height of 3 m in 3–4 months and has high leaf to stem ration compared to most improved grasses. The grass can also be grown on hard-to-irrigate areas but of course on soils with good irrigation, making it suitable for the sub-Saharan climate. The grass is also native to sub-Saharan Africa. The author calls upon researchers, government structures responsible for agriculture, and development partners to promote establishment and utilization of the

miracle grass in order to improve livestock production and livelihoods and reverse the terrible effects of climate change in sub-Saharan Africa.

It is preferable to include a Conclusion(s) section, which will summarize the content of the book chapter.

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Conflict of interest

Matore Z, the author of this book chapter, states that there is no conflict of interest in this book chapter.

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