TVET CERTIFICATE III in ANIMAL HEALTH

FODDER CROPS AND PASTURES MANAGEMENT

ANHFC302

Manage fodder crops and pasture

Competence

Credits: 6

Learning hours: 60

Sector: Agriculture and Food processing

Sub-sector: Animal Health

Module Note Issue date: October, 2020

Purpose statement

This module covers the knowledge; skills and attitudes required to provide a balanced feeding to domestic animals by managing fodder crops and pasture in an optimum manner. Upon completion of this module, the trainee will be able to: Cultivate fodder crops, perform pastures lay out and improvement and Manage pasture grazing.

Table of Contents

Elements of competence and performance criteria		Page No.
Learning Unit	Performance Criteria	
Learning Unit 1 – Cultivate fodder crops	1.1 Appropriate identification of fodder crops according to their characteristics	4
	1.2 Proper site selection of fodder crops cultivation as per soil types and fodder species	
	1.3 Proper preparation of the land according to fodder species	
	1.4 Proper selection of seeds according to fodder species	
	1.5 Proper planting of fodder crops according to their species.	
	1.6 Proper application of fodder maintenance techniques according to the species and growth stage	
	1.7 Appropriate application of harvesting techniques according to fodder species	
Learning Unit 2 – Perform pastures layout and improvement	2.1 Proper identification of common pasture fodder trees and shrubs according to their botanical characteristic	64
	2.2 Proper identification of common pasture grasses and legumes according to their botanical characteristics	
	2.3 Appropriate maintenance of pasture according to their levels of exploitation	
	2.4 Proper Integration of legumes within pastures according to their types and requirements of animals	
	2.5 Proper fencing and paddocking of the pasture according to the size and animal species	
	2.6 Proper water supplying according to the farm requirements	
Learning Unit 3 – Manage pasture grazing	3.1 Proper organization of the herd and flock in the pasture according to their species and requirement	80
	3.2 Adequate estimation of pasture productivity according to the standard	
	3.3 Adequate calculation of pasture carrying capacity according to the size of pasture and animal species	
	3.4 Proper application of pasture rotation and ranching method according to the size of pasture and number of animals	
Learning Unit 4 – Improve nutritive value of crops residues and straws	4.1 Proper Identification of common crop residues according to their nutrient content	86
	4.2 Proper Improvement of crop residues and straws qualities according to their nutritional values	
	4.3 Proper use of crops residues and straws according to their standards	

LU & PC is linked in LO inside the content

Total Number of Pages: 92

List of tables

Table 1: Classification of concentrate feeds 7
Table 2: Advantages and disadvantages of sowing in line and Broadcasting.....59
Table 3: Amounts of lime to apply to lands according to the pH of the soil 62
Table 4: Herd composition for different species of animals.....81
Table 5: Common crop residues.....88
Table 6: Crop residues amount to use.....92
Table 7: Constraints to better utilization of crop residues and suggested remedies 93

List of pictures

Picture 1: Desmodium uncinatum (Silverleaf Desmodium) 9
Picture 2: Desmodium intortum (Greenleaf Desmodium) 11
Picture 3: *Medicago sativa* (Lucerne or Alfalfa): Ruzerine 13
Picture 4: Macroptilium atropurpureum (Siratro) 15
Picture 5: Centrosema pubescens, Syn: Cenrosema molle (centro or butterfly-pea) 17
Picture 6: Mucuna pruriens (Velvet bean) Mucuna 18
Picture 7: Trifolium spp (clover): Urizi 20
Picture 8: Glycine javanica Syn. Neonotonia wightii 22
Picture 9: Cajanus cajan (Angola pea, cajan, Congo pea, pigeonpea): umukunde 24
Picture 10: Leucaena leucocephala (leucaena; wild tamarind, lead tree 26
Picture 11: Calliandra carothyrsus.....28
Picture 12: Cut forage of calliandra 29
Picture 13: Pennisetum purpureum Syn: Cenchrus purpureus 31
Picture 14: Setaria sphacelata (African bristle grass) 33
Picture 15: Tripsacum laxum Syn: Tripsacum andersonii (Guatemala grass).....35
Picture 16: Brachiaria ruziensis Syn: Urochloa ruziziensis.....36
Picture 17: Pennisetum clandestinum Syn: Cenchrus clandestinus.....38
Picture 18: Chloris gayana (Rhodes grass) 40
Picture 19: Andropogon gayanus (Gamba grass): Itete.....42
Picture 20: Cynodon dactylon (bahama grass, bermuda grass) 43
Picture 21: Digitaria decumbens Syn: Digitaria eriantha.....45
Picture 22: Eragrostis curvula Syn: E chloromelas; E robusta; E subulata.....47
Picture 23: Hyparrenia rufa (jaragua grass): Umukenke 49

Picture 24: *Themeda spp: (grader grass, habana grass and kangaroo grass): Igikaranka* 51
Picture 25: Seedling in nursery.....61
Picture 26: *Accacia nilotica*: thorny acacia 65
Picture 27: *Acacia angustissima* or *Acacia boliviana* 66
Picture 28: *Ficus toniingy* (Strangler Fig): Umuvumu 67
Picture 29: *Sesbania sesban* (Egyptian pea, river bean,): Umunyegenyege.....69
Picture 30: Fencing with posts and barbed wires and Woody fencing 77
Picture 31: Live hedges of ficus spp and of bamboo.....77
Picture 32: Dam as source of water in the pasture.....80

Learning Unit 1 – Cultivate fodder crops

Some important definitions in animal feeding

Feeding: Study of feeds consumed by animals or human being. It combines different feeds so that they constitute a balanced ration able to cover animal or human nutrients needs.

Feeds: Natural or artificial nutritional substances having nutritional properties (able to supply energy, protein, minerals, and vitamin) to animal organism. Feed must be free from toxic substances

Pasture: Grassy area where animal such as cow, sheep, goat, can graze.

Fodder plant (forage): Any consumable (edible) non-toxic plant eaten by animals.

Rangeland: Unimproved land that is suitable for the grazing of livestock.

Crop: A plant, especially a cereal, grown to be harvested as food, livestock fodder or for any other economic purpose.

Animal foods classification

Feedstuffs are classified based on chemical composition and nutritional characteristics:

- Dry forages and roughages, eg. Hay, straw, maize cobs
- Pasture, range plants and forages fed green
- Silage
- Energy or basal feeds, eg. Cereals, molasses, cassava flour
- Protein supplements, eg. Fish meal, soybean, cottonseed cake

- Minerals, eg. Common salt, limestone, lake shells,
- Vitamin supplements
- Non-nutritive additives, eg. Anti-oxidants, condiments.

In simple classification of livestock feed, animal feeds are classified into three major groups namely:

- Roughages
- Concentrates
- Feed additives

Roughages

These are bulks feeds of plant origin. They however have low food value content. Roughages include; fodder, silage, hay, pastures.

Roughages enable the proper functioning of the digestive system. Roughages make up the largest portion of the ruminant's diet

Characteristics of roughages

The following are the characteristics of roughages:

- They have high moisture content except hay
- They have high fiber content
- They have low digestibility
- Their feeding value is not known (variable)
- They have low energy and protein content
- They are mainly derived from green fodder, hay and silage.
- They have a low palatability or acceptability.

Categories of roughages

Succulent (green pasture, Guatemala, potato vines, peelings of bananas, sweet potatoes, silage) and dry roughages.

Dry roughages have a low moisture content, high fiber content, low digestibility and nutritive value.

Feeding ruminants on a high amount of roughages leads to high acetic acid concentration. This is important in the synthesis of milk butter fat content (BF)

Concentrates

These are commercially prepared feeds usually rich in food value and energy.

Concentrates can be made from grains and grain by-product such as maize bran, a mixture of blood and bones, the oil-extracting factories where cotton and groundnut seed residues are obtained. Sugar refineries are also source of molasses which too, are used as ingredients.

Concentrates are characterized by:

- High food value both in energy and protein,
- Low moisture content
- High digestibility,
- Highly palatability,
- Their feeding value is fairly constant (known),
- Low fiber content,
- Originate from both plants and animals.

Classification of concentrates

Concentrate are classified as follows:

- Protein concentrates
- Energy concentrates
- Mixed concentrates

Table 1: Classification of concentrate feeds

Protein concentrates	Energy concentrates	Mixed concentrates
Cotton seed cake	Molasses	Starter mash
Fish meal	Maize grain	Grower's mash
Groundnut cake	Maize bran	Layer's mash
Skimmed milk	Wheat bran	Broiler finisher mash
Condemned meat	Barley	Dairy meal
Blood meal	Sorghum	Sow and weaner meal
Soybean/ soybeanmeal	Rice bran	
Sunflower cake	Rice polishing	
Dried brewers yeast	Cane molasses	
Dry poultry waste	Fats and oils	

Feed additives

Feed additive is any intentionally added ingredient not normally consumed as feed by itself, whether or not it has nutritional value, which affects the characteristics of feed or animal products.

Feed additives are in form of growth hormones, antibiotics, wormicides and flavourings.

Importance of feed additives:

- Antibiotics are added to feeds and water to protect animals against disease outbreaks e.g penicillin.
- Wormicides control internal parasites such as tape worms
- Mineral licks provide minerals to the animals,
- Vitamins supplements are contained in most ingredients used when mixing mineral feeds.
- Flavourings improve palatability and intake of feed.
- Growth hormones e.g thyroxin,

L O 1.1– Identify fodder crops

Fodder crops are high yielding, high quality crops grown specifically for providing feed in intensive livestock grazing systems.

Forage crops produce much higher yields than natural forages and because they produce high yields.

Importance of fodder crops

- Pastures and fodder crops are the cheapest form of animal feed available (in term of quantity and quality).
- They provide a way of introducing farmers to the concept of improved livestock nutrition
- They provide a large quantity of high quality and palatable fodder within a short time.
- They are easy to grow; the husbandry requirements are similar to other crops that are familiar to the farmer.
- Pastures and fodder, particularly the leguminous types, improve soil fertility through their ability to fix nitrogen.
- If well managed, planted pastures help control soil erosion.
- Pasture seed production and sale of excess fodder can be a good source of income.

Limiting factors causing low fodder crops production

The major problems and limiting factors causing low fodder crops production are:

- small land area under fodder crops cultivation
- cultivation of low yielding fodder crops
- common use of traditional practices
- lack of research based knowledge on fodder production and management
- poor soil fertility and poor irrigation practices
- low rainfall and draught conditions
- loss from insects, diseases and weeds
- limited use of chemical fertilizer
- Lack of quality and improved fodder seeds crop rotations and overgrazing pastures.

The fodder crops are grouped into **two main families:**

- Family of grasses/graminaceae plants
- Family of legumes /leguminous plants

- Content/Topic 1: Types and characteristics of common fodder crops Legumes/Leguminous plants

A. General characteristic of fodder crops Legumes

Plants in the Leguminosae family have a characteristic of leaves and pods that help identify them as legumes:

- The leaves are usually alternate and compound.
- They may be pinnate or trifoliate.
- All legumes have similar fruits, called `pods'.
- Within the Leguminosae, particular subfamilies and species can only be distinguished reliably by an examination of their flowers.
- The legumes provide high protein to the livestock and improve soil fertility by nitrogen.

B. Examples of the most popular fodder crop legumes

B.1. Desmodium (Umuvumburankwavu)

B.1.1. *Desmodium uncinatum (Silverleaf Desmodium)*

Morphological description



Inflorescence an open terminal or axillary raceme (cv. Silverleaf)

Robust perennial herb or subshrub with trailing, non-twining stems ascending to about 1 m at flowering; image with *Setaria sphacelata*, S. Qld, Australia (cv. Silverleaf)

Picture 1: *Desmodium uncinatum* (Silverleaf Desmodium)

Robust perennial herb or subshrub with trailing, non-twining stems to several meters long, radiating from a stout rootstock and ascending to about 1 m at flowering.

Leaves trifoliolate, petiole 2 - 6 cm long, densely uncinate-pubescent.

Inflorescence a fairly open terminal or axillary raceme (10-) 20 - 40 (-50) cm long, sometimes branching at lower floral nodes; flowers borne singly or in groups of 2 (- 4).

Pods falcate 10 -50 mm long, lower suture deeply constricted, upper suture smooth, thickened; comprising 3 - 8 (-12) segments,

Seeds mainly light brown with mixture of olive-green to cream, 200,000–220,000/kg in cv. Silverleaf.

Establishment

D. uncinatum is usually planted from seed into a well-prepared seed bed, but has been sod-seeded into herbicide-treated pasture. Seed should be inoculated with specific 'Desmodium' group rhizobium, particularly in more acid soils. Seedling establishment is initially slow, but the established legume starts to grow soon after the cool season.

Fertilization

High levels of fertility are needed for satisfactory growth and P, S, K and Mo may need to be applied before sowing and as maintenance.

Compatibility (with other species)

Silverleaf is usually grown with grasses that are also cold-tolerant, for example *Setaria sphacelata*, although it can combine with other tussock species. It has be grown with creeping grasses but does not persist under heavy grazing.

Pests and diseases

Silverleaf in Australia suffers from the root-chewing larvae of the weevils *Amenmus quadrituberculatus* and *Leptopius spp.* (Coleoptera: Curculionidae). It is susceptible to 'legume little-leaf disease' caused by phtoplasma infection by leafhopper (Hemiptera: Cicadellidae) vectors on individual plants. The degree of infection varies from year to year, but generally results in a fairly minor loss of production.

Uses/applications

Used as Forage and sown as the legume component in permanent mixed pastures for grazing. It can be made into hay or incorporated into silage to improve the protein content.

Production potential

Legume yields of 4–7 t/ha and legume/grass yields of 15 t/ha DM have been recorded.

The annual live weight gain from grazed *D. uncinatum* - grass pastures averaged some 340 kg/ha. The presence of *D. uncinatum* in a mixed sward with *Chloris gayana* resulted in similar or slightly greater live weight gain to that obtained from animals grazing only nitrogen-fertilized *Chloris gayana*.

B.1.1. *Desmodium intortum (Greenleaf Desmodium)*

Morphological description



Early flowering stage (cv. Greenleaf)



Leaflets usually ovate-acute, with dark spots on the upper surface (cv. Greenleaf)

Picture 2: *Desmodium intortum* (Greenleaf Desmodium)

Trailing, scrambling perennial herb or subshrub with strong taproot. Stems 1.5 - 4.0 mm diameter.

Leaves pinnately trifoliolate; stipules 2 - 6 mm long, usually recurved, often persistent; petiole 3 - 5(- 9) cm long.

Racemes terminal or axillary, to 30 cm long; rachis with dense appressed to spreading hooked hairs, 2-flowered at each node; corolla pink, purplish red to violet becoming bluish or greenish white, 9-11 mm.

Pod narrowly oblong, 15-50 mm × 3-4 mm, densely covered with short, brownish hooked hairy, up to 12-articulate, breaking up at maturity.

Seeds reniform, pale brown, about 2 x 1.5 mm. 300,000 - 830,000 seeds/kg depending on provenance

Establishment

Greenleaf desmodium has small seed resulting in slow seedling growth. It is usually established into a prepared seedbed, but it can be planted vegetatively from rooted cuttings. Oversowing seed into established pasture is not reliable because of slow seedling growth. Seed should be inoculated with specific rhizobia prior to sowing.

Fertilization

It requires at least moderate levels of fertility, and phosphorus, sulphur, potassium and molybdenum may need to be applied.

Compatibility (with other species)

Combines well with tussock and stoloniferous, grasses and will climb over small scrubs. Because it is adapted to cooler climates, it is often grown with subtropical grasses, e.g. Setaria.

Pests and diseases

Stands in Australia have been severely attacked by the root-eating Amnemus weevil (*Amnemus quadrituberculatus* Coleoptera: Curculionidae), that will also eat the leaves. Leaf fungus can affect stands under high rainfall conditions, especially in Central America. *D. intortum* largely resists legume little-leaf disease except under very wet conditions. Meloid beetles (Coleoptera: Meloidae) eat the flowers.

Uses/applications

Used as Forage for dryland and irrigated long-term pastures, requiring careful management for longer-term persistence. It is also used for conservation as hay and silage, and for cut-and-carry systems.

Production potential

DM yields of 12–19 t/ha have been recorded. LW gains have exceeded 500 kg/ha/yr off grass legume pastures using *Megathyrsus maximus* or *Digitaria eriantha*.

B.2. *Medicago sativa* (Lucerne or Alfalfa): Ruzerine

Morphological description



Leaves trifoliolate, leaflets narrow, oblong to ovate or obovate (cv. Trifecta)



Inflorescences in dense racemes with 10 –35 flowers

Picture 3: *Medicago sativa* (Lucerne or Alfalfa): Ruzerine

Herbaceous perennial with deeply penetrating taproot. Stems procumbent, ascending to erect, arising from a woody base, 30–80 (–120) cm long.

Leaf trifoliolate; stipules triangular, 5–15 mm long; pubescent on lower surface, glabrous on upper surface, coarsely toothed; petiole pubescent, 5–30 mm long, leaflets narrow, oblong to ovate or obovate. Inflorescences in dense racemes with 10–35 flowers, on peduncles 1–5 cm long; pedicel 1.5–2 mm long; corolla purple or blue, rarely white.

Pod curled, 3–10 mm in diameter, indehiscent, not spined, containing 2–6 seeds.

Seeds yellow to brown, kidney-shaped to ovoid, 1–2.5 mm × 1–1.5 mm. 240,000–500,000 seeds per kg

Establishment

Lucerne should be established in a fine, firm and weed-free seedbed. Sowing rate depends on what the stand will be used for; pure swards under irrigation should be sown at 12–15 kg/ha, dryland pure swards at 4–8 kg/ha and mixed swards for grazing at 1–3 kg/ha.

Fertilization

Lucerne needs medium to high fertility soils with a neutral to moderately alkaline pH for optimum production. Potassium, phosphorus and sulphur levels need to be maintained at the following levels: K, 0.3 meq/100 g; P, 25 mg/kg; and S, 10 mg/kg. The plant's nodules should satisfy nitrogen requirements if inoculation is effective. Aluminium toxicity can occur on soils with pH of lower than 5.5.

Compatibility (with other species)

Lucerne is compatible with tropical grasses under rain grown conditions, especially in drier environments (<600 mm). In higher rainfall areas, disease and grass competition limit its life span to 1–2 years. Lucerne is compatible with temperate grasses, especially prairie grass (Bromus spp.), under irrigation.

Pests and diseases

Lucerne is susceptible to an extremely large range of pests and diseases in warm climates. Phytophthora root rot, anthracnose and other crown rots, rhizoctonia and the leaf diseases (stemphylium and pepper spot) are the most serious diseases. Spotted and blue green aphids, jassids and leaf roller are the most damaging pests. Considerable breeding effort has gone into improving the pest and disease resistance of current lucerne cultivars.

Uses/applications

Used as Forage, M. sativa was one of the first forage crops to be domesticated. It is used as multi-purpose high protein forage in both grazing and conservation (hay, silage, meal and forage dehydration) systems.

Production potential

Under irrigation, lucerne is capable of producing 25–27 t/ha dry matter in the first year of a stand and this can fall to as little as 8–15 t/ha by the third year.

When green feed is available, daily live weight gains for beef cattle will be around 0.7 kg/head/day compared with 1 kg/head/day on oats, improved tropical pasture and native pasture. This reduced weight gain is a result of the lower energy availability.

Supplementing dairy cows grazing tropical grasses with lucerne can raise milk production from 10–12 to 14–15 L/cow/day. This can increase to 20 L/cow/day if the cows are further supplemented with grain to combat the energy deficiency. Sheep numbers can be increased from 6 to 15/ha by supplementing native pasture with lucerne. Irrigated lucerne can carry more than 80 dry sheep equivalents/ha from October to May.

B.3. *Macroptilium atropurpureum (Siratro)*

Morphological description



Inflorescence a raceme comprising 6-12 often paired flowers on a short rachis



Minimal lobe development on cvv. Siratro and Aztec

Picture 4: *Macroptilium atropurpureum* (Siratro)

Morphological description

Perennial herb with deep, swollen taproot and trailing, climbing and twining stems. Stems at the base of older plants fibrous, >5 mm diameter; younger stems mostly 1–2 mm diameter

Leaves trifoliolate; leaflet blades 2–7 × 1.5–5 cm, darker green and finely hairy on the upper surface, grey-green, pubescent on the lower surface, with leaf margins sparsely to densely and finely ciliate.

Inflorescence a raceme comprising 6–12 often paired flowers on a short rachis; peduncle 10–30 cm long. Flower: corolla with conspicuous wings 15–17 mm long, deep purple with reddish tinge near base; standard smaller than wings.

Pods straight, linear-cylindrical, acuminate-beaked, pubescent, 5–10 cm long, 3–5 mm diameter, containing up to 12 (–15) seeds.

Seeds flattened ovoid, 4 × 2.5 × 2 mm, speckled, light brown to black. 75,000 seeds per kg.

Establishment

Seed is best sown at 1–2 (–5) kg/ha into a well-prepared seedbed. Seedlings are vigorous and can also establish with minimal cultivation, into herbicide-killed grass, or following a burn.

However, the less competition for the developing seedling, the better the establishment. *M. atropurpureum* has a broad symbiont range for nodulation, and can nodulate effectively on native rhizobia in most soils.

Fertilization

Additional phosphorus may be required at establishment (20–30 kg/ha P), and for maintenance (10–20 kg/ha/yr P) on soils with less than about 8 ppm available phosphorus. Siratro is responsive to molybdenum, requiring 100–200 g/ha Mo at establishment on deficient soils, and 100 g/ha Mo every 4–5 years as maintenance.

Compatibility (with other species)

Combines best with erect or tussock grasses, and legumes requiring similar grazing management. It is less compatible with aggressive creeping grasses such as *Paspalum notatum* and *Digitaria eriantha* (pangola).

Pests and diseases

During periods of high rainfall and high humidity, foliar blight caused by *Rhizoctonia solani* can reduce leaf yields by 80%. Plants recover with a return to dry conditions. Bean rust (*Uromyces appendiculatus* var. crassitunicatus) gives rise to many brown pustules on the leaves of susceptible varieties, leading to severe leaf drop and pasture quality decline.

Uses/applications

Used as Forage and mainly used for permanent and short-term pastures. While best suited to grazing, it can also be used for cut-and-carry or conserved as hay (usually with an associated grass), although the twining habit can make harvesting difficult. Its value as a protein bank for dry season feeding is reduced by its tendency to drop leaf under very dry conditions.

Production potential

DM yields are mostly in the range of 5–10 t/ha/yr, although yields are lower under more regular defoliation or grazing.

LWG/ha is good at medium stocking rates but yields/ha are moderate because of legume decline and loss at high stocking rates. In subtropical E Australia, annual LWG improved from 100 kg/hd to 140–200 kg/hd

and from 30 kg/ha/yr to 170 kg/ha/yr when native pasture of *Heteropogon contortus* was replaced with *Cenchrus ciliaris and* 'Siratro'.

B.4. *Centrosema pubescens, Syn: Cenrosema molle* (centro or butterfly-pea)

Morphological description



Pale lilac flowered form



Trailing, climbing and twining perennial

Picture 5: *Centrosema pubescens, Syn: Cenrosema molle* (centro or butterfly-pea)

Perennial, trailing-climbing-twining herb with strong taproot system; under appropriate soil moisture conditions able to root at nodes of trailing stems. Stems slightly hairy, becoming woody when old.

Leaves trifoliolate, leaflets elliptical, ovate-oblong or ovate-lanceolate, 1–7 cm long, 0.5–4.5 cm wide, rounded at the base and mostly acuminate at the apex, slightly hairy, especially on the lower surface;

Inflorescence an axillary raceme with 3–5 papilionate flowers, light to dark lilac in colour, sometimes white

Pod linear, compressed, 4–17 cm long and 6–7 mm broad, straight to slightly bent and beaked, with prominent margins, dark brown when ripe and containing up to 20 seeds.

Seeds transversely oblong to squarish with rounded corners, 4–5 mm × 3–4 mm × 2 mm in size, brownish-black, mostly with dark mottles; approx. 40,000 seeds/kg.

Establishment

Seeding rate: 3–5 kg scarified seed/ha or more, e.g., when broadcast; full seedbed preparation recommended, sod-seeding also possible. Slow to establish but on good soils, under appropriate moisture conditions and in pure stands, forming a 40–50 cm thick ground cover 4–8 months after sowing.

Fertilization

With effective Bradyrhizobium strains (e.g. CB 1923 and 2947), nitrogen fixation estimates 70–280 kg/ha/year in grazed mixtures with grasses; sensitive to P, K, Ca, Mo deficiency.

Compatibility (with other species)

Quite compatible depending on management (i.e., proper fertilization and stocking); e.g., persisted in the humid tropics of Australia for more than 11 years in mixture with *Megathyrsus.*

Pests and diseases

Relatively insensitive, but can be affected by Cercospora leaf spot, anthracnose, Rhizoctonia foliar blight, red-spider mites.

Uses/applications

Used as Forage. In grazed pastures in mixture with grasses or as legume-only protein bank; also as cut-and-carry forage, mainly for fresh consumption.

Production potential

In pure stands, up to 12 t DM/ha/year possible; in mixed pastures, 1–3 t/ha/year.

260–600 kg/ha/year LWG reported for mixtures with a grass (e.g., *Megathyrsus maximus*; with daily LWG of 400–600 g/animal under proper grazing management; carrying capacity in the humid tropics can be 900–1,000 kg LW/ha

B.5. *Mucuna spp , M. pruriens* (Velvet bean) Mucuna

Morphological description



Vigorous annual (sometimes biennial), twining herb; lateral leaflets conspicuously asymmetrical



Inflorescence a many-flowered, pendulous axillary raceme, Laos

Picture 6: *Mucuna pruriens* (Velvet bean) Mucuna

Vigorous annual (sometimes biennial), twining herb, stems extending to 18 m in length.

Leaves trifoliolate; lateral leaflets 7–15 (–19) cm long, 5–12 cm wide.

Inflorescence a many-flowered, pendulous axillary raceme 15–35 cm long; flowers white, mauve or dark purple; standard 1.6–2.5 cm.

Pods oblong, 4–13 cm long, 1–2 cm wide, usually more or less sigmoid in shape, finely pubescent with white to light brown hairs.

Pods contain up to 7 oblong-ellipsoid seeds, 1–1.9 cm long, 0.8–1.3 cm wide, 4–6.5 mm thick and of variable colour (black, maroon, creamy, white, grey, beige, brown, and mottled), hilum surrounded by a prominent, cream-coloured aril. 1,200– 1,800 seeds per kg.

Uses/applications

Used as Forage. Velvet bean is primarily used as a green manure, but also as cut-and-carry forage, and can be conserved as silage and hay. The seeds can be used as concentrate feed. It has been successful in cut-and-carry systems in eastern and southern Africa (e.g. Uganda, Malawi and Zimbabwe), and usage is rapidly increasing.

Establishment

Does not require a high degree of land preparation. Best results are with drilling with an arrangement of about 1 m between rows and 20–80 cm between plants (20–40 kg/ha seed); seeds are large and so seeding depth can be as deep as 10 cm but mostly 3–7 cm. Seed does not require scarification or inoculation with rhizobia prior to planting.

Fertilization

Despite its ability to grow on soils with low available soil Phosphorus, Mucuna responds to phosphorus applications. There are also reports of responses to applications of lime on acid soils either from amelioration of pH or from Mg and Ca applications.

Compatibility (with other species)

Velvet bean is very vigorous and its growth suppresses companion species. If grown in interrow cropping systems, it should be sown well after the other crop such as maize, as much as 45 days after, to overcome this competition. Sowing two weeks after maize results in a good mix for silage.

Pests and diseases

Few problems with insect pests, likely due to toxic compounds.

Production potential

Mucuna has high DM production. Yields range from 5 to 12 t/ha depending on rainfall. Mucuna can produce high yields even in soils with marginal or even low available phosphorus.

Tried mainly for protein supplementation in bovines, sheep and goats. As an example, a daily liveweight gain of 60 g/animal compared with 44 g with commercial concentrates has been obtained with sheep.

Also, velvet bean hay has been successfully substituted for dairy concentrates without decline in milk yield or quality and has been recommended for this purpose.

B.6. *Trifolium spp* (clover): Urizi

Morphological description



T. decorum, an herbaceous annual with glabrous stems ascending to 50 cm tall (CPI 100016)



T. mattirolianum large globose many flowered inflorescence (APG 63683)



T. usambarense inflorescence and leaves; leaflets cuneate-oblanceolate (P

Picture 7: *Trifolium spp* (clover): Urizi

Herbaceous annual to 50 cm tall, stems ascending, glabrous.

Leaflets ovate to suborbicular, 30–45 × 18–28 mm, narrowed towards base and with finely toothed margins, especially in the upper part. Petioles up to 120 mm long on lower leaves, upper leaves short-stalked.

Inflorescences almost round 15–25 mm diameter, 6–15-flowered, long pedunculate of 20–60 mm borne in the axils of leaves. Corolla purple, 10–14 mm long, twice as long as calyx or more, standard slightly longer than the wings and keel.

Pods 6 mm long and 3-5 seeded. Seeds oval, brown and usually 1.5 × 2 mm.

Establishment

While most are usually sown at 1–2 kg/ha, *T. tembense* is sown at 5–6 kg/ha. Seeds are hard and require scarification before planting to ensure uniform germination. Seedbeds should be well prepared to a fine, firm tilth. Seeds are best sown just below the surface, lightly covered and rolled. Seeds can also be sown directly into grass stubble, with no further seedbed preparation, and covered using a roller or by light disking. Germination occurs in about 5–7 days and young seedlings can be observed about 2 weeks after planting.

Fertilization

Fertilizer (di-ammonium phosphate: DAP) is generally recommended when grown on poor soils at a rate of 25–30 kg/ha P with large dry matter yield increases seen in response to P application on poorer soils. The application of 30 kg/ha P can lead to a significant increase in root weight and the number of nodules in *T. rueppellianum, T. steudneri* and *T. tembense*.

Compatibility (with other species)

Annual clovers combine well with other annual clovers and short-growing grasses. When grown together with *T. quartinianum*, grasses were reported to accumulate more dry matter, crude protein.

They have been used successfully for intercropping with wheat and barley without significant reductions in grain and straw yields.

Pests and diseases

Under cool damp conditions seedlings are sensitive to damping-off disease, mainly caused by the soil-borne fungal pathogen *Pythium spp*., which results in rapid seedling death. Plants are susceptible to red spider mites (*Tetranychus urticae* Acarina: Tetranychidae) when grown in the greenhouse or shade areas. *T. rueppellianum* is susceptible to root-knot nematode, *Meloidogyne incognita*.

Uses/applications

Used as Forage, The East African annual *Trifolium spp*. are considered to make a valuable contribution in native pasture grazing systems, with potential for use as annual legumes for pasture improvement in high altitude areas. They can be used for intercropping with wheat or barley in tropical highlands to improve quality of residues for livestock feed, and can also be used for hay and silage production.

Production potential

In general, at least 1,000 mm rainfall is needed for high forage production. Yields are variable and dependent on soil temperature, rainfall, fertility and genotype. T. decorum can commonly produce annual dry matter yields of 3–4 t/ha (and up to 6 t/ha with application of 40 kg/ha P).

T. decorum, T. steudneri and *T. tembense* forage have been shown to be beneficial for dairy and beef cattle, and for horses. Hay containing 30% *T. tembense* increased milk yield by around 10%. Care should be taken not to use these as the sole feed to avoid bloat.

B.7. *Glycine javanica Syn. Neonotonia wightii* (glycine or perennial soybean or wild soybean) Umurangagashi

Morphological description


Leaves pinnately trifoliolate


Inflorescence a dense or lax (open) axillary raceme

Picture 8: *Glycine javanica* Syn. Neonotonia wightii

Trailing, climbing, or twining perennial with strong taproot, and woody base to 25 mm diameter in advanced plants, climbing to 10 m on appropriate framework (e.g. trees). Herbaceous stems slender (mostly 2–3 mm diameter).

Leaves pinnately trifoliolate; leaflets elliptic, ovate, or rhombic-ovate, acute to obtuse, 1.5–15 cm long, long and 1.3–12.5 cm wide.

Inflorescence axillary, dense or lax racemes, 2–35 cm long on peduncles 3–12.5 cm long, comprising 20–50 flowers; flowers 4.5–11 mm long, standard white to mauve-blue, sometimes with obscure small violet streaks on lower part, yellow to orange on senescence.

Pod brown, linear-oblong, straight or slightly curved at the apex, transversely grooved and weakly septate between the seeds, glabrous to densely pubescent with grey to reddish brown hairs, 1.5–4.0 cm long and 2.5–5 mm wide, containing 3–8 seeds, shattering at maturity.

Seeds oblong with rounded corners, laterally compressed, olive-green to light- to dark- and reddish-brown, occasionally mottled, aril white, 2–4 mm long, 1.5–3 mm wide and 1–1.5 mm thick; 50,000–170,000 (–330,000) seeds per kg.

Establishment

Seed can be broadcast onto the surface of a well-prepared seedbed, or drilled to to a depth of 1–2 cm at seeding rates of 1–5 kg/ha, and rolled with a heavy roller.

Germination is best at moderate temperatures, and declines markedly above 37 °C. Seedlings are initially slow, but vigour improves with the development of effective nodulation. With good conditions, ground cover can be achieved by about 2 months from sowing.

Fertilization

N. wightii requires fertile soil, and deficiencies or toxicities must be corrected for a productive stand. Main nutrients to consider are calcium, phosphorus, sulphur and molybdenum. On very fertile soils, no fertilizer may be required, but as a guide, a suitable establishment dressing is 40 kg/ha P together with 200 g Mo (= 600 g Mo trioxide or 300 g of Na molybdate). Follow-up dressings of 20 kg/ha P every 1 or 2 years, and 100 g/ha Mo every 3 years may be necessary. Need for copper should be monitored in areas of known Cu deficiency, since Mo and Cu are antagonistic

Compatibility (with other species)

The slow seedlings can be smothered by initial grass or weed growth if steps are not taken to reduce this competition. Cutting or grazing to about 15 cm every 9 weeks helps to minimise competition.

Pests and diseases

Generally few problems with pests and diseases. Under very wet conditions, leaf blight caused by *Rhizoctonia solani* can cause severe leaf damage. A leaf spot (Cercospora sp.), sclerotinia rot (Sclerotinia sclerotiorum) and another disease caused by *Synchytrium dolici* producing small yellow rust spots on the leaves and stems have also been recorded. Rust (*Phakopsora pachyrhizi*) is sometimes found on mature leaves but is not a problem in grazed stands where there is a regular turnover of leaves.

Uses/applications

Used as Forage, *N. wightii* cultivars have formed the legume base for warm season pastures in the subtropics and upland tropics for a number of decades. Pasture for grazing, cut-and-carry, and standover; makes good hay and silage. Suitable for open pasture or agroforestry, although the twining habit can lead to distorted growth in coppice and young trees.

Production potential

Dry matter yields vary according to soil and environmental conditions, and with variety and defoliation management. They generally range from about 3 to 8 t/ha/yr DM, and rarely to 12 t/ha.

Experimental data provide unrealistically low estimates of the value of *N. wightii* or compare different systems. Commercial dairy and beef producers have judged it favourably and continue to plant it.

B.8. *Cajanus cajan* (Angola pea, cajan, Congo pea, pigeonpea) :umukunde

Morphological description



Inflorescence an axillary, rarely terminal panicle (pseudo-raceme).



Young stems angled and pubescent; leaves pinnately trifoliolate

Picture 9: *Cajanus cajan* (Angola pea, cajan, Congo pea, pigeonpea): umukunde

An erect woody, annual or short-lived perennial shrub or small tree, 1–4 m tall with a deep taproot (to 2 m). Young stems are angled and pubescent.

Leaves pinnately trifoliolate, alternate, set in a spiral around the stem; leaflets elliptic to lanceolate, acute, 2–10 cm long and 1.5–4 cm wide, green, velvety pubescent above, greyish-green pilose beneath, both surfaces glandular.

Flowers usually yellow, sometimes with purple or red streaks or plain red; calyx velvety pubescent and glandular, 10–12 mm long with 5 linear teeth; standard 1.2–1.7 cm in diameter.

Pods acuminate, 4.5–10 cm long, 8–14 mm wide, 3– 4 mm thick, pubescent and glandular, containing 2–9 oval to round seeds varying in colour from light beige to dark brown. 16,000–18,000 seeds/kg.

Establishment

In most developing countries pigeonpea is grown as an intercrop with cereals or legumes, which are harvested to avoid competition before the pigeonpea flowers and sets seeds. Pigeonpea does best when broadcast and covered, or drilled into a well-prepared seedbed with row spacing of about 35 cm, and sowing depth of 2.5–10 cm. Sowing rates range from 0.5 to 4 kg/ha and between 5 and 7 kg/ha under irrigation.

Fertilization

Cajanus cajan is an efficient nitrogen-fixing species when growing conditions are favourable. While low inputs of nitrogenous fertilizer (20–25 kg/ha N) are recommended for pulse production, it is not a recommended practice if sown for forage and applications of 17–26 kg/ha P can increase seed yield by 300–600 kg/ha. Applications of 2–4 ppm zinc as 0.5% zinc sulphate with 0.25% lime have been effective to overcome zinc deficiencies.

Compatibility (with other species)

As a forage shrub, pigeonpea can be inter-planted with grasses. Tall late flowering varieties are commonly grown as a food grain crop intercropped with sorghum or millet in the semi-arid tropics. Has grown well with *Chloris gayana* and been planted into pangola grass (*Digitaria eriantha*).

Pests and diseases

Some of the more common insect pests are the pod borer (*Helicoverpa armigera*), legume pod borer (*Maruca testulalis*), pod fly (*Melanagromyza spp.),* blister beetle (*Mylabris spp.),* pod bug (*Clavigralla spp.),* plume moth (*Exelastis atomosa*) and blue butterfly (*Lampides boeticus*). Pigeonpeas are susceptible to Fusarium wilt especially on wet soils. They are also infected by numerous other fungal, viral and bacterial diseases of leaf and stem, as well as by a range of soil nematodes.

Uses/applications

Used as Forage, Foliage can be browsed but branches are brittle and inclined to break as animals pull the leaves. Foliage may also be cut and fed to livestock fresh or conserved.

Production potential

In semi-arid conditions in the drylands of Africa, fodder yield is usually in the order of 2 t/ha. However, DM yields may be up to 25 t/ha and may reach up to 40 t/ha with 100 kg/ha N under optimal conditions. Leaves remain on the plant under dry conditions. Good yields of wood for fuel although calorific value is low. The crop is best cut for forage when the first pods begin to ripen, or alternatively at the pre-flowering

stage. To obtain good regrowth, plants should be cut high, at 50–75 cm in taller varieties, allowing them to regrow to 150 cm before the next harvest

Cattle on pigeonpea pasture gained 0.7–1.25 kg/day at carrying capacity of 1–3.75 cattle/ha, with liveweight gains of 200–500 kg/ha/yr.

B.9. *Leucaena leucocephala (leucaena; wild tamarind, lead tree, jumby bean; white popinac) Rusena*

Morphological description



Capitula borne singly or in pairs in leaf axils



Windbreak plants in Western Lowlands, Eritrea

Picture 10: *Leucaena leucocephala* (leucaena; wild tamarind, lead tree

Deep-rooted shrub or tree 2–6 (–20) m tall; form varies from shrubby and highly branched (ssp. leucocephala) to arborescent with a short clear bole to 5 m, upright angular branching and an open, rounded crown.

Leaves alternate, to 35 cm long, paribipinnate with (3–) 6–10 pairs of pinnae 2– 10 cm long.

Flowers white to pale cream; calyx c. 3 mm, glabrous at base, puberulent at apex, 5-toothed; petals narrowly oblanceolate.

Pod 3–20 (–45) per capitulum, linear-oblong, acute (beaked) or rounded at apex, attenuate at base, 9–19 (–26) cm × 1.5–2 cm, pendant, glabrous or puberulous, brown at maturity, bearing (8–) 18–25 seeds/pod, dehiscing along both sutures.

Seeds are ovoid, flat, 6–10 mm long, 4–6.3 mm wide, brown. 15,000–20,000 seeds per kg.

Establishment

For best results plant on deep, well-drained soils with pH >5.5 and maintain a weed-free area of at least 2 m either side of the establishing plants. Seed must be scarified to break the impermeable testa.

Complete cultivation is recommended in extensive plantings. Planted into rows 4–9 m apart at seeding rates of 1.5–3.0 kg/ha. Post-plant herbicides such as bentazone and imazethapyr can be used to control weed seedlings in the rows. Rolling cultivators can be used to control very young weed seedlings and break soils crusts after emergence of leucaena seedlings. Seedlings can also be raised in beds and removed for planting as bare-rooted seedlings if 'topped and tailed'.

Fertilization

Normally not fertilized under rain-grown conditions. Starter N and P may be used when establishing into depleted soils on cropping lands. Leucaena in Australia has occasionally responded strongly to added sulphur. On acid-infertile soils it is essential to add lime, P and K at planting and after each cut.

Compatibility (with other species)

Compatible with a range of grass species. Can be difficult to establish leucaena into existing grass pastures without complete grass control or clean cultivation. Normally grown as a hedgerow with grasses or crops grown between hedgerows. Can be grown as a sole species as a protein bank.

Pests and diseases

Main insect pest is the psyllid, *Heteropsylla cubana*, a small aphid-like sucking insect that reduces production of all L. leucocephala cultivars and accessions. Psyllid population outbreaks are generally episodic, occurring when climatic conditions are conducive.

A range of pathogenic fungi and insects occasionally attack *L. leucocephala*.

Damping-off diseases caused by the fungal species *Pythium or Rhizoctonia* commonly kill newly emerged nursery and field-grown seedlings. The soft scale (*Coccus longulus Hemiptera*: Coccidae) attacks the tall stems of *L. leucocephala* causing a reduction in productivity.

Uses/applications

Used as Forage. Highly valued as ruminant forage either as browse in pastures and/or protein banks or cut-and-carry.

Production potential

Yields of forage vary with soil fertility, rainfall, altitude, density and cutting frequency from 1 to 15 t/ha/year. Leaf yield is maximized by cutting at 6–12 week intervals during the growing season.

Fuelwood yields compare favourably with the best tropical trees, with height increments of 3–5 m/year and wood increments of 20–60 m^3/ha/year for arboreal varieties.

Excellent growth rates of 1.26 kg/head/day for cattle grazing leucaena-buffel grass (*Cenchrus ciliaris*) pastures over a 6-month period were reported, although growth rates are more commonly 250–300 kg/head/year (0.7–0.85 kg/head/day). Under irrigation, annual liveweight gains of up to 1,700 kg/ha/year have been recorded for cattle grazing at 6 head/ha.

B.10. *Calliandra spp.* (calliandra, powderpuff tree, red calliandra): Kariyandara

Morphological description



Thornless, multi-branched shrub or small tree



Bipinnate leaves with mostly 15-20 pairs of pinnae, each with 19-60 pairs of pinnules

Picture 11: *Calliandra carothyrsus*

Shrub or small tree, (2–) 5–6 (–12) m high, dense canopy; evergreen in humid climates and semi-deciduous in areas with long dry season. Trunk to 20 (–30) cm diameter, bark white-reddish brown bark; stems thornless.

Leaves bipinnate, alternate; rachis 10–20 cm long.

Inflorescence a terminal paniculate raceme with flowers opening acropetally borne in umbelliform clusters with thickened and raised margins, finely pubescent or brown and dehiscing elastically from the apex when mature, 8–12 seeded.

Seeds ellipsoid, flattened, attenuate to the base and sharply acute at the apex, shiny, dark brown, sometimes mottled. 14,000–17,000 seeds/kg.

Establishment

Seed requires scarification. Use scarified seed planted at 1–3cm depth or seedlings raised in nurseries when the plants are 20–50cm tall. Seedlings can be planted 0.5–1.0 m apart in hedgerows spaced 3–4 m

apart, or in fodder banks spaced 0.5–1.0 m apart in a grid pattern. Attention to early weed control will shorten the establishment period. Although promiscuous in its Bradyrhizobium requirements, calliandra may benefit from inoculation in new areas. Early growth is slow. Once the species is mycorrhizal, growth is vigorous and the tree reaches a height of 3.5 m in 6 months.

Fertilization

Use of fertilizer on infertile soils will improve early growth, but it is less responsive to fertilizer than some other tree species.

Compatibility (with other species)

Calliandra is not compatible with other species at the seedling stage and should be a sole component of the stand until reasonably developed at which time grasses can be introduced. If the calliandra is planted in rows, the row spacing and defoliation management of the calliandra will determine light availability to the interrow, and hence compatibility of the grass with the calliandra. Shade tolerant grasses may be the best option.

Pests and diseases

Damaging insects include cerambycid and scarabaeid beetles, scale insects, aphids, termites and the larvae derived from various moth families. An undiagnosed problem has appeared with symptoms of poor vigour, dieback, wilting, chlorosis, stunting, premature flowering, and darkening and hardening of the branches. Fusarium and Phomopsis fungi have been isolated from affected plants, but are not necessarily the cause. Bruchid beetles can destroy a high proportion of stored seed if seed is not kept under cold conditions.

Uses/applications

Used as Forage, A multipurpose species grown for high protein forage to supplement low quality roughages for ruminant livestock, primarily in cut-and-carry systems.



Cut forage



Cut forage (Calliandra + Gliricidia), Bali Indonesia

Picture 12: Cut forage of calliandra

Production potential

Produces DM yields of 3–14 t/ha/year, depending on climate and soil fertility.

Generally used to improve the utilization of low quality grasses or as a replacement for concentrate feeds. In goat, Weight gains of 24 g/day were achieved when supplemented with 140 g/day DM of calliandra leaf. Sheep liveweight gains increased from 26 up to 52 g/day when supplementation levels of fresh calliandra leaf increased from 0 to 35% of total ration.

Cattle direct grazing calliandra over a 12-month period in Indonesia gained 0.33 kg/head/day compared with 0.16 kg/head/day from those grazing an Imperata cylindrica control.

Despite the promising early results, calliandra proved unable to withstand direct grazing and experienced 100% plant mortality over a 2-year period.

- Content/Topic 2: Types and characteristics of common fodder crop Grasses/graminaceae plants

A. General characteristics of fodder crop grasses

The large plant family Gramineae (or Poaceae), characterized by:

- Mostly herbacous but sometimes woody plants with hollow
- hallow jointed stems,
- fasciculate roots system,
- Narrow sheathing leaves,
- Petalless flowers borne in spikelets, and
- Fruit in the form of seed like grain.

They are grown to provide livestock feed especially in zero-grazing systems.

B. Examples of the common fodder crop grasses

B.1. *Pennisetum purpureum Syn: Cenchrus purpureus* (Elephant grass, barner grass; bush sugarcane, merker grass, napier grass): Urubingo

Morphological description



Young growth (too early to cut)



Elephant grass (tall type) -too mature for forage



Leafy stage ready for harvest.



Minimum cutting height 15cm; early tiller regrowth

Picture 13: *Pennisetum purpureum Syn: Cenchrus purpureus*

Robust perennial forming large, bamboo-like clumps, spreading by short rhizomes; extensive root system penetrating to 4.5 m. Culms initially erect/geniculately ascending, 2–4 m tall, 1–2 (–3) cm diameter near the base and branched towards the top; outer culms becoming decumbent extending to 7.5 m and developing stolon-like characteristics, forming plantlets and rooting from lower nodes.

Leaf blades green, sometimes purple, linear, 30–120 cm long, 1–5 cm wide.

Inflorescence a bristly spiciform panicle 7–30 cm long, 1.5–3 cm wide (excluding bristles), dense, usually yellow-brown in colour, more rarely greenish or purplish. About 3 million 'seeds' (fertile spikelets)/kg

Establishment

Can be established from seed (no post-harvest dormancy), although plants produced are not necessarily like the parents due to outcrossing. However, Napier grass is almost invariably planted from setts/cuttings

(pieces of cane) or splits (rooted pieces of clump). Setts are taken from the basal 2/3 of moderately mature stems and should contain at least 3 nodes. These are pushed into the soil at 45º, basal end down, with 2 nodes buried. They can also be planted horizontally into a furrow, to a depth of 5–10 cm. Normally planted in rows 0.5–2 m apart, and 0.3–1 m apart within rows, depending on rainfall and cutting management.

Fertilization

Should be planted into fertile soil. Once established, Napier requires, 150–300 kg/ha/yr N, together with other nutrients as indicated by soil tests.

Compatibility (with other species)

Competes vigorously with other species with adequate fertility and moisture. Weeds invade if fertilizer regime relaxed.

Pests and diseases

Napier grass stunt (NGS) disease associated with the 16SrXI phytoplasma (*Candidatus Phytoplasma oryzae*) is by far the most devastating disease of Napier grass.

Napier is also attacked by another phytoplasma associated with African sugarcane yellow leaf (ASYL) disease. Both cause foliar yellowing, small leaves, proliferation of tillers, and shortening of internodes with severely stunted clumps. Often, the whole grass stool is affected with a complete loss in yield, leading to eventual death of the infected plant.

About 70 different fungi are reported to infect *C. purpureus*. The three most serious are eyespot caused by *Helminthosporium spp*, snow mould or white mould caused by *Beniowskia sphaeroidea* and head smut caused by *Ustilago kamerunensis*. The last one is the most damaging causing major productivity losses, but is currrently restricted to the African continent. *Pyricularia grisea* and *P. oryzae* also produce leaf spots on infected plants, although some varieties are resistant.

Also attacked by *Pectobacterium carotovorum*. Pseudo- Fiji Disease, chlorotic streak, a disease of sugarcane, leaf mottle virus and nematode attack by *Aphelenchus avenae*, *Meloidogyne incognita acrita*, *M. javanica* and *Pratylenchus brachyurus* can also lead to reduced performance.

Uses/applications

Used as Forage, Mostly planted for cut-and-carry application, and but not well-suited to long-term grazed pastures. Young growth makes good hay, which can be fed as hay or pellets. Coarse stems in older growth make it unsuitable for hay. Makes good silage if harvested early, although inferior to maize and sorghum.

Production potential

Yields depend on cultivar, soil fertility, moisture, temperature and management. DM yields of 10–30 t/ha/yr are common if the stand is well fertilized, and 2–10 t/ha/yr if unfertilized.

More frequent cuts (up to 45 days) give less dry matter, but better leaf production than infrequent cuts.

As with dry matter, animal production from *C. purpureus* depends on growing conditions (including management) for the grass. Live weight gains of 1 kg/hd/day during the growing season and 480 kg/ha/yr, and milk yields of >11 kg/day (4% fat) are achievable. Capable of carrying 2–7 animals/ha in a grazed system.

B.2. *Setaria sphacelata* (African bristle grass, African pigeon grass, common setaria, dog's tail, golden bristle grass, golden millet): Setariya

Morphological description



S. sphacelata var. *anceps* x *splendida* cv. Splenda



Many tillered tussock growth habit



Leaves folded in bud; leaf sheaths keeled, glabrous



Inflorescences; tightly contracted panicle producing a false spike

Picture 14: *Setaria sphacelata (African bristle grass)*

Perennial tussock; rhizomes short or elongated, culms 20–300 cm tall, erect or decumbent at base, usually branched from the lower and middle nodes; culm-nodes glabrous.

Leaf sheaths keeled, glabrous, the margin hyaline. Leaves bluish grey-green; leaf blades 7–0 (–80) cm long; 3–20 mm wide.

Inflorescence a tightly contracted panicle producing a false spike, 3–30 (–50) cm long and about 8 mm wide (excluding the dense, radiating golden-yellow bristles). Spikelets falling entire when mature. Seeds average about 1.5 million per kg.

Establishment

Fresh seed is dormant and should be stored for at least 2 months before sowing. *S. sphacelata* is normally sown at 2–5 kg/ha.

Var. splendida produces little or no viable seed and is normally planted from rooted tillers; clumps/splits are topped to about 15 cm and separated into pieces each with 2–3 tillers; planting material should be freshly prepared and not allowed to dry out; they are planted with tops exposed on a grid from 70 × 90 cm to 45 × 100 cm.

Fertilization

Normally planted with a basal NPK dressing. Setaria competes strongly for nutrient and potassium uptake is very high; regular applications of K fertilizer may be necessary in low K soils to maintain vigour of the setaria and the associated species. Responds well to nitrogen, producing about 30 kg DM and 3 kg CP per kg N applied.

Compatibility (with other species)

Setaria combines well with legumes if soil fertility, particularly potassium, is maintained, but will suppress legume if not well managed or well fertilized with P and K. N fertilizer increases competitiveness of the grass. *Var. splendida* and 'Kazungula' are more competitive than other cultivars/varieties.

Pests and diseases

Leaf spot caused by *Pyricularia grisea* affects 'Nandi' and 'Narok' under hot, humid conditions but usually not 'Kazungula'. Fungal diseases caused by *Tilletia echinosperma* (bunt) in Kenya and *Sphacelotheca sp.* and *Fusarium nivale var. majus* in DRC can seriously reduce seed crops. The buffel grass seed caterpillar (*Mampava rhodoneura*) can also damage seed crops. Attacked by insects such as army worm (*Pseudaletia convecta* in Australia and *Spodoptera exempta* in Africa) that attack other tropical grasses. Var. splendida is not seriously affected by pests or diseases.

Uses/applications

Used as Forage, Permanent pasture for grazing and is popular among farmers for cut-and-carry systems because of comfort of handling by virtue of the soft foliage and absence of foliar bristles. It ensiles well and finer types are suitable for hay.

Production potential

Annual yields of 4 to about 26 t/ha DM, depending on fertility and moisture. Yields of as high as 31 t/ha have been recorded for *var. splendida* in the wet tropics. While high yields have been recorded from well-fertilized, irrigated stands, yields of the order of 10–15 t/ha DM are more common.

In the subtropics, steers continuously grazing setaria fertilized with 330 kg/ha/yr N, and stocked at about 3 steers per hectare, can produce live weight gains of 500–800 kg/ha per year.

B.3. *Tripsacum laxum Syn: Tripsacum andersonii* (Guatemala grass; Honduras grass)

Morphological description


Robust perennial bunch grass with short rhizomes


Leaves to 10cm wide; inflorescence a subdigitate panicle comprising up to 8 racemes

Picture 15: *Tripsacum laxum Syn: Tripsacum andersonii* (Guatemala grass)

Robust perennial bunch grass, monoecious, with short rhizomes; shallow-rooted. Stems somewhat compressed, up to 5 cm diameter at the base; flowering culms up to 4 m tall.

Leaf blades up to 120 cm long and up to 10 cm wide, shortly tomentose on the upper surface, glabrous on the under surface. Subdigitate terminal and axillary inflorescences with up to 8 slender racemes.

Establishment

Always planted from stem cuttings with 3–5 nodes, rooted culms or rhizomes (800–3,000 kg/ha) at spacings of 0.5 × 1 m. Can be cut 4–6 months after planting.

Fertilization

Heavy fertilizer applications (N-P-K) needed for optimum growth as herbage removal quickly extracts soil nutrients.

Compatibility (with other species)

May be grown with twining legumes (that rarely persist under the grass cutting regime) or with companion rows of shrub/tree legumes.

Pests and diseases

No major pests or diseases reported. Reported that Guatemala grass has the potential to harbor rodents more than other grasses which can lead to human health risks.

Uses/applications

Used as Forage, Perennial fodder bank for cut-and-carry, especially useful as green feed during dry conditions.

Recommended in Kenya as an alternative to Napier grass (*Cenchrus purpureus*) in dairy production in areas of the country that are prone to Napier stunt disease. Used to produce moderate quality silage.

Production potential

Annual DM yields in the range of 18–30 t/ha, cutting at 10–25 cm above soil surface.

LWGs of 280 g/head/day (300 kg/ha) over 10 months with rotational grazing in Suriname were reported

B.4. *Brachiaria ruziensis Syn: Urochloa ruziziensis* (Congo signal grass; prostrate signal grass, ruzi grass): Ruzi or Ivubwe

Morphological description



A tufted and spreading perennial with decumbent culms shown here with fruit trees.



Well fertilized young ruzi grass

Picture 16: *Brachiaria ruziensis Syn: Urochloa ruziziensis*

A tufted, spreading perennial grass forming a dense leafy cover. Culms decumbent, geniculately ascending, 50–100 cm long, 3–4 mm diameter, arising from short rhizomes, sometimes rooting from lower nodes; fertile culms to 1.5 m high.

Leaf sheath longer than internode, loose, covered with dense tuberculate hairs; ligule a fringe of hairs; leaf-blades lanceolate to oblong lanceolate, contracted at base, tapering to an acute apex.

Inflorescence a panicle comprising (3–) 5–7 (–9) racemes, 5–10 cm long borne along one side of a central axis (rachis) 4–12 cm long; rachis, broadly winged, foliaceous, triquetrous, 2–3.5 mm wide, ciliate on margins. 170,000–270,000 per kg.

Establishment

Ruzi grass seed needs to be stored for at least 6 months after harvest to overcome dormancy, but quality deteriorates if seed is kept too long at high temperatures and high humidity. Seed is normally sown at 2.5–10 kg/ha (depending on seed quality) onto a well-prepared seedbed and lightly covered, no deeper than 2 cm. Seedlings grow vigorously. Ruzi grass can also be established vegetatively using stem cuttings with rooting nodes.

Fertilization

Ruzi demands high soil fertility. Nutrient deficiencies, primarily P and K, should be corrected prior to planting, adequate maintenance fertilizer, particularly N, should be used to maintain productivity under grazing or cutting.

Compatibility (with other species)

While ruzi grass forms a dense cover and competes with weeds under light grazing, the sward opens under heavier grazing, allowing broad-leaf weeds to establish. It will combine with a range of twining, erect and shrub legumes.

Pests and diseases

Ruzi is severely attacked by spittlebug (Aeneolamia, Deois, Mahanarva, Zulia spp.; Hemiptera: Cercopidae) in tropical America. Nymphs and adults damage the host plant by sucking its sap and injecting a toxin, that initiates yellowing and death of the forage, making it unpalatable for cattle. Leaf is attacked by foliar blight (*Rhizoctonia solani*) in tropical America. Seed heads are attacked by an ergot fungus (*Sphacelia/Claviceps*) in DRC.

Uses/applications

Used as Forage. Permanent or semi-permanent pasture for grazing or for cutting for green feed and conservation. Sufficiently shade tolerant to be planted for grazing under coconut.

Production potential

Less productive than *U. decumbens* in Australia and South America although yields have exceeded 20 t/ha/year with high rates of nitrogen.

In Sri Lanka, DM yields of 16.8, 22.0 and 25.6 t/ha/year were achieved with N applications of 112, 224 and 366 kg/ha, respectively. On an oxisol at Coronel Pacheco, Brazil, ruzi grass produced 6.0 t/ha DM without added fertilizer and 12.0 t/ha with 150 kg/ha N fertilizer.

Liveweight gains have exceeded 1,000 kg/ha/year on pastures of ruzi with legumes, and over 1,500 kg/ha/yr with 200 kg/ha N fertilizer. Steers grazing *B. ruziziensis* on Brazilian savannas at 2 head/ha gained 285 kg/ha/year.

B.5. *Pennisetum clandestinum Syn: Cenchrus clandestinus* (Kikuyu grass) Umucaca

Morphological description



Flower with stamen filaments and feathery stigmas



Seed crop (cv. Noonan)

Picture 17: ***Pennisetum clandestinum Syn: Cenchrus clandestinus***

Stoloniferous and rhizomatous perennial, 30–40 (–70) cm tall, rhizomes slender, elongated, stolons much-branched and closely appressed to the ground, forming a turf under regular defoliation. Vegetative shoots with short stems and long leaves; vegetative shoots lower-growing than sterile shoots and with shorter leaves.

Leaf sheath pale yellow-green, usually with fairly dense, fine tubercular-based hairs, sometimes glabrous; ligule a dense rim of hairs.

Inflorescence reduced to a cluster of (1–) 2–4 (–6) very shortly stalked fertile spikelets, almost enclosed in the uppermost leaf sheath. Spikelets linear-lanceolate. Approx. 400,000 caryopses/kg.

Establishment

Kikuyu is readily established vegetatively or from seed. Harvested pieces of stolon or rhizome can be planted on a regular grid, or broadcast and cultivated into the soil surface. Subsequent rolling ensures better establishment. Seed is sown at 1–2 kg/ha when soil temperature reaches 20 °C.

Fertilization

Kikuyu is particularly demanding for N and P. Good production requires at least 150 kg/ha N applied in split dressings in spring and autumn, although linear responses to levels well above this have been obtained. Available soil P levels should be maintained at or above 15 ppm.

Compatibility (with other species)

Kikuyu is very competitive and generally incompatible with other grasses. Ryegrasses (Lolium spp.) can be oversown in autumn if the kikuyu is weakened by ploughing or with chemical prior to sowing. Weeds tend to be a problem only in degrading forages.

Pests and diseases

A leaf-spot caused by *Pyricularia penniseti* causes a leafspot, death of leaf tips, and in severe cases death of seedlings – usually only in nutrient deficiency-weakened plants. Black spot (*Bipolaris setariae*) produces a characteristic black spot on the leaf and yellowing of the leaf tip, making the pasture less palatable to stock. Rust caused by (*Phakopsora apoda*) decreases photosynthetic capacity of infected leaves, but does not kill plants.

Uses/applications

Kikuyu is mostly used as irrigated or dryland permanent pasture in the subtropics or upland tropics. In irrigated situations it can be used as the source of warm-season feed in conjunction with oversown ryegrass (*Lolium spp.)* for cool season feed. While it can be readily used for silage or wrap-bale haylage, opinion among farmers is divided on its suitability for hay making.

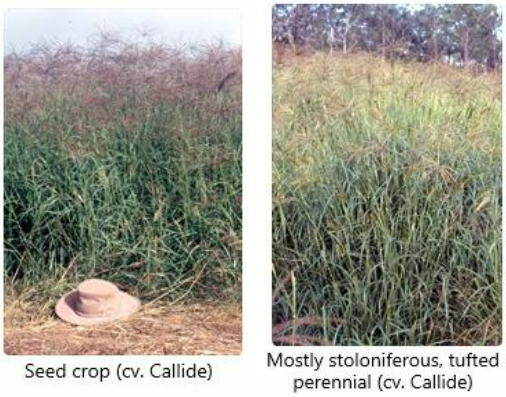
Production potential

DM yields are only limited by soil fertility and moisture availability. Under optimum conditions, it is capable of producing 30 t/ha/yr, but is unproductive if not fertilized. Responses in the order of 15–30 kg DM per kg N applied are reported.

Well fertilized pastures are capable of carrying 1.5–3.0 adult cattle/ha. Dairy cows can produce over 15 L milk/hd/day, and beef animals over 400 kg/ha/yr LWG from vigorous kikuyu pastures. To maintain animal production in winter, kikuyu pastures can be oversown with temperate species (e.g. Lolium spp., Trifolium repens) following spraying with low concentrations of glyphosate (1–2 L/ha in 100 L/ha of water).

B.5. *Chloris gayana* (Rhodes grass)

Morphological description


Seed crop (cv. Callide)

Mostly stoloniferous, tufted perennial (cv. Callide)

Picture 18: *Chloris gayana* (Rhodes grass)

Tufted perennial, usually stoloniferous (varies with genotype), with foliage from 0.5 to 1.2 m, and fertile tillers from 0.9 to 2 m tall. Leaves glabrous, with 2–3 mm long hairs near the collar.

Inflorescence a digitate (single whorl) or subdigitate (double whorl), comprising (3–) 6–15 (–20) ascending or spreading, spike-like racemes 4–15 cm long, usually light, greenish brown (rarely yellow) in colour, ripening to darker brown. About 2 million caryopses/kg.

Establishment

Can be propagated vegetatively or from seed. Planting material can be obtained by breaking up larger clumps into pieces, or using the small tussocks along the stolons that establish readily. Either is planted on about a 1 m grid. A more rapid cover can generally be obtained by planting from seed, usually at sowing rates of 0.5–1 kg/ha. Seed germinates in 1–7 days, and seedlings develop rapidly.

Fertilization

Although Chloris gayana can survive on infertile soil, it is very unproductive, and may eventually die out, particularly if grazed regularly. Responds to phosphorus in poorer soils, and gives a linear yield and crude protein response of up to 300 kg/ha of nitrogen if other nutrients are adequately supplied. Split applications, each of 50–100 kg/ha N, are normally used when economically feasible.

Compatibility (with other species)

Grows well with temperate and tropical legumes, by virtue of its open stoloniferous ground cover.

Pests and diseases

Fungi: *Aspergillus flavus*, *Cerebella andropogonis, Cladosporium sp., Claviceps sp*., *Cochliobolus heterostrophus*, *Cochliobolus chrolidis* (leaf blight) *Drechslera australiensis* (drechslera leaf spot), *Fusarium equiseti, F. gramineum* (smut) and Rhizoctonia solani (summer blight).

Nematodes: *Helicotylenchus dihystera, H. nannus, H. pseudorobustus, H. cavenessi, Hemicycliphora truncata, Hoplolaimus pararobustus, Meliodogyne acronea, M. incognita acrita, M. javanica, Pratylenchus brachyurus* and *Rotylenchulus reniformis* (reniform nematode)

Insect pests: Include fall armyworm (*Spodoptera frugiperda*), Rhodes grass scale or Rhodes grass mealybug (*Antonina graminis*), chinch bugs (Blissus spp. Hemiptera: Lygaeidae) and the two-lined spittle bug (*Prosapia bicincta Homoptera*: Cercopidae). Some of these can severely damage stands if conditions are suitable.

Chloris striate mosaic virus, which may also attack, *Avena sativa*, *Hordeum vulgare*, and *Zea mays* is transmitted by Nesoclutha (obscura) pallida (Cicadellidae), and may be carried in the seed, parasitise *Chloris gayana*.

Uses/applications

Used as permanent or annual forage in grass-legume or grass pastures in dryland and irrigated permanent systems. Can also be undersown into maize. Makes good hay if cut at or just before flowering. Generally not suitable for silage. Provides fair standover roughage when mature, better than *Cenchrus ciliaris* and *Megathyrsus maximus* due to its greater cold resistance and lower loss of dry leaves.

Production potential

DM yields generally range from about (2–) 10–25 t/ha, depending on variety, soil fertility, environmental conditions, and cutting frequency.

Yields in the second year may be double those of the establishment year, but this also depends on management and environmental conditions. Yields of 35–60 t/ha DM are reported, but these are not the norm.

Can carry about 1–4 beasts/ha depending on pasture productivity. Annual liveweight gains of up to 160 kg/head and 850 kg/ha are achievable. Production declines without a vigorous legume or the use of fertilizer nitrogen.

B.7. *Andropogon gayanus* (Gamba grass): Itete

Morphological description



Leafy young growth



A tall perennial grass with short rhizomes, forming tussocks up to 1 m diameter

Picture 19: *Andropogon gayanus* (Gamba grass): Itete

A tall perennial grass with short rhizomes, forming tussocks up to 1 m diameter; culms to 4 m.

Leaves (up to 1 m long) green, becoming bluish under moisture stress, with a strong white midrib; hairy on both surfaces, particularly when young; leaf sheath up to 20 cm long, hairy at base.

Inflorescence is a false panicle (synflorescence) composed of paired racemes (rames) 4–9 cm long, bearing about 17 spikelet pairs. Caryopsis, 2–3 mm long, 1 mm wide, about 890,000/kg, light brown to brownish black.

Establishment

Gamba can be planted from seed (1–10 kg/ha) into prepared or semi-prepared seedbeds; it can also be established from young rooted tillers. Seed should not be sown within 6 months of harvest due to dormancy.

Fertilization

Gamba grass is tolerant of low fertility but seedling growth may be slow unless some additional P and K is applied on deficient soils. Without added N, it produced twice as much dry matter as *Urochloa decumbens* or *Megathyrsus maximus*.

Compatibility (with other species)

This tall tussock grass will combine well with twining and erect shrub legumes, but may need heavy defoliation to reduce competitiveness.

Pests and diseases

Good resistance to spittlebug (*Deois flavopicta*) in Brazil due to antibiotic, physical and anatomical features. In South America, colonies of leaf cutting ants (Atta and Acromyrmex spp.) can destroy stands of the grass.

Uses/applications

Sown as permanent pasture; can be stocked heavily during the wet growing season (at 4–5 head/ha) making it useful for holding paddocks as it can feed a large number of cattle for a short time. Also cut for fresh feed and for fodder conservation by smallholders.

Production potential

Highly productive but DM yield (4–25 t/ha) up to 30 t/ha will depend on soil fertility and rainfall. In Brazil, A. gayanus has out-yielded species of Urochloa.

Animal production on gamba grass savannah is low at 90–120 kg liveweight gain/head/yr because of weight loss during the dry season. Addition of a legume can raise this to 150 kg/head/yr.

B.8. *Cynodon dactylon* (bahama grass, bermuda grass, couch grass): Urwiri

Morphological description



Giant Bermuda Grass



Prolific flowering

Picture 20: *Cynodon dactylon* (bahama grass, bermuda grass)

A fine to robust stoloniferous, sward-forming perennial herb, with rhizomes that can penetrate 40–50 cm in clay soil and 70–80 cm in sand.

Foliage dense, 10–40 cm deep; culms 0.5–1 mm diameter, erect or geniculately ascending to 40 (–60) cm; leaf blades 3–15 (–20) cm long and 2–4 (–6) mm wide,

Inflorescence a digitate panicle, comprising (2–) 4–5 (–7) racemes (in robust forms up to 10 racemes, sometimes in 2 whorls); racemes 1.5–6 (–10) cm long.

Caryopses ovoid, about 1.5 mm long, yellow to reddish; 3–4.5 million seeds/kg.

Establishment

Propagated by seed or vegetatively (turfs or stolon/rhizome pieces (sprigs). Normally sown at 5–10 kg/ha dehulled seed, the higher rate being used for more rapid cover. Seed is best sown onto a very well prepared, fine, weed-free seedbed and rolled in. Seedlings usually root down quickly. Turfs or sprigs can be planted at 3.5–7 m^3/ha (40–80 bu/ac) or on a 90 cm (or less) grid, into a roughly or well-prepared seedbed, but rolling is still essential.

Fertilization

Survives at low fertility possibly due to non-symbiotic N fixation in the rhizosphere, measured at 30 kg/ha N in a 100-day period.

Responds well to improved fertility, with applications of a minimum of 10 kg/ha/month N and up to 60 kg/ha/month N necessary for moderate to high productivity, particularly in some of the improved hybrids.

Compatibility (with other species)

C. dactylon is very competitive, particularly in fertile soils, and only aggressive legumes are capable of forming an association with it. It suppresses weeds well if kept mown or grazed closely and fertilized.

Pests and diseases

Rust (*Puccinia graminis*) and Helminthosporium leafspot are the major fungal diseases of *Cynodon dactylon*, although resistant types are available.

Other fungal diseases include Bipolaris, Gaeumannomyces, Leptosphaeria, Marasmius, and tar spot (Phyllachora.

Also attacked by the bacterium *Xanthomonas cynodontis*, and by barley yellow dwarf virus, lucerne dwarf virus, and viral stripe diseases (which affect corn and rice), as well as by a range of nematodes, the main one being root knot nematode (*Meloidogyne spp*.).

Armyworm (*Spodoptera spp*.), tropical grass webworm (*Herpetogramma licarsisalis*), spittlebug (*Prosapia bicinata*) and bermudagrass mite (*Eriophes cynodoniensis*) are major pests. The parasitic flowering plants *Cuscuta pentagona*, *Nuytsia floribunda*, *Striga harmonithica*, and S. lutea can adversely affect stands.

Uses/applications

Used in permanent pastures for grazing or cut-and-carry, and for hay or pellets and silage production. Provides useful standover or deferred feed.

Production potential

Productivity depends on the cultivar used, the time of year and the amount of nitrogen available. DM yields of 1,000–3,000 kg/ha per month are possible in summer and 100–1,200 kg/ha in winter. 'Coastal' yields up to twice as much as most common ecotypes.

Liveweight gain of cattle ranges from 200 to 300 (–500) kg/ha/yr, or over 700 g/hd/day, when moderate rates of N and other fertilizers are applied and at stocking rate of about 2 or more beasts/ha.

B.9. *Digitaria decumbens Syn: Digitaria eriantha (pangola grass, common finger grass, digit grass)*

Morphological description



Picture 21: *Digitaria decumbens Syn: Digitaria eriantha*

Perennial grass incorporating a number of morphologically different former species. Stoloniferous with internodes glabrous or hairy, or tufted-rhizomatous with rhizomes knotty and unbranched; culms, simple or branched, 35–120 (–180) cm tall.

Basal leaf sheaths mostly silky and hairy (rarely glabrous); leaf blades 5–60 cm long, 1.5–14 mm wide. Inflorescence a digitate (single whorl) or subdigitate (2 or more whorls, axis to 3 cm long) panicle comprising 3–17 racemes, 5–20 cm long. About 3 million seeds/kg.

Establishment

Many of the stoloniferous types produce little or no seed and must be propagated vegetatively. This is then cultivated into prepared ground and rolled. Alternatively pieces of stolon can be pushed into the soil on about a metre grid. Under good growing conditions, vegetatively planted swards establish rapidly, suppressing weeds in the process. Seeding varieties require a fine, firm, clean seedbed for establishment, to avoid competition in the early stages. Mixing seed with superphosphate, or sawdust or pelleting facilitates flow. Stoloniferous types establish more readily than tufted ones.

Fertilization

D. eriantha is tolerant of, but unproductive under low fertility conditions. 'Pangola' responds well to nitrogen, giving linear increases up to 300–350 kg/ha N.

Other types also respond well to improved nitrogen fertility, but perhaps not to the same extent as 'Pangola'. 100–300 kg/ha N should be applied in split applications according to needs and environmental conditions.

Compatibility (with other species)

Tussock types combine well with other species, but stoloniferous types can be very competitive and suppress companion legumes.

Pests and diseases

Susceptibility to rust (*Puccinia oahuensis*) varies among genotypes. False smut (*Ephelis sp.)* in seed heads is a minor problem, particularly during prolonged wet periods.

Pangola grass is also attacked by the fungi, *Mycosphaerella tassina*, *Piricularia grisea*, and *Rhizoctonia solani*. The most serious disease of *D. eriantha* is pangola stunt virus, transmitted by whitebacked planthopper (Sogatella furcifera Homoptera: Delphacidae), or S. kolophon. Symptoms are stunting,

yellowing, reddening, and twisting of leaves and inflorescences, swelling of small veins, and excessive tillering.

Nematodes include: 'Pangola' is largely resistant to root-knot nematode and is recommended as a rotation crop on sandy soils infested with cotton root-knot nematode (Meloiodogyne incognita).

Insect pests include spittlebugs (*Tomaspis flavopicta, T. humeralis, Prosapia bicincta*), rhodes grass mealy bug (*Antonina graminis*), chinch bug (*Blissus leucopterus*), sugarcane aphid (*Sipha flava*), army worms (*Laphigma spp., Spodoptera spp.* and *Mocis spp.),* mole crickets and leafhoppers.

Uses/applications

Permanent pasture species but can be used for grazing, hay or silage. Suitable for cut-and-carry.

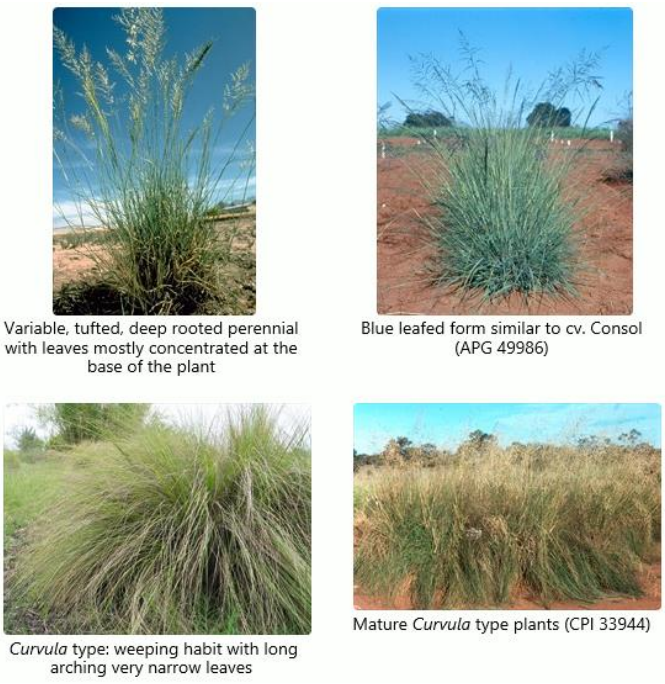
Production potential

DM yields vary with fertility, genotype, and environmental and management conditions, but normally range from about 10 to 20 t/ha, and under ideal conditions may exceed 40 t/ha with high fertilizer inputs.

An excellent species for beef and milk production. N fertilized pasture can produce >1,000 kg/ha/yr LWG and 6,000 kg/ha/yr milk, with stocking rates of 2.5–7.5 animals/ha.

B.10. *Eragrostis curvula Syn: E chloromelas; E robusta; E subulata* (boer love grass; weeping grass): Ishinge

Morphological description



Variable, tufted, deep rooted perennial with leaves mostly concentrated at the base of the plant

Blue leafed form similar to cv. Consol (APG 49986)

Curvula type: weeping habit with long arching very narrow leaves

Mature *Curvula* type plants (CPI 33944)

Picture 22: *Eragrostis curvula Syn: E chloromelas; E robusta; E subulata*

Variable, tufted, deep rooted perennial with drooping leaves mostly concentrated at the base of the plant to 30 or 50 cm. Culms erect, 0.3–1.2 (–1.8) m tall.

Leaf sheaths keeled; basal sheaths strongly striate, densely to sparsely hispid below; ligule a rim of hairs 0.3–1.0 mm long; leaf blades variable in colour from bluish to green, curling at the tip when dry.

Panicle much branched, sometimes narrow and contracted, with branches appressed to the main axis but mostly loose and spreading. Spikelets greyish-green, flattened, linear-oblong to linear elliptic, 3–10 mm long and 1–1.5 mm wide. About 3.5–5 million caryopses or 110,000 spikelets per kilogram.

Establishment

The very small seed size of *E. curvula* demands a clean fine seedbed for successful establishment. Seed can be broadcast or drilled, and covered to less than 1 cm. Rates of 1–5 kg/ha seed give good stands with broadcast sowings, although this can be reduced to as low as 0.25 kg/ha for row planting. Row spacing can be from 0.6 to 1.2 m. Good seedling vigour and rapid early growth contribute to ease of establishment.

Fertilization

Survives on poor soils, but needs extra nitrogen for high production. In hay crops, potassium may also become necessary. Phosphorus does not seem to be as important as it might be with some of the panicoid grasses. Nitrogen may be applied at this time at rate of 10–20 kg/ha, with additional nitrogen applied as top-dressing once seedlings are well established.

Compatibility (with other species)

E. curvula is a pioneer species, and competes aggressively, particularly in disturbed situations, and in sandy soils.

Uses/applications

E. curvula is used for pasture and hay, but must be utilized when young to obtain real benefit.

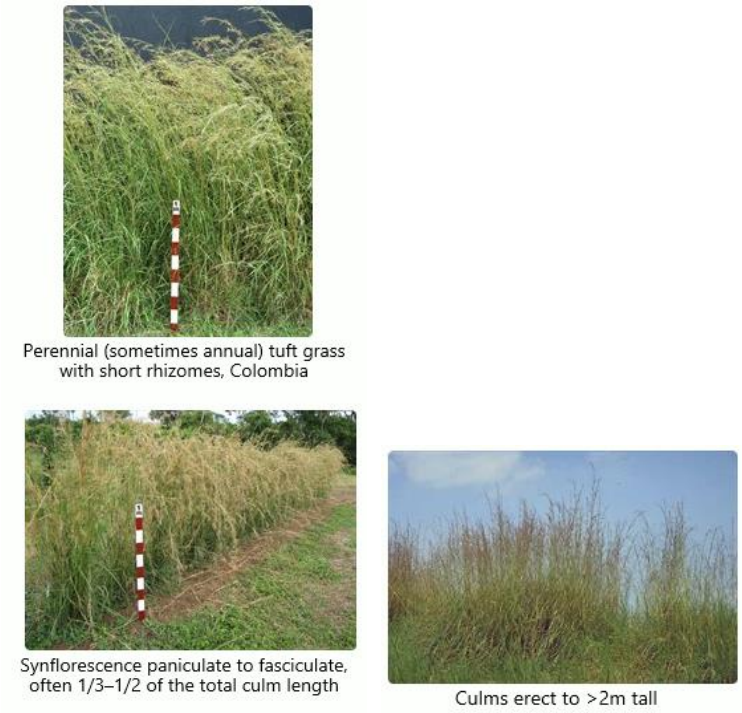
Production potential

Dry matter yields are generally low at 3–10 t/ha/year. Yields can be more than doubled through applications of 100–200 kg/ha N. In more favorable environments and with adequate nitrogen and sometimes irrigation, yields of 20–30 t/ha DM are achievable.

Heifers stocked at about 12/ha have produced a live weight gain of 550 kg/ha over summer, and sheep 53/ha over 130 days produced a live weight gain of 160 kg/ha. At lower stocking rates (1.5 steers/ha), animals can gain 0.7–1 kg/day during the growing season.

B.11. *Hyparrenia rufa (jaragua grass): Umukenke*

Morphological description



Picture 23: *Hyparrenia rufa* (jaragua grass): Umukenke

Perennial (sometimes annual) tuft grass with short rhizomes; culm erect, 30–250 cm long, 2–6 mm diameter, nodes glabrous; leaf blades 30–60 cm × 2–8 mm.

Inflorescence a rather lax false panicle (synflorescence), much branched, 5–80 cm long (often 1/3–1/2 of the total plant height), composed of terminal and axillary racemes.

Establishment

Seed can be broadcast into ashes after burning of native vegetation; however, fully or roughly prepared seed bed gives better results; 15–20 kg 'seed'/ha. Establishment is rather slow.

Fertilization

Responds positively to moderate applications of N and P fertilizer, but less demanding than species such as *Chloris gayana* and *Megathyrsus maximus*.

Compatibility (with other species)

Jaragua grass competes strongly with other vegetation such as weeds and can smother them.

Pests and diseases

While a number of fungal organisms such as *Curvularia sp., Fusarium sp., Phoma sorghina* and *Sphaeropsis sp.* have been isolated from foliar lesions on *H. rufa*, no major diseases or pests are known.

Uses/applications

As native pasture, also for hay or silage, in East Africa and Latin America for beef cattle production.

Production potential

Dry matter yields recorded are in the range of 3.5–10.3 t/ha/yr (up to 19 t/ha).

The low nutritive value of Jaragua grass is reflected by rather low daily LWGs of cattle (280–450 g/head, depending on fertilization). For acceptable LWG the grass is considered to require supplementation with nitrogen (legume tree leaves, legume grasses or a nitrogen-rich by-product) and energy sources (molasses, citrus pulp, cereal bran).

B.12. *Sporobolus pyramidalis* (giant rat's tail grass; smutgrass): Umutsina

Morphological description





An erect, perennial tussock grass usually growing to 2 m in height. Alternately arranged leaves with leaf blades being 6 cm to 18 cm in length, glabrous, acuminate and weakly convoluted. Inflorescence is paniculate, pyramidal, open and exserted. The seed head can range from 25 to 80 cm long and side branches from 3 to 8 cm long. It changes shape from a 'rat's tail' when young to an elongated pyramid shape when mature.

Sporobolus pyramidalis is a highly invasive tussock grass probably native to the African region. In many counties is considered as pasture weed.

Establishment

Sporobolus pyramidalis is Seed and Vegetatively propagated in a fine well prepared land.

Uses/Applications

There are few productive uses for this plant. Some landholders manage the problem by preventing the grass from maturing and thereby getting some grazing utility from it.

B.13. Themeda spp: (grader grass, habana grass and kangaroo grass): Igikaranka

Morphological description



Picture 24: ***Themeda spp: (grader grass, habana grass and kangaroo grass): Igikaranka***

Themeda quadrivalvis known as grader grass is an annual grass growing up to 2 metres (6 ft 7 in) tall. The usually folded leaves are up to 60 centimetres (24 in) long.

The seed heads are rounded or fan-shaped and are accompanied by leaflike bracts. The grass becomes orange, red or golden brown at maturity.

The clustered spikelets in the seed heads have some tubercle-based hairs and twisted awns, which can be up to 5 centimeters long.

Grader grass is a prolific producer of seed; there can be up to 1000 seeds in a single seed head. The seed is dispersed by graders, on fur and clothing, and as a contaminant of pasture seed supplies.

Themeda triandra is a perennial tussock-forming grass widespread in Africa, Australia, Asia and the Pacific. In Australia it is commonly known as **kangaroo grass** and in East Africa and South Africa it is known as **red grass**.

Themeda triandra is a grass which grows in dense tufts up to 1.5 metres (4 ft 11 in) tall and 0.5 metres (1 ft 8 in) wide. Plants from higher altitudes tend to be shorter and dark purple, whereas at lower altitudes plants are often lighter coloured and flushed only with purple.

It flowers in summer, producing large red-brown spikelets on branched stems. The leaves are 10–30 cm (3.9–11.8 in) in length and 1–8 mm (0.039–0.315 in) wide. Its inflorescence is compounded, fasciculated, is 10–30 cm (3.9–11.8 in) long and composed of a single raceme.

Establishment

After the rains in February and March, seeds can be planted but these will only germinate the following spring. Although clay soils with a high organic content are preferred, if Themeda is occurring naturally in your area, you could try to grow it. Once established, little maintenance is needed except cutting back in winter to about one-third of its size and removing most of the old dead leaves.

Uses/Applications

The young growth is palatable to stock. *T. triandra* seed has been used as a famine food in Africa. It also serves as a food source for several avian species, including the long-tailed widowbird. It is also occasionally used as an ornamental plant. To date, not much is known about the cultivation of our indigenous grasses in gardens, and only some nurseries have started selling them. However, this is changing as more and more people are becoming aware of the beauty of grasses and their usefulness in attracting animals, especially birds, to their gardens.

L O 1.2 – Select site for fodder crops cultivation

- Content/Topic 1: Site selection criteria for fodder crops cultivation

A. Requirement of a site for fodder crop cultivation

The specific agronomic requirements for growing of forages differ from species to species and may be site specific. The following are factors that make particular place suitable for specific fodder crop:

Altitude

Some fodder crop better suited for low altitudes, while others prefer high altitudes

Temperature

Temperature has a very strong impact on crop growth.

Physiological plant activities affected by temperature are: cell division, tissue growth, photosynthesis, germination, flowering, ripening, etc.

Very high temperatures, speed up the rate of water loss through transpiration and evaporation, thus leading to the wilting and eventual death of plants.

Low temperatures, on the other hand, reduce the rate of cell division and plant growth, and the death of plants under a heavy frost.

Soil types

All fodder crops do not grow well in some types of soil. The availability of fodder crop, the acidity or alkalinity depth, drainage, aeration, etc.., all contribute to making the area suitable for specific fodder crops and unsuitable for others.

Rainfall

Plants cannot survive without water. Rain, being a natural source, different fodder crops have different water requirement ranges.

Fodder crops that require a little amount of water in their life cycle are more suitable for arid and semi-arides areas, while those that need plenty of water can only be grown in regions which receive a reasonably well distributed rainfall through the year.

Sunlight

All plants require light from the sun for photosynthesis during their period.

Shortages of sufficient light lead to etiolated growth in plants, while too much sunlight and heat in the early stage of plant growth are equally harmful.

Humidity

Relative humidity in the atmosphere is dependent on temperature.

A high humidity lowers the rate of evaporation and transpiration and, consequently, water intake through the roots.

Warm temperatures in a humid environment conduce to the rapid multiplication of disease causing germs and, therefore, are not good for susceptible plants.

Access to the area

A nice driveway or road that gives easy access to the cultivation area can be close. It's also nice for transporting the hay or fresh fodder not to have to carry it too far.

Availability of water

Water is needed for watering and irrigation of fodder crops in dry season.

L O 1.3 – Prepare the land

Forage crops can be an important tool for farmers and carefully managed during establishment and grazing ensures that the maximum productivity will be achieved.

- Content/Topic 1: Seedbed Preparation operations

A. Seedbed Preparation

A seedbed is a piece of land that has been prepared in such a way that it is ready to receive the seed or planting material.

For the land to be ready for planting, the clods, depth of soil and the looseness of the soil must facilitate planting, germination of the seed and subsequent growth of the plants.

Seedbed preparation operations include activities such as:

- Primary operation: Ploughing or digging (if hand tools are used)
- Secondary operation: Harrowing to break large soil clods into smaller ones, and sometimes rolling of the ground to firm the soil

The main reasons for preparing a seedbed are:

- To kill the weeds either by burying them or by desiccation through exposures to the sun.
- To bury crop residues from previous season's crop so as to make it easy to plant. By burying the trash, decomposition of animal and vegetable matter is speeded up resulting in addition of organic matter into the soil as well as releasing of nutrients for use by the plants.

- Seedbed preparation operations loosen up the soil thereby facilitating rainfall infiltration into the soil as well as improving soil aeration. A well aerated promotes rapid root growth as well as increasing final yields.
- Seedbed preparation may be aimed at breaking hard soil surface that may sometimes form with the result that rainfall acceptance of the soil is impeded.

L O 1.4 – Select seeds

- Content/Topic1: Seeds selection criteria

Selection criteria of suitable fodder crops:

- Nutritive value
- Growth rate
- Persistence
- Ease of establishment
- Ability to mix with other crops
- Cost of establishment and maintenance

A. Seed considerations

When selecting seeds for fodder crops cultivation you should consider the following:

- **True variety**: The seed must be true to the variety one is intending to plant. To assure this it is advisable to obtain seed from a reputable source.
- **Seed quality**: Quality is a function of purity (free from weed seeds, broken seed, chaff, soil, etc) and viability (ability to readily germinate).
- **Seed dormancy** (inability to germinate) is a natural protective phenomenon which prevents premature germination of seed to ensure long-term survival of species.

Causes of seed dormancy

Seed dormancy could be due to either:

- an inactive embryo that fails to germinate (e*mbryo dormancy*)
- A hard seed coat restricting entry of water and air (d*ormancy due to seed coat characteristics*).

B. Techniques to overcome seed dormancy

Overcome seed dormancy due to seed coat characteristics

Mechanical scarification

The seed coat is abraded by passing over abrasive surfaces:

- Rubbing with sand paper if sowing small quantities for seed (Figure 2).
- For large quantities, a drum scarifier can be used (seed-mixer drums the inside surface lined with abrasive material)

Acid treatment

Immersion of seed in concentrated acid such as sulfuric acid, the duration of treatment depending on species.

Hot water treatment

Immersion of seed in water, the temperature and duration of treatment depending on species

Inoculation

Inoculation applies to legumes. Pasture legumes require the presence in the soil of a strain of nitrogen-fixing bacteria (*Rhizobium*) suited to an effective symbiosis. Some legumes are very specific in their rhizobium demands. Inoculation is recommended particularly when introducing new species into new areas to ensure that the species are modulated by the most effective and efficient *Rhizobium* bacteria strains.

The culture is most commonly in the form of a peat culture (a black powder), but may also be a slope culture on agar gel, or rarely a freeze-dried culture.

Inoculation procedure:

- Make a slurry of the inoculant in water and mix with the seeds thoroughly to make all seeds wet.
- Add a small quantity of sugar solution (10%) to the slurry to make it sticky.
- For inoculating 1 kg of seed, one-half teacup full of sugar is sufficient.
- Inoculation and drying should be done in the shade.
- Inoculated seeds should be sown within 24 hours after inoculation.

C. <u>Seeds selection criteria</u>

Yield Potential: Most farmers would first consider the yield of a particular seed before an acquisition. Of course, it is important to consider because it very much will determine the profitability of their farms. The yield of a crop is measured per unit area of cultivated area eg. 10 t/ha.

Cost of Seed (affordability): Simply, farmers look for seeds within the limits of their budget. Relative to other factors, there may be some indirect costs to the seeds which are considered. These costs may be; seed handling and transportation, seed preparation, seed dressing, germination tests etc.

Free from infection: Seeds should be harvested on plants free from diseases and pests. This will be considered for maximized yield and the crops become more profitable.

Disease resistance: Crop diseases may cause devastating losses to the farmer. This makes them always desirable of seeds that do not yield to crops diseases. Seeds that are resistant to diseases will help reduce risks and losses in cropping.

Animal preference: A quality seed must have high consumer preference (animals). There varying characteristics and usability of the produce from seeds. You must choose seeds based on some of these features that consumers prefer such as acceptability and palatability of a plant.

Adaptability: Adaptability to the existing soil and climatic conditions. Some will survive high temperatures and low humidity and also do well in areas of relatively high humidity. On the contrary, there are others that suit specific areas and climatic zones. You have to be sure of your seeds adaptability to your area before the acquisition.

Availability: The seeds should be available on markets locally or from recognized foreign seed producers with certified companies.

Soil requirements: Suitability to the ecological local zone-Selected planting seeds should be favourable to the prevailing ecological conditions. Soil acidity and alkalinity should be considered.

L O 1.5 – Plant fodder crops

- Content/Topic 1: Planting techniques

Most fodder crops do better if they are planted early in the growing season so as to make use of the rains. Early planting is especially critical in areas which have a very short and often unreliable rainy season.

A. Planting by seed (Sowing method)

Broadcasting method

Procedures:

- spread the seeds by hand, taking care to ensure uniform distribution;
- Divided the area into equal parts and the seeds divided into similar equal parts; Each portion of seed is broadcasted into one area.
- Wind is a factor to be considered especially with light seeds which may be blown over some distance.
- Mixing the seeds with materials such as sawdust, sand and fertilizers helps distribute the seed more evenly. All grasses and small seeded legumes are planted at a depth of 1.2-1.5 cm.
- Planted seed must be lightly covered with soil using a rake or leafless branch to ensure good seed and soil contact and for protection from birds and being washed away by rain.

Sowing in line method

This refers to planting crop seeds in rows.

Enough space is provided between one plant and another along the line and also between one row and the next. It can be done either manually or by machine by seed drilling, depending on what the farmer thinks appropriate within his means.

Procedures: Establishment from seeds for Desmodium

- requires a fine, firm and weed free seedbed;
- Seedbed preparation should be done well before the onset of rain.
- Use 3 - 5 kg Desmodium seeds/ha. (2kg/acre).
- During planting, mix seed with 2 bags of TSP or 4 bags of SSP fertilizer. Farmers can also use 5 - 10 tons per hectare of well decomposed farm yard manure.
- Drill the seed into shallow furrows of 2.5 deep spaced at 30 cm or 50 cm and then cover with little soil.

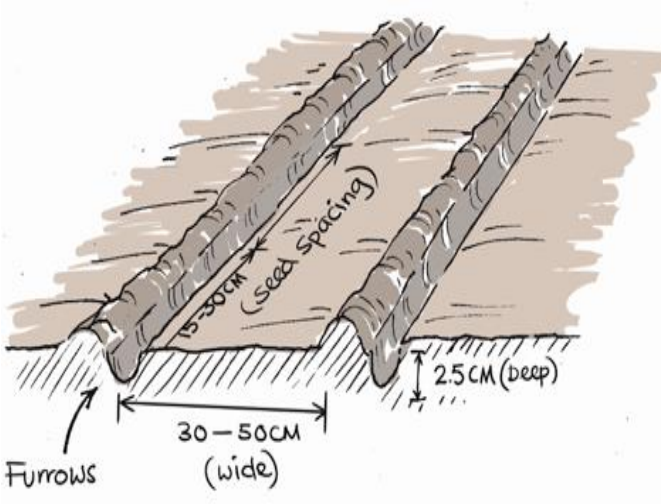


Table 2: Advantages and disadvantages of sowing in line and Broadcasting

Line planting	Broadcasting
Advantages 1. It economizes seed 2. It is easy to regulate plant population 3. It gives plant quite enough space 4. It is easy to regulate the plant depth 5. It is easy to carry out various essential growing operations like weeding, pruning, spraying, fertilizer application and harvesting. 6. It is easy to use machine.	**Advantages** 1. It is faster than the row planting. 2. It can be easily used for obtaining a higher plant population than would be the case with row planting especially in growing fodder crops. 3. It is ideal for small seeded crops. 4. It provides a good soil cover quickly.
Disadvantages 1. It requires that farmers have the knowledges and skill of proper planting and spacing 2. It takes more time and labour to finish the some acreage as would be covered when broadcasting is used. 3. Where wide spacing is used a bigger surface area is exposed to erosion.	**Disadvantages** 1. It is wasteful because it uses more seeds unnecessarily. 2. It is difficult to regulate the plant population. 3. It is difficult to use machine.

B. Planting by vegetative parts

This is a method by which plants reproduce themselves from part that is not associated with the reproductive organs.

Most of them have ample storage organs that serve as reserves when conditions are unfavorable. As soon as the conditions allow, the plants rejuvenate and start growing a fresh.

Tuft splits Methods

Procedures: Establishment of Setaria

- This fodder grass requires a well-prepared seedbed

- Tuft splits (rooted cuttings) are dug out by hand of by hoe and taken to the establishment area and planted in furrows.
- The spacing used on soil bunds is 50 cm between plants and 50 cm between rows.
- Where a pure stand of *Setaria phacelata* is to be established, closer planting of 30x30 cm is recommended.

Stem cuttings Method

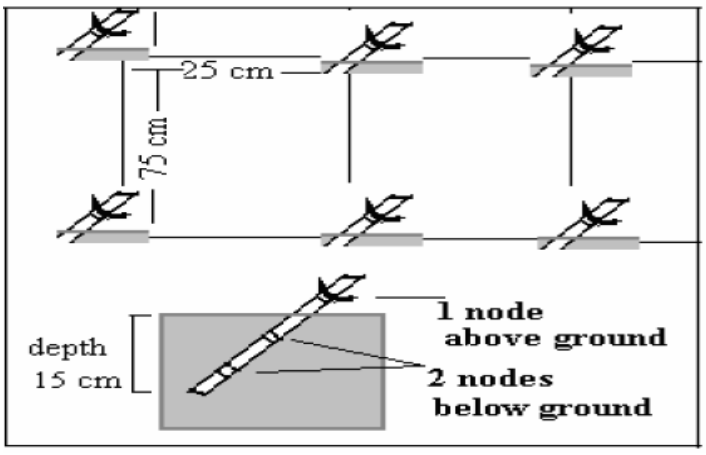
Plenty soil moisture is necessary.

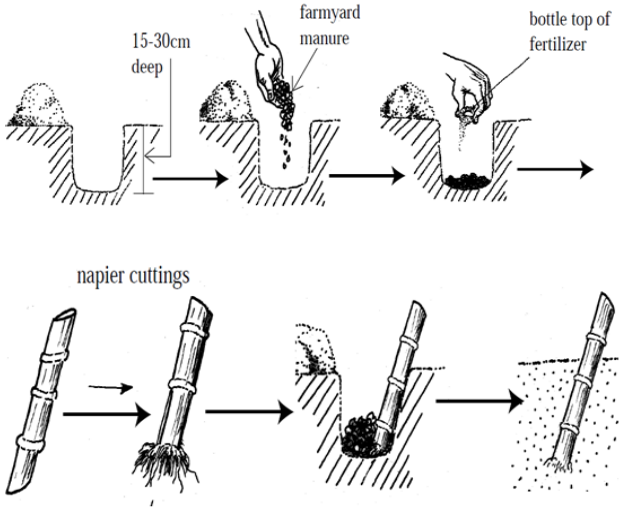
Procedures:

- Mature stems bearing three nodes are cut;
- Cuttings are planted in furrows or surface broadcast and covered with soil;
- The two nodes buried and one left above ground;
- The spacing is 0.7 X 0.3 m inter-row and for runner grasses 2 X 2m;
- Planting one cane/root split in holes 15-30 cm deep.

Note: spacing in the row is recommended if weed control is adequate and early season grazing avoided. The spacing is 0.5m x 0.5m in areas with over 1400mm of rainfall. In areas with 900-1400mm rainfall the spacing is 1m by 0.5 m.

Stem cut planting method





C. **Planting by seedlings**



Picture 25: Seedling in nursery

For browse trees and shrubs, it is advisable to raise seedlings some two months ahead of the rainy season using plastic bags in a nursery house.

The procedures are:

- Prepare a mixture of fine sand, forest soil and farmyard manure.
- Mix well and moisten by sprinkling with water and filling the plastic pots.
- Arrange the pots under a nursery shed and plant viable seeds (two seeds per hole if seed is not limiting)
- Supply adequate water every day. Monitor germination and remove any weeds.
- Thin seedlings to one strong plant per pot.
- At the start of the rainy season dig out planting holes in the target field a week or so before planting to allow adequate water infiltration.
- Preferably on a cloudy day, plant the seedlings in the prepared holes and return the topsoil followed by the subsoil and press firmly.

L O 1.6 – Apply fodder maintenance techniques

- Content/Topic 1: Fertilization

Farmers need to adopt good soil management practices should aim at not only maintaining soil fertility but also improving it. Such management practices should include the use of organic manure, inorganic fertilizers, liming and pH control.

A. Organic manure

Green manure, farm yard manure and compost are the most important organic materials incorporated in the soil to improve and maintain the soil fertility. Where available farm yard manure is a less expensive option for the smallholder, it can be applied at the rate of 5-10 tons/ha.

B. Inorganic fertilizers

Inorganic fertilizers are concentrated chemical compounds which are manufactured to supply specific requirements of plant nutrients. If applied, they enrich the soil with the particular element which is deficient. Most soil usually lack nitrogen, phosphorous and potassium.

It is important to establish the exact nutrient that is lacking by the soil analysis, followed by the selection of the right type of fertilizer before treating it.

Generally, when the soil is depleted of nutrients by continual cropping or soil erosion basal applications of the macro-nutrients, especially nitrogen (100-150 kg/ha urea) and phosphorus (50 kg/ha triple superphosphate), are helpful for successful establishment on most soil types.

C. Liming

The soil has to be tested early to determine the need for lime. If lime is needed to neutralize soil acidity, it should be applied prior to the first tillage and, if possible, several months before planting.

Table 3: Amounts of lime to apply to lands according to the pH of the soil

Soil pH	**Apply this amount of limestone**	
	kg/ha	g/m^2
<5	3000	300
5.0–5.4	2500	250
5.5–5.9	2000	200
6.0–6.4	1500	150
6.5–7.0	1000	100

One method of overcoming the problems caused by variations in yield and quality of feed due to the seasonal rainfall pattern is the use of fodder crops. These may be grown for grazing or for conservation as hay or silage.

- Content/Topic 2: Weed Control

Definition: A weed is defined as any plant growing where it is not wanted, of plant out of place.

Some plants are more susceptible to competition than others, and in some cases yields will be drastically reduced if weeding is not carried out regularly.

Weed control methods

Weed control methods may be divided into three main categories:

- **Cultural or mechanical:** Cultural methods involve such practices as correct spacing of plant; application of fertilizers, planting of weed-free seeds, etc. some cultural methods may entail the use of machine, e.g .cultivation, and can therefore be classified as mechanical.
- **Biological:** biological control involves the use of biological agent, for example an insect or other animal to control the weeds
- **chemical method:** Chemical weed control relies on the use of chemical weed-killers called herbicides,

- Content/Topic 3: Pest control

Definition: A pest is defined as anything that is destructive or a nuisance. As far as cultivated fodder crops are concerned, a pest is any organism that is destructive to fodder crops, either directly by damaging the plant, or indirectly through the introduction of disease-producing organisms such as virus.

Methods of pest control

The methods of pests control have been divided into three main categories:

- **Cultural control:** Some of the important cultural methods of pests control, include the following:
  - Early planting
  - Use of clean planting materials
  - Manure application
  - Field hygiene

- Fodder crop rotation
- Weed control
- Growing resistant varieties
- Quarantine and legislation

- **Chemical control –pesticides:** Chemical pest control involves the dusting, spraying of fumigation of a plant with a substances specifically harmful to the particular pest, or 'targeted organism'.

Certain insecticides, the organo-chlorines, such as DDT are persistent substances which remain indefinitely in the soil, water and in food crops. Some pesticides are toxic to man, and therefore great care must be exercised in their use.

- **Biological control:** Biological control involves the use of living agent or agent for the control of the pest. Thus the agent can be insect, virus or bacterium. The control agent controls the pest by feeding on it.

However, the modern approach aims at using a combination of all methods wherever and whenever possible for maximum efficiency.

Learning Unit 2 – Perform pastures layout and improvement

Pasture can be defined as any plant community in which forages namely, grasses, legumes, herbs and trees form the dominant vegetation upon which domestic ruminant livestock depend for food.

L O 2.1 – Identify common pasture fodder trees and shrubs

- Content/Topic 1: Types of pasture fodder trees and shrubs

A. Acacia spp (*Vachellia* or *Accacia nilotica*: thorny acacia , *Acacia angustissima* or *Acacia boliviana*)

***Accacia nilotica*: thorny acacia (Umunyinya)**

Morphological description



Shrub or tree, mostly 2.5–10 m tall. N Queensland, Australia



Long spines in young trees, Queensland Australia



Spines in axillary pairs, 5–7.5 cm long in young trees, commonly absent in mature trees.



Leaves bipinnate often with petiolar glands on rachis between adaxial pinnae; peduncles clustered at nodes; golden yellow flowers in globulous heads

Picture 26: *Accacia nilotica*: thorny acacia

Variable species; perennial shrub or tree, 2.5–10 (–20) m tall. Branches spreading, forming a dense flat or rounded crown with dark to black coloured stems; branchlets purple-brown, shortly or densely pubescent, with lenticels. Bark rough, longitudinally fissured, deep red-brown to black. Deep tap root where conditions permit (well-drained, deep soil), but predominance of lateral roots in less well-drained situations. Leaves bipinnate 30–70 mm long.

Flowers prolific, golden yellow, in globulous heads 1.2–1.5 cm in diameter. Pods straight or slightly curved, 5–15 cm long on a pedicel, 0.5–1.2 cm wide, with constrictions between the seeds (torulose), fleshy when young, indehiscent, becoming black and hard at maturity. Seeds deep blackish-brown, smooth, sub-circular, compressed, areole 6–7 mm long, 4.5–5 mm wide. 5,000–16,000 seeds per kg.

Uses/applications

Browse and drought forage; foliage and seeds eaten by a wide range of herbivores.

Used as pioneer species in land rehabilitation and as a barrier to desertification.

Timber has been used to produce railway sleepers, fence-posts and as fuel-wood. Source of gum/resin, tannin /dyestuff; traditional medicine and vertebrate poisons. The wood is heavy and durable and is used for heavy construction as well as tool handles and carts. Makes high quality charcoal and fuelwood.

Acacia angustissima* or *Acacia boliviana

Morphological description



Leaves and inflorescences (CPI 40175)



A. angustissima, Walkamin RS, Australia



Leaves and Inflorescence



A. angustissima CPI 40175, formerly identified as *A. boliviana*

Picture 27: *Acacia angustissima* or *Acacia boliviana*

These three species, being morphologically similar with similar environmental adaptation, are commonly confused with one another and misidentified. Consequently, this sheet deals with them as a group. They are thornless shrubs or small trees, 2–7 (–12) m high with a single short trunk. Twig pubescence varies from glabrous to short, appressed hairs, on the branchlets. Also variable in size and venation of the leaflets and size of flowers. Leaves bipinnate, predominantly asymmetric with a rachis 10–25 cm long, with 10–20 pairs of pinnae. Inflorescences ellipsoidal with whitish heads 1–1.5 cm in diameter, turning pinkish to dull orange when dry. Pods very thin-walled, papery, oblong, 3–6 cm long and 6–9 mm wide, with straight or sinuate margins, initially green, turning coffee-brown when ripe. Seed production is prolific. 90,000–100,000 seeds/kg.

Uses/applications

While Acaciella spp. are not used extensively as forages, they have been under evaluation throughout the tropics as dry season forages for many years.

Acaciella spp. have found application in agroforestry, and are being tested as a fallow species to restore soil fertility in dryland cropping systems.

Their benefits to crops as green manure are only realized in the second crop following application because leaf protein is bound in complexes with condensed tannins, resulting in the slow release of N for crop growth.

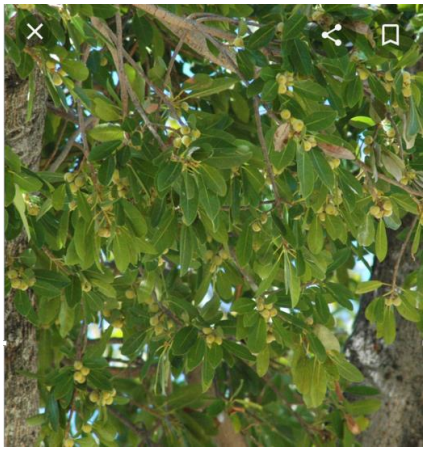
Wood can be used for fuel, flowers for bee forage, and the bark in the fermentation of traditional Mexican alcoholic drinks.

B. *Ficus toniingy* (Strangler Fig): Umuvumu

Morphological description







Picture 28: *Ficus toniingy* (Strangler Fig): Umuvumu

Strangler fig is an evergreen tree with a rounded to spreading, dense crown; it can grow 6 - 25 m tall. The plant often begins life as an epiphyte, growing in the branch of another tree; as it grows older it sends down aerial roots which, when they reach the ground quickly form roots and become much thicker and more vigorous. It eventually becomes a stilt-rooted, banyan-like tree with multiple ascending trunks and massive wide-spreading branches.

Uses/applications

Forage Uses of Ficus thonningii

Ficus thonnningii is an important fodder plant.

Even if, oldest trees were planted for other purposes such as shade trees in churches and traditional meeting places, recurrent droughts have made local farmers to improvise using the drought resistant *F. thonningii* plants as dry season animal fodder and other multipurpose benefits. It has been evaluated the local use, feed value, browse biomass production, and effects on soil fertility of of *F. thonningii* and has

recommended its propagation and use in similar regions. In the pasture, it is used as shed for animals in summer, medicine, live hedge for fencing and food for animals.

Edible Uses

Fruit – cooked: A good jam can be made from the ripe fruits. Leaves - cooked. They are occasionally eaten as a vegetable

Medicinal

- The bark is important in local medicine, and it is used in treating colds, sore throat, dysentery, wounds, constipation, nose bleed and to stimulate lactation
- Extracts of the bark are used in baths as a treatment of nervous illnesses, tuberculosis, paralysis and leprosy
- The latex is used for wound fever.
- The milky latex is dropped into the eye to treat cataracts
- An infusion of the root and fibre is taken orally to help prevent abortion
- The powdered root is taken in porridge to stop nose bleed

Agroforestry Uses

- Large cuttings can be planted close to each other to form living fences and to help control erosion
- The leaf litter helps in the improvement of the nutrient status and water-holding capacity of the soil
- The tree has an aggressive root system and should not be planted in a small garden or near buildings, swimming pools or paths

Other Uses

Bark cloth is obtained by cutting out a strip or cylinder of bark, which causes the tree to produce a fine, matted covering of red, slender roots over the wound. An excellent cloth

Bark fibre is used for making mats. The twined bark produces a strong rope, which is mostly used for fastening bundles of firewood before they are carried to the homestead for fastening slates onto a roof

The wood is creamy brown, has a fairly uniform structure, is light (510 kg/cubic m), soft to moderately hard, with a rough texture, tough, strong, easy to work; it finishes smoothly and holds nails firmly. Its durability is low, and it is easily attacked by termites.

Branches are used for firewood.

A. ***Sesbania sesban* (Egyptian pea, river bean,): Umunyegenyege**

Morphological description


Leaves paripinnate with more than 6 pairs of pinnae.


Pendulous, subcylindrical pods up to 30cm long

Picture 29: *Sesbania sesban* (Egyptian pea, river bean,): Umunyegenyege

Deep-rooted, short-lived (to 10 years) shrub or small tree 2–4 (–8) m tall. Main stem 6–8 (–12) cm in diameter.

Leaves paripinnate, 2–18 cm long; pinnae linear-oblong to oblong-lanceolate, opposite or nearly so in 6–27 pairs, 13–26 mm long, 3–4 (–6) mm wide.

Racemes unbranched or branched, 2–20-flowered,Corolla predominantly yellow or standard adaxially dark purple or purple spotted, abaxially yellow, red and purple, and wings and keel partly purplish black or red; standard transversely elliptic.

Seed subcylindrical, ends rounded, 3–4.5 mm × 2 mm, olive-green or brown, usually mottled. 55,000–80,000 seeds per kg.

Uses/applications

S. sesban is used in grazing systems and as a source of cut-and-carry forage. Its leaves are a good source of protein for cattle and sheep.

It makes an excellent green manure crop by virtue of high nitrogen fixation. In a one year rotation with maize, yields can be increased from 2 to 4 tonnes per hectare without the application of nitrogen fertilizer.

L O 2.2 – Identify common pasture grasses and legumes

- Content/Topic 1: Types of common pasture grasses and legumes

Common Pastures grass in Rwanda

A. ***Andropogon gayanus (Gamba grass)***

Sown as permanent pasture; can be stocked heavily during the wet growing season (at 4–5 head/ha) making it useful for holding paddocks as it can feed a large number of cattle for a short time. Also cut for fresh feed and for fodder conservation by smallholders. Low fertility demand has allowed rehabilitation of run-down paddocks and degraded fields of *Megathyrsus maximus* without the use of weed control or fertilizer.

Used in Nigeria for reclaiming overgrazed land. 10 m wide strips of *A. gayanus* have been planted in fields of millet to reduce wind erosion occurring at start of wet season. Strips captured >2,000 t sand/ha within 3 years.

B. *Brachiaria ruziensis*

Permanent or semi-permanent pasture for grazing or for cutting for green feed and conservation. Sufficiently shade tolerant to be planted for grazing under coconut. It is also used as ground cover in coffee.

C. *Chloris gayana (Rhodes grass)*

Used as permanent or annual forage in grass-legume or grass and pastures in dryland and irrigated permanent systems. Can also be undersown into maize. Makes good hay if cut at or just before flowering. Generally not suitable for silage. Provides fair standover roughage when mature, better than *Cenchrus ciliaris* and *Megathyrsus maximus* due to its greater cold resistance and lower loss of dry leaves.

In some cultivation systems, it is used as a short- to medium-term pasture ley to restore soil structure, improve organic matter levels, and reduce nematode numbers. Develops good ground cover and effectively controls erosion once established (needs regular defoliation to stimulate stolon development to maintain cover). Also effectively suppresses woody regrowth provided trees and shrubs are not well established prior to planting the grass.

D. *Cynodon dactylon*

Used in permanent pastures for grazing or cut-and-carry, and for hay or pellets and silage production. Provides useful standover or deferred feed.

Valuable for soil conservation on slopes and for providing cover in drainage lines.

E. *Digitaria spp*

Permanent pasture species but can be used for grazing, hay or silage. Suitable for cut-and-carry.

Stoloniferous types provide good ground cover for soil conservation and restoration of heavily disturbed land.

F. *Hyparrenia rufa*

As native pasture, also for hay or silage, in East Africa and Latin America for beef cattle production.

It can have an adverse effect on the environment, by replacing less aggressive native grasses, particularly through its tolerance of fires, and dominating the under storage of open woodland areas. This increase in the fuel load increases the frequency and intensity of future fires, thus leading to eventual replacement of native savannas and woodlands with an exotic grassland.

G. *Pennisetum clandestinum*

Kikuyu is mostly used as irrigated or dryland permanent pasture in the subtropics or upland tropics. In irrigated situations it can be used as the source of warm-season feed in conjunction with oversown ryegrass (Lolium spp.) for cool season feed. While it can be readily used for silage or wrap-bale haylage, opinion among farmers is divided on its suitability for hay making.

It can produce an excellent, stable ground cover to combat surface soil erosion. However, it has been observed kikuyu can create problems during floods where it is used for stabilising river banks, because the stable mat can actually encourage erosion if the eddying water undermines the sward.

H. *Themeda spp*

Themeda triandra is a very important and well-known grazing grass that is palatable especially when young. In some parts of Africa it is used for thatching, but the forms found in southern Africa tend to be flimsy and not durable enough. In Lesotho and bordering areas it is used sometimes for thatching and some basketry. Paper pulp can also be made from the culms (stems). In Australia it has been used as an ornamental and landscape plant.

Common pasture legumes in Rwanda

A. *Centrosema pubescens*

In grazed pastures in mixture with grasses or as legume-only protein bank; also as cut-and-carry forage, mainly for fresh consumption.

In SE Asian tree plantations, often in a ground cover mixture with other legume species. Soil improvement when used as ground cover and green manure. Reduction of herbicide use when used as cover crop for weed control. Folk medicinal application for treatment of wounds.

B. *Glycine javanica (N. wightii)*

N. wightii cultivars have formed the legume base for warm season pastures in the subtropics and upland tropics for a number of decades. Pasture for grazing, cut-and-carry, and standover; makes good hay and silage. Suitable for open pasture or agroforestry, although the twining habit can lead to distorted growth in coppice and young trees.

It can be used in small areas as a fallow crop in old cultivation and as a cover crop for weed control in overgrazed pastures and orchards. Care should be exercised to prevent the vigorous vine spreading into tree canopies.

C. *Trifolium repens* (white clover)

The East African annual Trifolium spp. are considered to make a valuable contribution in native pasture grazing systems, with potential for use as annual legumes for pasture improvement in high altitude areas. They can be used for intercropping with wheat or barley in tropical highlands to improve quality of residues for livestock feed, and can also be used for hay and silage production. Used for intercropping with wheat or barley in tropical highlands to improve soil nitrogen.

L O 2.3 – Maintain pasture

- Content/Topic 1: Types of pasture

There are two major types of pastures: Natural and Artificial

A. Natural pasture

It is a pasture which has developed naturally under the ecological conditions of the prevailing environment conditions. Natural pasture is native or hard.

Characteristics of natural pasture

- Grasses grown in wasteland offers this facility for natural pasture.
- In this method, grasses get established spontaneously without sowing and provides excellent grass cover under good management by nature.
- Some of the pastures are allowed for grazing and some are also used for hay making.
- After allowing the grasses to grow to the full potential, these pastures are called meadows.
- The grasses that establish after the main harvest is called the aftermath, which in latter stage can be used for the animals to graze.

B. Artificial, or planted pasture

It is a pasture that contains grasses that are domesticated, non-native or soft and tend to have a much higher forage biomass over a growing making them ideal for grazing.

Artificial pastures contain grasses that are more vigorous, competitive in a controlled system over a nomadic pastoral system typical of natural pastures.

Characteristics of artificial pasture

- The inclusion of grasses in crop rotation is common feature in foreign countries.
- Grasses kept in field for 3 to 10 years, then field is ploughed and brought under other crops.
- These grasslands are otherwise called as temporary pasture or ley farming or leys.
- The land is prepared similar to other crops.
- In this method seeds of grasses and legumes are mixed together and sown as a mixed crop.
- Legumes are rich in protein and they raise protein content of the feed. They enrich soil by fixing atmospheric nitrogen and consequently the grasses that are associated with legumes make a better growth than the grasses which are grown alone.
- The grasses and legumes selected should be rich in foliage growth which in turn have rich protein and minerals.

- Content/Topic 2: Pasture maintenance practices

Generally, there are 4 essential activities to be done for maintaining natural pastures:

- Bush and weed control
- Provision of water
- Over sowing/Reseeding
- Fertilization

A. Bush and weed control

Bushes and weeds reduce grass productivity while some are poisonous. Food reserves in the root systems are exhausted by frequent uprooting and slashing, leading to their stunted growth and eventually death.

Hoes, pangas or slashers are very useful tools for this activity. The hoe, in particular, is a good tool because its action on the soil ensures sustainable soil management. Uprooting and slashing should be done, preferably, before the plants begin to shed seed.

B. Provision of water

In the open grazing system, water should be evenly distributed on the farm to avoid overgrazing and soil erosion around the watering point.

Where only one watering point is available, paddocks should be constructed in such a way that animals can access the water while they are in any one paddock.

In areas with water shortage, harvesting rain water should be done.

C. Over sowing/Reseeding

Oversowing is the introduction of improved pasture species (grasses or legumes) to a natural pasture.

Oversowing increases forage quality and productivity of natural pastures. It is the easiest and most cost-efficient strategy for improving natural pasture.

Application of oversowing

Over sowing should be promoted in areas where:

- Soils are poor and where a higher cost system of pasture improvement cannot be justified.
- Soils are light and loose.
- Pastures lack good legume content.

Technics of over sawing

Oversowing can be done in two ways:

- Overgraze the natural pasture field then broadcast the improved pasture species (grass or a legume seed).
- Overgraze the natural pasture field then harrow or ox-plough or hand hoe and broadcast the improved pasture species (grass or legume seed).

Steps of oversowing

The steps involved are as follows:

- Seed of improved species are mixed with fertilizer and broadcasted on the overgrazed area at the rate of 10kg grass seed or 2-3kg of legume seed (*Desmodium or Stylosanthes*) with 1-2 bags of Triple superphosphate (TSP) or 2-4 of Single superphosphate (SSP) per hectare
- Graze heavily for one or two days to ensure that seeds come in contact with soil due to cattle trampling.
- Then remove the livestock from the field to allow the new species to establish.

D. Fertilization

To attain maximum production, the grass requires additional nutrients in the form of inorganic fertilizer or farmyard manure:

- During the establishment year of oversowing soil nitrogen is adequate for grass productivity.
- In subsequent seasons top-dress (manure application on established fodder) grass with 5-10 tons of farmyard manure.
- In areas with phosphate deficiencies topdressing with 2 bags SSP or 1bag of TSP per ha per year after the establishment year. This is in addition to the nitrogen fertilizers.
- Nitrogen fertilizer could be applied one or two months before the dry season in order to increase yields during the dry season.

L O 2.4 – Integrate legumes within pastures

- Content/Topic 1: Importance of mixing grasses and legumes in the pastures

The association of grasses with legumes has several advantages:

- Legumes fix atmospheric nitrogen and reduce requirements in nitrogen fertilizers;
- Legumes facilitate grass growth in combination.
- Legumes increase protein concentration in the basic feed ration
- Legumes prolong the time of use (grazing days or carrying capacity) in dry seasons,
- They facilitate the germination of grasses and annual plants,
- They can be used as "nursery" for seedlings.
- Association is much more competitive with weeds than grasses or legumes alone.
- Association has a better ground cover, which helps fighting against erosion.

- Content/Topic 2: Types of Legumes to associate with grasses in pasture

A. Annual plants

Clover: can be associated with *Cenchrus clandestinus, Cenchrus geniculatus, Cenchrus sphacelatus, Cynodon dactylon* and *Setaria sphacelata* in pastures.

B. Multiannual plants

Desmodium: may be associated with *Cenchrus clandestinus, Digitaria eriantha* (pangola), *Setaria sphacelata*. It will also combine with *Megathyrsus maximus* and *Cenchrus purpureus*.

Alfalfa: may be associated with *Bromus spp*. (cooler upland environments), *Cenchrus ciliaris, Chloris gayana, Megathyrsus maximus, Panicum coloratum, Setaria incrassate*.

C. Climbing plants

Peas: may be associated with *Chloris gayana, Digitaria eriantha* (pangola grass), *Megathyrsus maximus, Cenchrus clandestinus, C. purpureus, Setaria sphacelata, Urochloa decumbens* in a pasture.

Mucuna: Velvet bean is very vigorous and its growth suppresses companion species. No association.

Fodder trees

Leucaena: may be associated with *Cenchrus ciliaris, Chloris gayana, Megathyrsus maximus, Panicum coloratum* in sub-humid environments. In the humid tropics, *Digitaria eriantha*

Calliandra: Has been grown as a hedgerow in signal grass (*Urochloa decumbens*), buffalo couch (*Stenotaphrum secundatum*), guinea grass (*Megathyrsus maximus*) pastures and in stands of *Imperata cylindrica.*

L O 2.5 – Fence and Paddock the pasture

- Content/Topic 1: Importance of the pasture fencing

Fencing is important for:

- Excluding non-farm animals' access to the pastures.
- Controlling grazing.
- Allowing for paddocks hence rotational grazing.
- Helping farmer to implement pasture improvement techniques.
- Protection of fodder banks.

- Content/Topic 2: Pasture fencing methods

The popular methods of fencing in Rwanda are:

- Fencing posts and barbed wire

- Live hedges

A. Fencing posts and barbed wire



Picture 30: Fencing with posts and barbed wires and Woody fencing

These are quite expensive, in terms of cost and assembly. They cannot be transported easily.

Bush poles are cheaper but are attacked by termites and need frequent replacement.

Treating these poles with used engine oil reduces termite attack and reduces rate of damage.

Suitable tree species like *Ficus* spp. can be used as live fence posts because they root and require no frequent replacement. Treated posts, if affordable, with barbed wire make a durable fence.

B. Live hedges



Picture 31: Live hedges of ficus spp and of bamboo

These are cheaper and last for a long time. When well established, they also keep intruders away. The maintenance costs, in terms of trimming, may be high. Trees for live hedges include *Euphorbia tirucalli*, *E.candelabrum* and *Erythrina abyssinica*.

- Content/Topic 3: Paddocking system

A. Definition

Paddocking (Rotational grazing) involves fencing a pasture into several small paddocks. Subdivision is a useful way to balance livestock needs with forage supply .The recommended paddock size is 1ha but this can be varied depending on the land available and the number of animals on the farm.

B. Importance of paddocking system

Paddocking has many advantages to the pastures grazing system:

- Paddocking enables rotational grazing. It is possible to limit the use of pastures to specific periods and particular animals.
- Livestock graze paddocks in series, moving to a new paddock when the forage is ready for grazing. In general, put livestock into a paddock when the forage is 25-30cm tall; remove livestock when the pasture is grazed down to 8cm .A relatively high stocking rate for the size of the paddock forces the animals to be less selective.
- Rotational grazing ensures pasture re-growth and helps to maintain or improve the condition of the pasture.
- Graze any given paddock for a period of 1 to 2 weeks followed by a 4 to 8 week of rest period.

This will result in optimum production of pasture and force a break the life cycle of most internal parasites that may be present. The grazing and resting periods should be flexible depending on weather conditions.

C. Paddocks size

How Large Should A Paddock Be?

Paddocks are going to vary in size based on several factors: topography of the land, soil fertility, and soil production potential.

Sizing paddocks should start by considering how many animals you expect to graze in a group. Plan for an average amount of forage in the paddock that would be available to feed those animals for four or five days.

Sizes can be adjusted using temporary fencing based on the amount of forage available in the field at any given time. It typically takes several years of grazing a paddock to learn what size works best during certain times of the year.

When extra forage is available, especially during the spring of the year, these fields can be harvested as hay to prevent the plants from becoming mature and their feed value decreasing. Therefore, when pastures

are growing rapidly, graze those fields that do not lend themselves to mechanical harvesting. During the drier and slower growing months of the year, the animals can graze fields more easily harvested for hay.

How Long Should the Pasture Rest?

Pasture rest periods vary greatly throughout the growing season. When pastures are growing rapidly in the spring, many producers will use a faster rotation, sometimes referred to as flash grazing, in order to graze the tops off the plants and delay flowering and seed production. This keeps the animals grazing high quality forages, while waiting for plant growth to slow as the temperatures increase, the soil becomes drier and plant growth decreases. At this time of the year, rest period may be as short at 10 days.

Once the weather changes to hot days and dry soil conditions, plant growth slows considerably. During the summer months, pasture rest periods may increase to as much as 45 days or longer.

L O 2.6 – Supply water

Water accounts for 50-80 per cent of an animal's overall weight and is involved in every physiological process.

Managing water quality should be as important as the feed source and ration planning in any livestock management program.

- Content/Topic 1: Importance of supplying water in the pasture

During a drought, a lack of drinking water is often a bigger problem for livestock than a lack of forage. Livestock are removed from pastures with adequate feed left in them because there's no drinking water after the pond or stream dries up. Ensuring reliable, adequate drinking water can help guarantee that it's always possible to utilize forage when it's available.

The **advantages** of abundant, clean water include:

- Ensure high production and good health
- Increased dry matter intake
- Increased average daily gains
- Increased milk production
- Decreased potential for illness and disease
- More efficient grazing and forage management
- Improved manure distribution

The **disadvantages** of limited water availability and/or poor water quality are:

- Reduced dry matter intake
- Inefficient average daily gains
- Reduced milk production
- Increased susceptibility to heat stress
- Illness or death caused by certain algal blooms or other water quality pollutants
- Inefficient grazing and forage management
- Concentrated manure distribution

- Content/Topic 2: Sources of water

A. Dam

Farm dams are essential infrastructure for many farming operations, including for livestock and irrigation. Healthy farm dams can provide higher quality drinking water for livestock, improve your farm's productivity and provide habitat for a wide variety of native wildlife.



Picture 32: Dam as source of water in the pasture

B. Wells

A general term used for a man-made excavation, constructed for the purpose of drawing water from, or monitoring, the groundwater system.

Old wells were often dug by hand and relatively shallow, the depth being limited by the ability of the diggers to pump or lift water out of the hole as they deepened it - it was not possible to dig by hand under water.

The two main types of wells are **bored wells** and **drilled wells** :

- **Bored wells:** are generally constructed where the groundwater source is relatively close to the surface (30 metres) and are usually large-diameter installations. In the prairies, 76 millimetres (mm) is the most common diameter.
- **Drilled wells**: are smaller in diameter and are typically constructed to reach much greater depths.

Because bored wells are shallow, they are affected more by variations in precipitation (recharge) than drilled wells. However, the large diameter of a bored well effectively means that the well itself potentially could provide some storage.

Unless the well is a flowing artesian well, a pump will be required to extract and distribute the water.

C. Borehole

It is a particular type of well - a narrow hole in the ground constructed by a drilling machine in order to gain access to the groundwater system. Boreholes are usually narrow (typically 150 mm (6 inches) in diameter) and can be constructed quickly.

Learning Unit 3 – Manage pasture grazing

When managing a grazing livestock, the farmer should make best use of the whole pasture, to maximize the production while avoiding the deterioration of the pasture. For that, he must be able to determine the carrying capacity of that field, depending on his grass and its production. In case of a poor quality pasture, he must be able to improve the quality of the grass. Furthermore, he must be able to manage his entire pasture to optimally and homogeneously exploit it through paddocks.

L O 3.1 – Organize the herd and flock in the pasture

- Content/Topic 1: Herd/flock composition

Herd structure means the proportion (in terms of number of head) of the herd of a single species which is formed by different age and sex classes of animals.

In grazing it is advisable to give the first grass, of better quality, to the group that needs a better feed; the second group will then graze the already partially grazed pasture, with a lower quality grass. The table below shows the herd structure for different species of animals.

Table 4: Herd composition for different species of animals

Sex	Cow	Sheep	Goat	Pig
Male	bulls, young, steers(the	rams, intact males, wethers	bucks, buck	boars, piglets,

	castrated male of cattle especially one raised for beef), immature steers, mature steers, calves weaned and suckers	(castrates), lambs, hogget (young sheep of either gender from about 9-18 months of age)	kids, intact males, castrates	feeder pigs, hogs
Female	Calves, cows in milk, dry cows, heifers not yet calved, bred heifers, virgin heifers, yearlings (1-2 years old animal).	ewes, lambs, hoggets	does, lactating does	gilts, sows, weaners (weaned pigs)

- Content/Topic 2: Considerations when organizing herd or flock in the pasture

When organizing herd of flock in the pasture the following factors should be considered:

- **Animal species:** Animal species should be considered because varies in size and utilize pasture differently
- **Ages:** As the age increases, the animal daily feed intake increase
- **Animal Productivity:** The type of production will influence the use of pasture by animals
- **Pasture carrying capacity:** The number of animals the pasture will support in a year should be considered when organizing a herd to avoid pasture overgrazing.
- **Pasture fodder nutrients content:** The nutritive value of pasture fodder should be evaluated to meet daily animal nutritional requirement.
- **Animal nutritional requirements:** This is crucial factor when organizing herd in pasture because it help to know the number of animals to graze the pasture.

L O 3.2 – Estimate pasture productivity

- Content/Topic 1: Techniques of pasture productivity estimation

A. Definition of Pasture productivity

The productivity of a pasture is biomass formed during a specific time (usually one year), on a given area. The latter depends on several factors (type of grass, soil richness, rainfall...).

This production is always estimated in kg of DM / ha.

B. Techniques of pasture productivity estimation

Pasture productivity is done by Determining the location of the plots, that is to say the squares of 4 to 25 m^2 (Representative samples of the plant cover), and protecting them by a fence if they are still grazed by cattle. Making a regular mowing each time cattle could graze. We weight the grass (fresh matter), and after we dry in oven at 105° C to determine the dry matter weight.

By summing annual cuts, we obtain the production level per year of a plot, from which we calculate the productivity of the whole pasture (the productivity is to say, DM/ha/year and production that is to say the production of the whole pasture).

L O 3.3 – Calculate pasture carrying capacity

- Content/Topic 1: Carrying capacity calculation

A. Definition of Carrying capacity

The term "carrying capacity" is a measure of the number of animals that can be placed on a pasture reported on an average per day and throughout the year to achieve a targeted level of animal production without causing deterioration of the pasture resource.

B. Carrying capacity calculation

The carrying capacity can be determined using the following formula:

$$\textbf{Number of animals} = \frac{Pasture\ size\ x\ pasture\ yield\ per\ hactare}{Daily\ intake\ x\ average\ animal\ weight x\ Days\ of\ grazing}$$

The formula is completed with the following:

- Pasture size in hectares
- Pasture yield in kilograms per hectare of dry matter
- Daily intake of stocked animals
- Average animal weight in pounds for the grazing herd
- Length of the grazing season in days

Example:

Determine the number of 400kg cows that a 50ha pasture will support for 100 days, given a pasture yield of 3,000 kg of dry matter per ha.

$$\textbf{Number of animals} = \frac{50haX3000kg}{0.025X400X100days}$$

Number of animals = 150

L O 3.4 – Apply pasture rotation and ranching method

- Content/Topic 1: Rotational grazing systems

A. Importance of rotational grazing

The pasture area is divided into two or more sub pastures, also called "paddocks," with each sub pasture being grazed and "rested" in turn.

Putting the whole herd in a small paddock results in rapid use of available forage. When a paddock is grazed off, animals are moved to a fresh one, allowing each paddock to be grazed clean and to have a rest period. The rest period is critical for the continued productivity of some forage species.

Rotational or periodic grazing is usually recommended for the following advantages**:**

- Prevention of pasture overgrazing
- Prevention of loss of soil through erosion
- High level of pasture productivity
- Control of internal and external parasites.

Time that animals are on a paddock is referred to as the **grazing period**; time off the paddock is the **rest period**.

B. Calculating paddock size and number

Two questions that will immediately come up for someone think a rotational grazing system are:

- How many paddocks should I have?
- How big should the paddocks be?

Essentially, answers to these two questions can be easily acquired by utilizing the following formulas:

Paddock number $= \frac{\text{Rest period(days)}}{\text{Grazing period(days)}} +$ Number of animal groups

Number of animal groups: is the subdivision of the herd in general, the herd is divided into two groups: dairy cows and young calves (group 1) and other animals (group 2).

Then, to calculate the size of each paddock in hectares, use this formula:

Paddock size$=\frac{\text{Daily herd forage requirement(kilograms)X grazing period(days)}}{\text{Avaible forage per hectares(kg)}}$

- Content/Topic 2: Ranching system

A. Definition of Ranching

A rang or ranch is extensive grazing land (pastures) usually covering several hundreds of hectares. The pasture is usually growing grass which may be improved by oversowing, fertilizer application, and weeding out undesirable shrubs and grass species.

B. Ranch management

In addition to rotation grazing and short season grazing there are two other ways of keeping the range land productive with adequate forage for grazing. It can be achieved by controlled grazing, controlled stocking and reseeding.

Deferred grazing

Here one paddock or area of the range land is left ungrazed every year. This allows seeds to develop, drop and germinate, thus maintaining the botanical composition of the pasture. Ticks decrease in number if cattle are absent for four months.

Continuous grazing

The stocking rate is one animal to between two and five hectares and the land is grazed continuously. This is suitable where large areas of land are available. Continuous grazing has disadvantages in that all nutritive species of pasture disappear with time due to selective grazing, and animals generally do not meet their nutritional requirements. There may also be a buildup of internal worms.

Distribution of animals

Even distribution of animals on the ranch is important to avoid overgrazing certain areas. It is achieved by fencing, both perimeter and internal division fences, or by herding, which however is expensive. Distribution of animal can also be achieved by providing water at various points rather than having only one where animals crowd.

Water supply should be adequate, reliable and clean. It may be obtained by construction of earth dams, tapping natural streams, dipping wells, or use of natural springs.

Mineral licks should be moved from time to time as leaving them in one place leads to overgrazing and destruction of pasture in that particular area.

Breeding season and time of calving

On a ranch it is appropriate to have regulated breeding and calving times instead of letting the animals breed and calve at random. This enables a number of animals to mature simultaneously so that a farmer has a larger number of animals to market at the same time. In Rwanda unlike temperate regions, it is possible to have two breeding and calving seasons in a year. That is, April to June and October to December. These are times when there is plenty of pasture, and there is less menace from warble flies and incidence of diseases

Round up

This refers to the times of bringing in animals at least twice a year, for example, between April and June, and October and December, which could coincide with the breeding seasons and calving times.

The purpose of round up is:

- To do assessment of the animals
- To castrate the male
- For identification of the animals, usually by branding
- To vaccinate, spray, dip or otherwise treat against diseases such as anthrax, foot and mouth disease, rinderpest etc.
- To take an accurate count of the stock
- To separate breeding animals from steers and heifers
- To wean calves
- To cull and market selected animals.

- Content/Topic 3: Grazing habits of livestock

Grazing habits of different animals

Different animal species have different grazing behaviors. In addition, the animals eat different forage species in different ways. If grazing more than one species of livestock, it is best to graze the picky (selective) grazers first and follow with the less picky grazers (e.g., horses or cattle followed by sheep or goats.

Cattle

Cattle typically tear off large mouthfuls of forage. Older cows are spotty eaters. They avoid zones near manure drops and eat other areas very close to the ground. With proper grazing supply management, yearlings graze quite uniformly, often to the base of leaves.

Horses

Horses are spotty eaters and tend to bite off forage close to the ground. They are extremely picky grazers and rarely touch weeds and woody species.

Sheep and goats

Sheep and goats bite off plants close to the ground, which may lead to overgrazing when forages are rare. Close grazing by sheep and goats couples with their sharp hoof action may lead to erosion problems, especially on overgrazed slopes. Goats prefer the leaves and stems of woody plants over grass and can be used to clear land. Sheep will eat more weeds.

Pigs

Pigs, natural rooters, may eat entire plants, root and all, which they dig and pull out of the ground with their snouts; this is very disruptive to a pasture. They are excellent grazers, however, when snout rings prevent them from rooting.

Learning Unit 4 – Improve nutritive value of crops residues and straws

Crop residues are the fibrous parts of plant that remain after the harvest of crop for human consumption. Amongst crop varieties, the cereal crops produce large quantities of stem and leaf besides crop harvest, which become part of livestock diet for conversion into economic products.

Crop residues are produced in crop farming systems. Most of them are normally left as waste or as mulch in the field or they are burnt.

Crop residues have common characteristics:

- Poor palatability
- Low in crude protein (mostly below 6%)
- High in cellulose and other structural carbohydrates (crude fiber)

- Low digestibility
- Low in calcium and phosphorus

L O 4.1 – Identify crops residues

- Content/Topic 1: Identification of crop residues

A. Common crop residues

Table 5: Common crop residues

Cereals	Legumes	Others
Maize stoves	Beans haulms	Banana pseudo steam
Sorghum stove	Soya beans haulms	Banana peelings
Barley straws	Groundnut haulms	Potato vines
Wheat straws	Cowpea haulms	Stripped maize leaves
Rice straws	Pigeon pea husks	Sugar cane tops
Finger millet straws		Vegetables wastes
		Cassava leaves
		Potato peelings

L O 4.2 – Improve crops residues and straws qualities

- Content/Topic 1: Methods of improving crop residues and straws quality

Several methods have been developed to improve the quality of crop residues, but chemical treatment has received the most attention.

Physical methods (chopping)

Chopping straw to 5 cm or a little longer before feeding is a common practice.

Importance of chopping

Scientific tests have shown that chopping does not improve straw digestibility, but:

- It does increase intake,
- Reduces wastage and
- Makes it easy to mix the straw with other feed components.

There is also **the salting method,** in which chopped straw is soaked in a dilute salt solution before feeding.

Supplementation and using additives

Supplementation of crop residues with grasses, legumes or concentrate feeds significantly improves feed intake and animal performance.

In dry land farming systems where forages are scarce, crop residues are supplemented with concentrate feeds.

Supplementation of the basal diet with good-quality forage or concentrates helps to overcome the problem of low palatability.

A. Treatment of crop residues with urea

Urea treatment purpose

The urea is converted to ammonia, which then breaks down some of the bonds in the fibrous material, making them accessible to microbial enzymes.

Urea can be used to improve the feed ration quality of the basic ration including forage, especially straws or crop residue that are low in nitrogen.

Indeed, microorganism in the rumen must regularly have nitrogen easily usable to well use low nitrogen roughage.

The role of urea is then to feed rumen microorganisms, and thus to increase forage digestibility.

Intoxication with urea

Acute urea poisoning quickly causes (20mn-2 hours) muscular contractions excessive salivation, tetany, falls, defective breathing and even death.

Intoxication by small dose of urea cause in long –term the presence of liver cirrhosis, ketosis, acetonemia and bloat, because the distribution of urea in excess contributes to the production of an exces of NH_3.Remedy in that case is to apply the dose to distribute and enough energy in the feed ration.

Urea is only used for cattle and other polygastrics animals. An animal with no microorganisms for pre-digestion (monogastrics) cannot degrade urea. The urea becomes toxic to the animals because it is absorbed as such into the intestine and causes liver problems.

Urea treatment techniques

Treating crop residues with 4% urea solution at 45–50% moisture improves the nutritive value by increasing the digestibility, palatability and crude protein content.

The chopped material is soaked in urea solution mixed at the rate of 4 kg urea (fertilizer grade) in 100 litres of water (4%).

The urea-water solution is sprinkled on batches of the chopped material as it is added to the pit.

The mixing can be done in the pit or on a plastic sheet on the ground before packing the pit. It is commonly recommended that the pit remains closed for at least 3 weeks and preferably 1 month, but treatment times longer than necessary do not have adverse effects.

Urea treatment procedure:

- weigh the straw to be treated
- weigh an equal amount of water to that of the straw
- add 40gm of urea per kg of straw and mix it thoroughly in water
- soak the straw into the mixture for 6 hours
- drain the straw and feed it to the cattle

B. Treatment of crop residues with molasses

Two syndromes can occur with molasses, both when there is very little other feed for cattle to eat: molasses toxicity and molasses bloat.

Molasses toxicity

The flow rate through the rumen is so slow that Vitamin B is destroyed. So the syndrome is actually a vitamin B deficiency and presents as ‘molasses drunkenness’; i.e. the animals stagger around blinded. Treatment with either a Vitamin B injection or green feed (e.g. lucerne) is usually spectacularly successful.

Prevention is simply achieved by adding salt at 1% to the mixture, and providing extra dry matter, even if it is a small amount of low-quality roughage. Both increase the flow rate through the rumen, thereby denying the opportunity for breakdown of all the Vitamin B.

Molasses bloat

The rumen blows up with the formation of a foam. Cattle can go down and die from respiratory failure, simply because of the pressure on the lungs. Treatment is the standard treatment for bloat.

Prevention is the same as for molasses toxicity, and is very effective. Bloat often occurs when cattle have a rapid intake of a molasses-protein meal mix after a period without feed, e.g. when intakes are being controlled by intermittent feeding.

Molasse treatment purpose

Most animals find molasses very palatable and it is often used to mask the taste of unpalatable ingredients such as urea and straws.

It is viscous and helps to bind small particles such as mineral and vitamin sources into the mass of mixed food. Molasses is widely used as an animal food ingredient and has been used as an animal food ingredient.

Molasse treatment techniques

However, molasses should not be used at more than about 20% of the diet. Because ruminants given molasses-based diets grow more slowly than when grain is used as the major energy source, even when the protein and mineral deficiencies of molasses are rectified. This poorer performance is partly due to the high mineral content which can lead to diarrhea and partly to the predominance of acetic and butyric acids in the end products of rumen fermentation. Molasses is not suitable for pre-ruminant calves, kids or lambs because they do not have an endogenous sucrose.

For overcoming the problems caused the use of molasses most farmers use urea–molasses solution which provide both to provide energy, protein and minerals to ruminants and thus improve the digestion of crop residues such as straw.

Note: The recommended ratio is 4kg urea: 10kg molasses: 80 -100 lit of water: 100kg of straw/Stover.

Preparation of water-urea-molasses-solution

Materials:

- Cut Jericans in small portion at the top and similar utensils with capacity enough to treat the prepared straw. For spraying the mixture of water-urea-molasses solution, farmers have used any can like utensils mainly with nozzle.
- For weighing urea, farmers have used a jug measuring 1 kg.
- For measuring water, they have used plastic buckets.
- For weighing straw, farmers used certain suck like material commonly found at home of individual farmer which, previously confirmed by weighing certain amount of straw.
- Fertilizer grade urea was employed for the treatment.

Procedure:

- The ratio of water-urea-molasses solution to straw was 1:1 (100 liters of solution for 100 kg of straw).
- To prepare 100 liters of solution, 5kg urea was added to 100 liter of water and stirred very well until urea was dissolved and clump of urea was disappeared from the solution.
- Then 10-liter of molasses was added and stirred very well until the molasses and the urea solution gets mixed up.
- The level of urea varies from country to country but is commonly between 4 and 5% of the air dry mass of straws or stovers.

The treatment period was 1 month. The treatment period can be as low as 7 days in warm climate and up to 8 weeks in cold climate

L O 4.3 – Use of crops residues and straws

- Content/Topic 1: Estimation of crop residues amount to use

Use crops residues

Crop residues can be used for feeding dairy cattle but cannot supply adequate nutrients without supplementation. Because of their low digestibility they remain in the rumen for a long time, limiting intake.

Crop residues should not be fed in large amounts to growing animals. If used, they should make up no more than 25% of the diet with the remainder comprising high quality feeds.

Table 6: Crop residues amount to use

Treatment method	Ingredients			
	Amount (kg)	Straw/stover (kg)	Water (kg)	Molasses (kg)
Urea	4-6	100	100	0
Urea-molasses	4-6	100	80	10

- Content/Topic 2: Benefit and Limitation of using crop residues

A. Benefit of using crop residues

The use of crop residues has benefit to the livestock such as:

- They can be an important source of animal feeds especially during the dry season

- They work well when used for mulching fields
- Legume crop residues have high protein and better feeding value than cereal residues.

B. Limitation of using crop residues

Unfortunately, the use of crop residues ha limitation:

- They are generally low in protein, energy, minerals and vitamins.
- They have a high fiber content resulting in low digestibility and intake.
- The can only provide enough nutrients for general body maintenance rather than for production. It is therefore necessary to supplement crop residues with planted fodder or concentrate feeds to improve their quality.
- They are also bulky, making their transportation and storage difficult and in addition often require forage choppers for processing.
- Some crop residues contain anti-nutritional factors like tannin and silica.
- Lack of synchronized planting time and scattered small farms makes uniform harvesting difficult.
- When they are used as feed, it is important to return manure to the field to restore the soil structure and add some nutrients for the next crop.

Table 7: Constraints to better utilization of crop residues and suggested remedies

Constraint	**Suggested remedy**
Low digestibility	Treat with alkali or urea to increase digestibility
Low fermentable nitrogen	Supplement with urea or poultry manure
Low bypass protein and low dietary fat	Supplement with bypass protein containing lipid, eg. Oilseed meal and fish meal
Low minerals	Add mineral nutrients especially sulphur
High fibre and low rate of passage	Supplement with legume fodder or young grass at 2 kg DM/100 kg LW

References

1. Aregawi T, Melaku S, Nigatu L. (2008); *Management and Utilization of browse species as livestock feed in semi-arid district of northwest Ethiopia*. Livest Res Rural Dev. 20(6).

2. Blum, F. et al. (2013). *Estimating livestock technical conversion factors*. Ministry of Livestock and Fisheries

3. Bogdan, A.V. (1969) Review article: *Rhodes grass*. Herbage Abstracts 39:1–13.

4. Bogdan, A.V. (1977) *Tropical Pasture and Fodder Plants*. Longman Inc., New York, USA. p. 1–215.

5. Daniel Kiftassa, 1988. *Role of crop residues as livestock feeds in Ethiopian Highlands*. pp. 430-439.

6. Dessalegn Molla. 2015. *Urea molasses multi-nutrient block production and utilization manual*. BDU-CASCAPE working paper 13. Pp. 9.

7. Evans, D.O. (1996) *Proceedings of the International Workshop on the Genus Calliandra*. Winrock International, Morrilton, AR, USA.

8. Ferguson, J.E. (1969) *Characterisation of introductions of Glycine javanica L. Queensland Journal of Agricultural and Animal Sciences*. 26:517–528.

9. Gibb, M.J. and Treacher, T.T. (1976). *The effect of herbage allowance on herbage intake and performance of lambs grazing perennial ryegrass and red clover swards*. Journal of Agricultural Science, Cambridge 86, 355–365.

10. Grönwall, J.; Oduro-Kwarteng, S. (2018), Groundwater as a strategic resource for improved resilience: A case study from peri-urban Accra. Environ. Earth Sci., 77, 6.

11. Hacker, J.B. (1992) *Desmodium intortum* (Miller) Urban. In: Mannetje, L.'t and Jones, R.M. (eds) Plant Resources of South-East Asia No. 4. *Forages. Pudoc Scientific Publishers*, Wageningen, the Netherlands. p. 114–115.

12. J.D. (ed) (1959). *The Measurement of Grassland Productivity*. London: Butterworths; t'Mannetje.

13. Love, R. M. (1944). *Preliminary trials on the effect of management on the establishment of perennial grasses and legumes*. Davis, California. Agronomy Journal 36: 699-703.

14. Mackey, A.P. (1996) *Prickly Acacia (Acacia nilotica) in Queensland.* Department of Natural Resources and Mines, Brisbane, Queensland, Australia.

15. Mannetje, L.'t (1992) *Pennisetum purpureum* Schumach. In: Mannetje, L.'t and Jones, R.M. (eds) Plant Resources of South-East Asia No. 4. Forages. Pudoc Scientific Publishers, Wageningen, the Netherlands. p. 191–192

16. Preston T. R., (1995). *Tropical animal feeding. A manual for research workers*. FAO Animal Production and Health Paper 126. FAO. Rome.

17. Teshome Derso. 2009. *On-farm Evaluation of Urea Treated Rice Straw and Rice Bran Supplementation on Feed Intake*, North Western Ethiopia.MSc. Thesis, Haramaya University.

18. https://www.pseau.org/outils/ouvrages/iahs_hand_dug_water_wells_a_vanishing_technology_2001.pdf (retrieved on October, 15th 2020)

19. http://www.TeAra.govt.nz/en/1966/pastures/page-3 (retrieved on October, 15th 2020)

20. http://www.fao.org/docrep/014/i2270e/i2270e00.htm (retrieved on October, 16th 2020)

21. http://www.webpages.uidaho.edu/rx-grazing/Handbook/ASITargetGrazingBook2006.pdf. (retrieved on October, 16th 2020)

22. https://globalrangelands.org/rangelandswest/glossary. (retrieved on October, 16th 2020)

23. http://extension.missouri.edu/publications/DisplayPub.aspx?P=MWPS14(retrieved on October, 18th 2020)

24. https://www.animalsciencepublications.org/publications/jas/pdfs/15/3/JAN0150030722. (retrieved on October, 18th 2020)

25. https://www.agric.wa.gov.au/sites/gateway/files/Hughes%2C%20Colin%20-%20Leucaena-species%20diversity%20and%20genetic%20resources.pdf (retrieved on October, 25th 2020)

26. https://hort.purdue.edu/newcrop/duke_energy/Calliandra_calothyrsus.html (retrieved on October, 25th 2020)

27. https://www.tropicalforages.info/text/entities/index.htm (retrieved on October, 25th 2020)