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ANS409

PASTURE AND RANGE PRODUCTION AND MANAGEMENT

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Course code: ANS 409

Course title: Pasture and Range Production and Management

Course credit load: 2 Units

Series 1 Adaptation and Botany of Pasture and Forage Plants

Part 1.1 Adaptation of Pasture and Forage Plants

- Sub-Part 1.1.1 Ecological requirements and adaptation to tropical environments
- Sub-Part 1.1.2 Factors influencing adaptation (climate, soil, management)

Part 1.2 Botany and Characteristics of Grasses

- Sub-Part 1.2.1 Morphological features of grasses
- Sub-Part 1.2.2 Growth habits and ecological roles

Part 1.3 Botany and Characteristics of Legumes

- Sub-Part 1.3.1 Morphological features of forage legumes
- Sub-Part 1.3.2 Roles of legumes in tropical farming systems

Part 1.4 Botany and Characteristics of Shrubs and Trees

- Sub-Part 1.4.1 Adaptation of shrubs and tree legumes
- Sub-Part 1.4.2 Importance of shrubs and trees in pasture systems

Introduction

Pasture and forage plants form the foundation of livestock production systems, providing the bulk of feed resources for ruminants. Their ability to adapt to different ecological conditions determines their survival, productivity, and usefulness in farming systems. Understanding their botany is equally important, as it enables us to identify species correctly, appreciate their growth habits, and manage them effectively. This Series therefore sets the stage for appreciating the diversity and resilience of pasture and forage plants in tropical environments.

The aim of this Series is to introduce you to the adaptation strategies and botanical characteristics of grasses, legumes, shrubs, and trees used in pasture and forage

systems. It seeks to equip you with the knowledge needed to distinguish species, recognise their ecological requirements, and appreciate their roles in animal production.

We shall commence this Series by examining how pasture and forage plants adapt to tropical environments and the factors influencing their survival. Next, we will explore the botany and characteristics of grasses, focusing on their morphology and ecological roles. Following that, we will move on to forage legumes, considering their features and contributions to tropical farming systems. Finally, we will wrap up by studying shrubs and tree legumes, highlighting their adaptation and importance in pasture systems.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define adaptation in the context of pasture and forage plants,
- **SLO 1.2** explain ecological requirements and factors influencing adaptation of pasture and forage species,
- **SLO 1.3** describe the morphological features of grasses,
- **SLO 1.4** analyse the growth habits and ecological roles of grasses,
- **SLO 1.5** describe the morphological features of forage legumes,
- **SLO 1.6** evaluate the roles of forage legumes in tropical farming systems,
- **SLO 1.7** explain the adaptation of shrubs and tree legumes, and
- **SLO 1.8** assess the importance of shrubs and trees in pasture systems.

1.1 Adaptation of Pasture and Forage Plants

1.1.1 Ecological requirements and adaptation to tropical environments

Adaptation refers to the ability of plants to adjust and survive under specific environmental conditions. Pasture and forage plants must adapt to factors such as temperature, rainfall, soil type, and light availability in order to thrive. In tropical environments, adaptation often involves tolerance to high temperatures, seasonal rainfall patterns, and sometimes poor soils.

For example, tropical grasses such as Panicum maximum are adapted to withstand high solar radiation and irregular rainfall, while legumes like Stylosanthes can tolerate acidic soils. Adaptation ensures that plants remain productive and resilient even under challenging conditions.

Fill in the blank: The ability of plants to adjust and survive under specific environmental conditions is called _____.

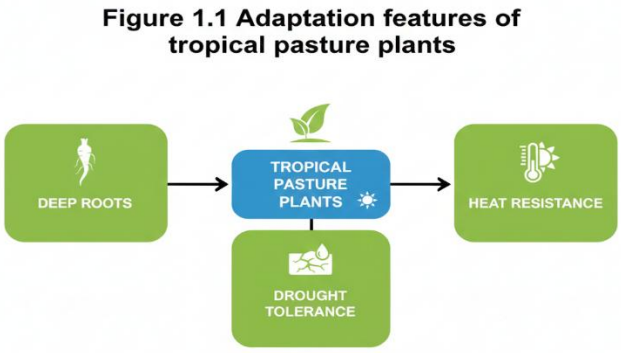

Diagram showing adaptation features of tropical pasture plants (deep roots, drought tolerance, heat resistance) Figure 1.1 Adaptation features of tropical pasture plants.

1.1.2 Factors influencing adaptation (climate, soil, management)

Several factors influence the adaptation of pasture and forage plants:

- **Climate**: Includes rainfall, temperature, and humidity. Plants adapted to humid climates may not survive in arid zones.
- **Soil**: Soil fertility, pH, and drainage affect plant growth. Some legumes thrive in acidic soils, while others require fertile, well-drained soils.
- **Management**: Practices such as grazing intensity, fertilisation, and weed control influence how well plants adapt and persist in a pasture system.

Adaptation is therefore not only a natural process but also shaped by human intervention. Farmers who manage grazing carefully and improve soil fertility can enhance the adaptation and productivity of pasture species.

Fill in the blank: Soil fertility, pH, and drainage are examples of factors that influence plant _____.

Table 1.1 Factors influencing adaptation of pasture and forage plants

Factor	Description	Example
Climate	Key atmospheric conditions, primarily rainfall (amount and distribution), temperature (extremes and average), and humidity.	Tropical grasses (e.g., Panicum maximum) are well-adapted to high rainfall and high temperatures, while temperate grasses struggle in these conditions.
Soil	Physical and chemical properties of the soil, including fertility (nutrient content), pH (acidity/alkalinity), and drainage (water-holding capacity).	Legumes (e.g., Stylosanthes) can often thrive in relatively acidic soils with low phosphorus fertility due to their nitrogen-fixing ability.
Biotic Factors	Living organisms in the environment, such as pests, pathogens, competing weeds, and symbiotic microorganisms.	Plants develop resistance mechanisms against pests and diseases native to their adapted region, or form beneficial relationships with rhizobia bacteria for nitrogen fixation.
Management	Human activities influencing the plant environment, including grazing intensity, fertilization regimes, weed control, and irrigation.	Improved adaptation (persistence) of a pasture stand can be achieved through controlled rotational grazing, which allows the plants adequate rest periods to recover.

Pilot questions 1.1

1. What does adaptation mean in the context of pasture and forage plants?
2. Give one example of a tropical grass adapted to high solar radiation.
3. State one ecological requirement that influences plant adaptation.
4. Which soil factor can affect the adaptation of legumes?
5. How can management practices influence plant adaptation?

1.2 Botany and Characteristics of Grasses

1.2.1 Morphological features of grasses

Grasses are monocotyledonous plants belonging to the family Poaceae. They are characterised by narrow leaves, hollow stems, and fibrous root systems. Their leaves usually grow in two ranks and have parallel venation. The stem, called a **culm**, is jointed and often hollow except at the nodes.

Grasses reproduce mainly through seeds, but many species also spread vegetatively using **rhizomes** (underground stems) or **stolons** (above-ground runners). These features make grasses highly adaptable and capable of covering large areas quickly.

Fill in the blank: The jointed stem of grasses, which is often hollow except at the nodes, is called a _____.

Figure 1.2 Morphological features of grasses

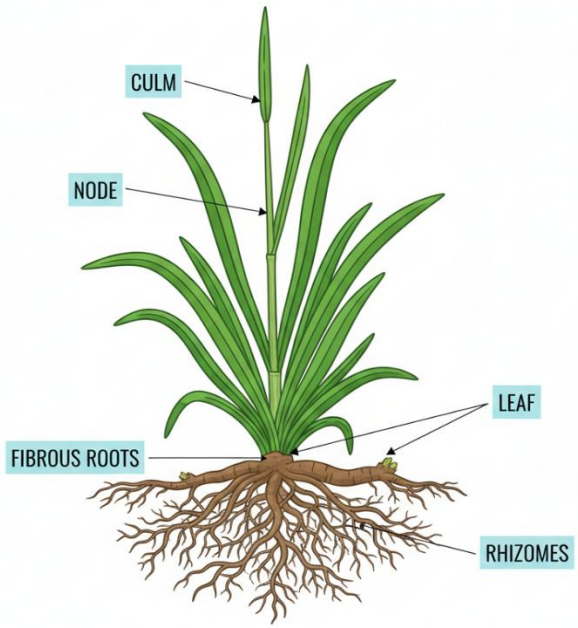

Diagram showing the morphological features of grasses (culm, nodes, leaves, fibrous roots, rhizomes) Figure 1.2 Morphological features of grasses

1.2.2 Growth habits and ecological roles

Grasses exhibit different **growth habits**, which influence their use in pasture systems. Some species are erect, while others are creeping or tufted. Creeping

grasses such as Cynodon dactylon spread rapidly and provide good ground cover, while erect grasses like Panicum maximum produce tall forage suitable for cutting.

The **ecological roles** of grasses are significant. They prevent soil erosion through their fibrous root systems, improve soil structure, and provide habitat for beneficial organisms. In pasture systems, grasses are the primary source of feed for ruminants, offering bulk energy and fibre.

Fill in the blank: Grasses that spread rapidly and provide good ground cover, such as Cynodon dactylon, are described as _____ grasses.

Box 1.2 Ecological roles of grasses in pasture systems

Role	Explanation	Impact on the Ecosystem
Soil Protection	The dense, **fibrous root system** of grasses acts as a natural net, binding soil particles together and providing excellent cover against wind and water.	Prevents **soil erosion**, especially on sloped land, and minimizes nutrient runoff into water bodies.
Soil Improvement	The extensive root mass adds **organic matter** when roots die and decompose. This activity, along with root exudates, encourages microbial growth and improves soil aggregation.	Enhances **soil structure**, increases water infiltration, and improves the soil's capacity to hold nutrients, benefiting subsequent crops or pastures.
Habitat Provision	The standing canopy and ground cover create a complex microclimate and physical structure that offers shelter, food, and breeding sites for various organisms.	Provides a **habitat** for beneficial insects (pollinators, predators), ground-dwelling birds, and vital soil fauna like earthworms.
Feed Supply	Grasses are the primary source of bulk **energy** (carbohydrates) and **fiber** (cellulose) for grazing ruminant livestock (cattle, sheep, goats).	Sustains animal production, converting solar energy into edible biomass, and maintaining the health of the ruminant digestive system.
Carbon Sequestration	Grasses remove carbon dioxide (CO_2) from the atmosphere during photosynthesis and store it as **carbon** in their roots and the soil.	Mitigates climate change by acting as a significant **carbon sink**, especially in well-managed grazing systems.

Pilot questions 1.2

1. What family do grasses belong to?
2. What is the jointed stem of grasses called?
3. Name one vegetative structure that helps grasses spread.
4. Give one example of a creeping grass species.
5. State one ecological role of grasses in pasture systems.

1.3 Botany and Characteristics of Legumes

1.3.1 Morphological features of forage legumes

Legumes are plants belonging to the family Fabaceae. They are characterised by compound leaves, swollen root nodules, and pods containing seeds. The root nodules house **rhizobia**, which are bacteria that fix atmospheric nitrogen into forms usable by plants. This makes legumes important contributors to soil fertility.

Morphologically, legumes may be herbaceous or woody. Their leaves are usually trifoliate (three leaflets), though some species have pinnate or simple leaves. The flowers are often papilionaceous, meaning they resemble a butterfly in shape, and they develop into pods that split open when mature.

Fill in the blank: The bacteria that fix atmospheric nitrogen in legume root nodules are called _____.

Figure 1.3 Morphorogial features of forage legumes

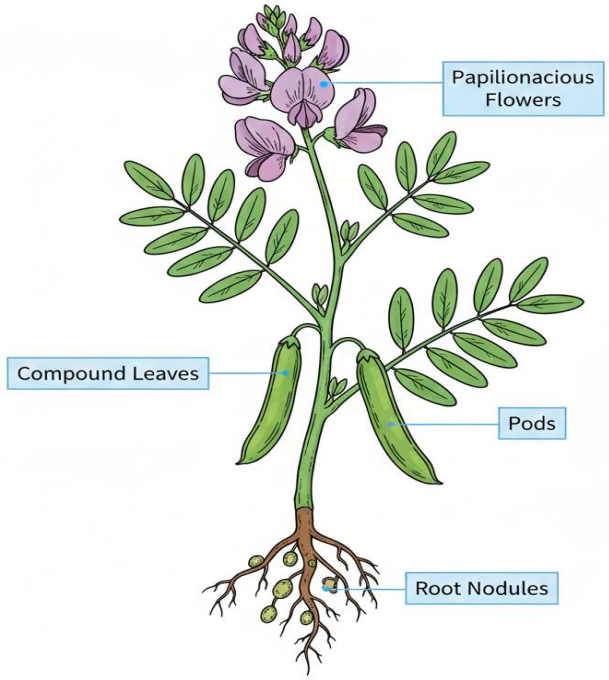

Diagram showing morphological features of forage legumes (compound leaves, root nodules, pods, papilionaceous flowers) Figure 1.3 Morphological features of forage legumes

1.3.2 Roles of legumes in tropical farming systems

Legumes play several important roles in tropical farming systems. Their ability to fix nitrogen improves soil fertility, reducing the need for synthetic fertilisers. They also provide high-protein forage for livestock, which complements the energy-rich grasses in pastures.

In addition, legumes can be used as cover crops to suppress weeds, reduce erosion, and improve soil organic matter. Shrub and tree legumes such as Leucaena leucocephala also serve as fodder banks, offering feed during dry seasons.

Fill in the blank: Legumes improve soil fertility by fixing _____ from the atmosphere into usable forms.

Box 1.3 Roles of legumes in tropical farming systems

Role	Explanation	Key Benefit
Nitrogen Fixation	Legumes form symbiotic relationships with *Rhizobia*	Significantly **improves soil fertility** and reduces the need

Role	Explanation	Key Benefit
	bacteria in their root nodules, converting atmospheric nitrogen (N_2) into plant-available forms.	for expensive, synthetic nitrogen fertilizers, making farming more economical and sustainable.
High-Protein Forage	Legume leaves and stems typically have a higher concentration of **crude protein** compared to most tropical grasses.	Provides **balanced nutrition** for livestock, improving animal performance (e.g., milk yield, growth rate) when mixed with energy-rich grasses.
Cover Cropping	When planted to cover the soil (often between cash crops), their rapid growth and ground coverage help protect the land.	**Suppresses weeds** by competing for light and nutrients, and **reduces soil erosion** from heavy tropical rainfall.
Fodder Banks and Supplements	Planted in dedicated small plots and harvested specifically to feed animals during periods of scarcity.	**Ensures feed availability** during the long **dry season** when grass quality and quantity are very low, preventing severe weight loss in livestock.
Soil Structure Improvement	Their tap roots penetrate deeper than grass roots, helping to break up compacted soil.	Improves **water infiltration** and aeration of the soil.

Pilot questions 1.3

1. What family do legumes belong to?
2. What type of bacteria is found in legume root nodules?
3. What is the typical shape of legume flowers?
4. State one role of legumes in tropical farming systems.
5. Give one example of a shrub or tree legume used as a fodder bank.

1.4 Botany and Characteristics of Shrubs and Trees

1.4.1 Adaptation of shrubs and tree legumes

Shrubs are woody plants smaller than trees, usually with multiple stems, while **tree legumes** are taller woody plants belonging to the family Fabaceae. Both shrubs and tree legumes are important in pasture systems because they adapt well

to tropical environments. Their deep root systems allow them to survive drought conditions, and their ability to fix nitrogen improves soil fertility.

Examples include Leucaena leucocephala and Gliricidia sepium, which are widely used in tropical farming systems. These species can withstand poor soils and irregular rainfall, making them reliable sources of forage during dry seasons.

Fill in the blank: Woody plants belonging to the family Fabaceae that improve soil fertility through nitrogen fixation are called tree _____.

Figure 1.4 Adaptation features of shrubs and tree legumes

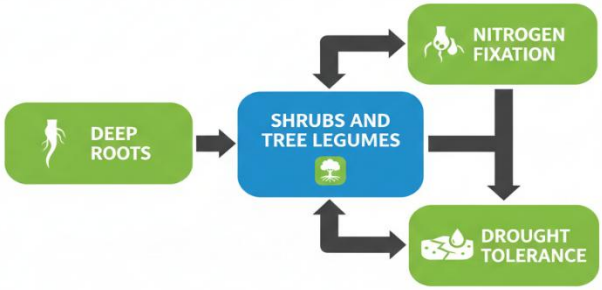

Diagram showing adaptation features of shrubs and tree legumes (deep roots, nitrogen fixation, drought tolerance) Figure 1.4 Adaptation features of shrubs and tree legumes

1.4.2 Importance of shrubs and trees in pasture systems

Shrubs and trees play multiple roles in pasture systems. They provide high-protein forage, especially during dry seasons when grasses are scarce. Their deep roots stabilise soils and reduce erosion, while their canopy offers shade for animals. In addition, they contribute to agroforestry systems by improving soil organic matter and supporting biodiversity.

Tree legumes such as Leucaena are also used in fodder banks, ensuring feed availability throughout the year. Their leaves are palatable and nutritious, making them valuable supplements to grass-based diets.

Fill in the blank: Shrubs and trees are particularly important in pasture systems because they provide high-_____ forage during dry seasons.

Box 1.4 Importance of shrubs and trees in pasture systems

Role	Explanation	Key Benefit
Forage Supply (Browse)	Many tree and shrub legumes (e.g., *Leucaena*) retain their leaves and high nutritional value, including protein, long after herbaceous plants have dried up.	Provides high-protein feed during the **dry season**, preventing weight loss and improving the overall nutrition of livestock.
Soil Stabilization	The extensive, **deep root systems** of woody plants anchor the soil over large areas and at depth, making them highly resistant to removal.	Significantly **reduces soil erosion** from wind and heavy rainfall, especially on hilly or degraded lands.
Shade Provision	The tree canopy breaks the intensity of direct solar radiation and wind, lowering the ambient temperature underneath.	Offers **shelter and thermal comfort** for grazing animals, reducing **heat stress**, which in turn improves feed intake and productivity (e.g., milk production).
Agroforestry Contribution	Their leaf litter contributes organic matter, and, for legumes, their root systems fix nitrogen deep in the soil profile.	**Improves soil organic matter**, soil structure, and overall **biodiversity** of the pasture system, promoting sustainability.
Nutrient Cycling	Deep roots can draw up nutrients (like phosphorus and calcium) from deeper soil layers unavailable to shallow-rooted grasses.	Redistributes nutrients to the topsoil through leaf drop, making them accessible to pasture grasses and annual crops.

Pilot questions 1.4

1. What family do tree legumes belong to?
2. Give one example of a shrub or tree legume used in tropical farming systems.
3. State one adaptation feature of shrubs and tree legumes.

4. Why are shrubs and trees important during dry seasons?
5. Mention one ecological role of shrubs and trees in pasture systems.

Series Summary

This Series has introduced you to the adaptation and botany of pasture and forage plants, which form the foundation of livestock production systems. The purpose was to help you appreciate how these plants survive in tropical environments and to recognise their structural features and ecological roles. By studying adaptation, grasses, legumes, shrubs, and trees, you have gained insight into the diversity and resilience of species used in pasture systems.

We began by examining how pasture and forage plants adapt to ecological conditions such as climate, soil, and management. Then we explored the botany of grasses, focusing on their morphology and ecological roles. Following that, we studied forage legumes, highlighting their nitrogen-fixing ability and contribution to tropical farming systems. Finally, we considered shrubs and tree legumes, emphasising their adaptation and importance in pasture systems. In line with the Series Learning Outcomes, you should now be able to define adaptation, explain ecological requirements, describe morphological features of grasses and legumes, analyse their roles, and evaluate the importance of shrubs and trees in pasture systems.

Concept Check Questions [Series 1]

Objective questions

1. Which family do grasses belong to? a. Fabaceae b. Poaceae c. Solanaceae d. Asteraceae (Linked to SLO 1.3)
2. What is the jointed stem of grasses called? a. Rhizome b. Culm c. Stolon d. Node (Linked to SLO 1.3)
3. Which bacteria are found in legume root nodules? a. Azotobacter b. Rhizobia c. Nitrosomonas d. Clostridium (Linked to SLO 1.5)
4. Which of the following is an example of a tree legume? a. Panicum maximum b. Cynodon dactylon c. Leucaena leucocephala d. Stylosanthes guianensis (Linked to SLO 1.7)
5. Which growth habit describes grasses that spread rapidly and provide ground cover? a. Erect b. Creeping c. Tufted d. Woody (Linked to SLO 1.4)

Short-answer questions

1. Define adaptation in the context of pasture and forage plants. (Linked to SLO 1.1)
2. State one ecological requirement influencing plant adaptation. (Linked to SLO 1.2)
3. Give one example of a creeping grass species. (Linked to SLO 1.4)
4. Mention one role of legumes in tropical farming systems. (Linked to SLO 1.6)
5. State one importance of shrubs and trees in pasture systems. (Linked to SLO 1.8)

Long-answer questions

1. Analyse the morphological features of grasses and explain how these features support their ecological roles. (Linked to SLO 1.3, SLO 1.4)
    - Basic response: Grasses have narrow leaves, hollow culms, fibrous roots, and vegetative structures such as rhizomes and stolons. These features allow them to spread quickly, stabilise soils, and provide bulk forage.
    - Value-added response: Outstanding learners may also highlight how these features contribute to resilience under grazing pressure, adaptation to diverse climates, and their role in maintaining biodiversity in pasture ecosystems.
2. Evaluate the roles of forage legumes in tropical farming systems. (Linked to SLO 1.6)
    - Basic response: Forage legumes fix nitrogen, improve soil fertility, provide high-protein forage, and serve as cover crops.
    - Value-added response: Outstanding learners may further explain their role in sustainable farming, integration into agroforestry systems, and their contribution to reducing dependence on chemical fertilisers.
3. Discuss the importance of shrubs and tree legumes in pasture systems. (Linked to SLO 1.7, SLO 1.8)
    - Basic response: Shrubs and tree legumes provide high-protein forage, stabilise soils, and offer shade.

- Value-added response: Outstanding learners may expand by discussing their role in fodder banks, dry season feeding strategies, and contributions to agroforestry and climate resilience.

Answers to Concept Check Questions [Series 1]

Objective questions

1. b. Poaceae
2. b. Culm
3. b. Rhizobia
4. c. Leucaena leucocephala
5. b. Creeping

Short-answer questions

1. Adaptation is the ability of plants to adjust and survive under specific environmental conditions.
2. Rainfall.
3. Cynodon dactylon.
4. Nitrogen fixation.
5. Providing high-protein forage during dry seasons.

Long-answer questions (Provided above under each question with basic and value-added responses.)

Answers to Pilot Questions [Series 1]

Part 1.1

1. Adaptation is the ability of plants to adjust and survive under specific environmental conditions.
2. Panicum maximum.
3. Climate.
4. Soil pH.
5. By controlling grazing and improving soil fertility.

Part 1.2

1. Poaceae.

2. Culm.
3. Rhizomes or stolons.
4. Cynodon dactylon.
5. Soil protection.

Part 1.3

1. Fabaceae.
2. Rhizobia.
3. Papilionaceous.
4. Nitrogen fixation.
5. Leucaena leucocephala.

Part 1.4

1. Fabaceae.
2. Gliricidia sepium.
3. Deep roots.
4. They provide high-protein forage.
5. Soil stabilisation.

Series 2: Establishment and Production of Pasture Lands

Part 2.1 Principles of Pasture Establishment

- Sub-Part 2.1.1 Site selection and land preparation
- Sub-Part 2.1.2 Choice of species and planting methods

Part 2.2 Pasture Production and Management

- Sub-Part 2.2.1 Fertilisation and weed control
- Sub-Part 2.2.2 Grazing management and pasture utilisation

Part 2.3 Maintenance of Permanent and Temporary Pastures

- Sub-Part 2.3.1 Practices for sustaining permanent pastures
- Sub-Part 2.3.2 Management of temporary pastures

Introduction

Pasture establishment and production are central to ensuring a reliable feed supply for livestock. Without proper planning and management, pastures may fail to provide adequate nutrition or may degrade quickly under grazing pressure. This Series therefore focuses on the practical steps required to establish, produce, and maintain pastures that are both productive and sustainable.

The aim of this Series is to equip you with the knowledge and skills needed to establish pasture lands, manage them effectively, and maintain their productivity over time.

We shall commence this Series by examining the principles of pasture establishment, including site selection, land preparation, and species choice. Next, we will explore pasture production and management, focusing on fertilisation, weed control, and grazing practices. Finally, we will conclude with the maintenance of permanent and temporary pastures, highlighting strategies for sustaining productivity and adapting to seasonal changes.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** explain the principles of pasture establishment,
- **SLO 2.2** analyse the factors involved in site selection and land preparation,
- **SLO 2.3** describe methods of species selection and planting for pasture lands,
- **SLO 2.4** apply techniques of fertilisation and weed control in pasture production,
- **SLO 2.5** evaluate grazing management strategies for effective pasture utilisation,
- **SLO 2.6** differentiate between permanent and temporary pastures, and
- **SLO 2.7** assess practices for maintaining productivity in both permanent and temporary pastures.

2.1 Principles of Pasture Establishment

2.1.1 Site selection and land preparation

Site selection refers to the process of choosing a suitable location for establishing pasture. The choice of site is influenced by factors such as soil fertility, drainage, topography, and accessibility. A fertile, well-drained soil will support vigorous plant growth, while poor soils may require amendments before planting. Accessibility is also important to ensure ease of grazing and management.

Once a site is selected, **land preparation** involves clearing vegetation, ploughing, and harrowing to create a fine seedbed. Proper preparation reduces weed competition and enhances seed germination. In some cases, soil testing is carried out to determine nutrient status and guide fertiliser application.

Fill in the blank: The process of choosing a suitable location for establishing pasture is called site _____.

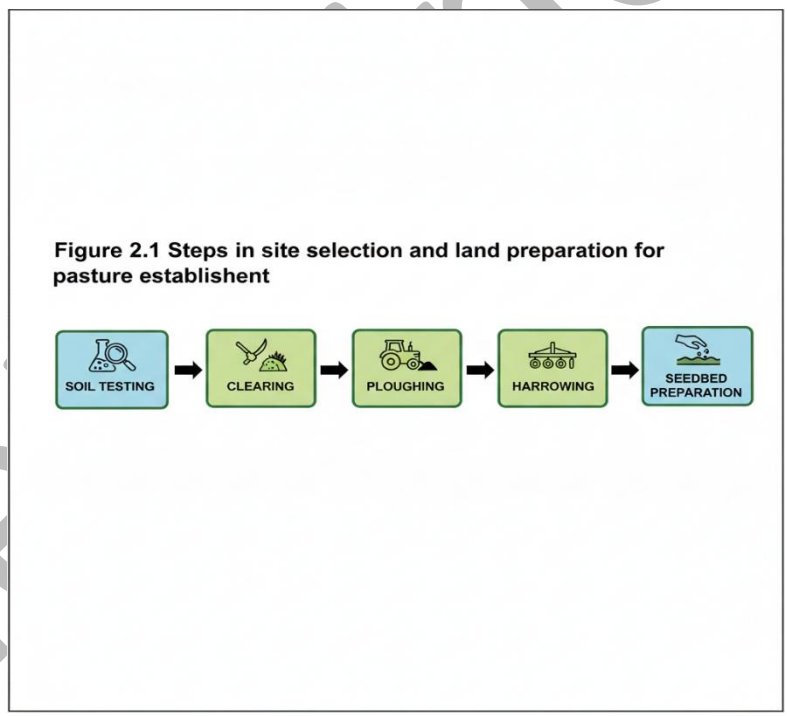

Diagram showing steps in site selection and land preparation (soil testing → clearing → ploughing → harrowing → seedbed preparation) Figure 2.1 Steps in site selection and land preparation for pasture establishment.

2.1.2 Choice of species and planting methods

Species selection is the process of choosing pasture plants that are well adapted to the ecological conditions of the site. Grasses such as Panicum maximum and legumes like Stylosanthes guianensis are commonly chosen for tropical pastures. The choice depends on factors such as climate, soil type, intended use (grazing or cut-and-carry), and nutritional value.

Planting methods vary depending on the species. Seeds may be broadcast, drilled, or planted in rows. Vegetative methods such as planting stolons or cuttings are also used for species that spread rapidly. Correct planting depth and spacing are critical for successful establishment.

Fill in the blank: The process of choosing pasture plants that are well adapted to ecological conditions is called species _____.

Table 2.1 Common species and planting methods in tropical pastures

Species	Type	Planting Method	Key Consideration
Panicum maximum (Guinea Grass)	Grass	**Seed drilling** or **broadcasting** (needs good seedbed and shallow planting).	High quality, but requires good soil fertility and moisture for establishment.
Cynodon dactylon (Bermuda Grass/Star Grass)	Grass	Planting **stolons** or **rhizomes/cuttings** (vegetative propagation) due to low seed viability.	Forms a dense, persistent sod; excellent for soil protection and intensive grazing.
Pennisetum purpureum (Napier/Elephant Grass)	Grass	Planting **stem cuttings** (often 2-3 nodes long) or **root splits**.	High biomass yield; mainly used for **cut-and-carry** systems (not typically grazed).
Stylosanthes guianensis (Stylo)	Legume	**Seed broadcasting** (requires scarification to break seed dormancy).	Drought tolerant; vital for improving protein content in grass pastures.
Centrosema pubescens (Centro)	Legume	**Seed broadcasting** or light drilling (requires seed scarification).	Excellent climbing habit; often sown with grasses to improve overall pasture quality.

Species	Type	Planting Method	Key Consideration
Leucaena leucocephala (Leucaena)	Tree Legume	**Direct seeding** into rows or transplanting **seedlings** (requires seed scarification).	Provides high-protein browse and deep-rooting benefits; must be managed to control mimosine toxicity.

Pilot questions 2.1

1. What is site selection in pasture establishment?
2. Name one factor that influences site selection.
3. What is the purpose of land preparation?
4. Give one example of a tropical grass species used in pastures.
5. State one planting method used for pasture species.

2.2 Pasture Production and Management

2.2.1 Fertilisation and weed control

Fertilisation refers to the application of nutrients to the soil to enhance plant growth. Pasture plants require essential nutrients such as nitrogen, phosphorus, and potassium. Nitrogen is particularly important for grasses, as it promotes vigorous growth and high forage yield. Fertilisation can be done using organic sources like manure or inorganic fertilisers such as urea.

Weed control is the process of reducing unwanted plants that compete with pasture species for nutrients, water, and light. Methods include manual removal, mechanical cultivation, and chemical herbicides. Integrated weed management, which combines several methods, is often the most effective approach.

Fill in the blank: The application of nutrients to the soil to enhance plant growth is called _____.

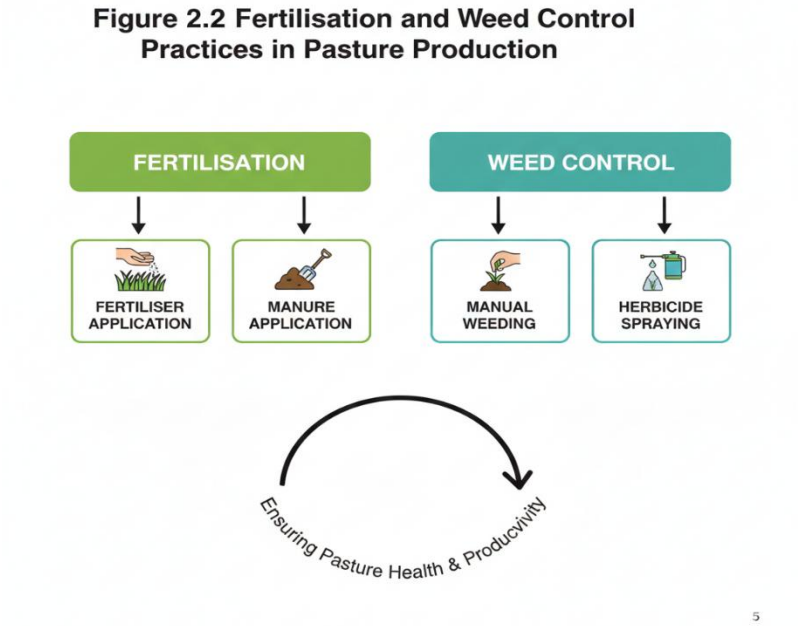

Diagram showing fertilisation and weed control practices in pasture production (fertiliser application, manual weeding, herbicide spraying) Figure 2.2 Fertilisation and weed control practices in pasture production.

2.2.2 Grazing management and pasture utilisation

Grazing management refers to the regulation of livestock feeding on pastures to ensure sustainable use. Overgrazing reduces plant vigour and leads to soil erosion, while undergrazing may cause weeds to dominate. Systems such as rotational grazing, where animals are moved between paddocks, help maintain pasture productivity.

Pasture utilisation involves balancing forage supply with animal demand. This requires monitoring stocking rates, adjusting grazing intensity, and ensuring that pastures recover after grazing. Proper utilisation maximises forage yield and maintains pasture health.

Fill in the blank: The regulation of livestock feeding on pastures to ensure sustainable use is called grazing _____.

Box 2.2 Grazing management strategies

Strategy	Explanation	Primary Goal
Continuous Grazing	Animals graze the **same pasture area constantly** throughout the entire grazing season, generally without set rest periods.	Simplicity and minimal infrastructure cost; however, often leads to uneven grazing (overgrazing of preferred areas).
Rotational Grazing	The pasture is divided into multiple **paddocks**, and animals are moved between them sequentially, allowing grazed paddocks a defined **rest and recovery period**.	Maximizes pasture utilization, improves forage quality, and enhances pasture persistence.
Deferred Grazing	Grazing is intentionally **delayed** for a specific period (usually until the end of the growing season) to allow the plants to reach full maturity and set seed.	Allows for seed production and seedling establishment, crucial for natural regeneration and building plant reserves.
Strip Grazing	Animals are confined to a **small, fresh strip** of pasture each day using temporary electric fencing, ensuring near-total utilization of the forage in that strip.	Highly efficient use of high-quality forage and minimizes wastage, often used for dairy cattle.
Creep Grazing	Young, smaller animals (e.g., lambs or calves) are allowed access to high-quality forage in an **adjacent paddock** through a fence opening too small for their mothers.	Provides the young animals with the best quality forage to maximize their growth rate.

Pilot questions 2.2

1. What is fertilisation in pasture production?
2. Name one nutrient essential for vigorous grass growth.
3. What is weed control?
4. State one method of weed control.
5. What is rotational grazing?

2.3 Maintenance of Permanent and Temporary Pastures

2.3.1 Practices for sustaining permanent pastures

Permanent pastures are grasslands that remain in use for many years without being reseeded. They are usually composed of a mixture of grasses and legumes

that regenerate naturally after grazing. Sustaining permanent pastures requires careful management to prevent degradation.

Key practices include controlled grazing, application of fertilisers to replenish nutrients, and reseeding of desirable species when necessary. Regular monitoring of pasture condition helps identify areas that need improvement. Permanent pastures are valuable because they provide long-term feed resources and reduce the cost of frequent re-establishment.

Fill in the blank: Grasslands that remain in use for many years without being reseeded are called _____ pastures.

Figure 2.3 Practices for sustaining permanent pastures

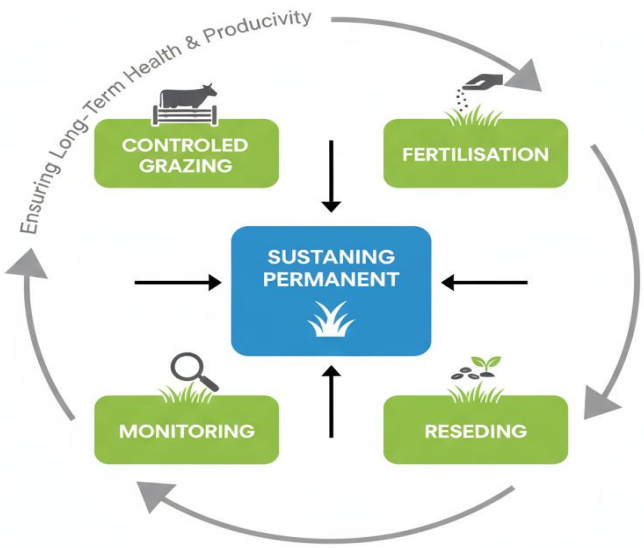

Diagram showing practices for sustaining permanent pastures (controlled grazing, fertilisation, reseeding, monitoring) Figure 2.3 Practices for sustaining permanent pastures

2.3.2 Management of temporary pastures

Temporary pastures are established for short-term use, often to provide feed during specific seasons or to supplement permanent pastures. They are usually planted with fast-growing species that can be grazed or cut within a few months.

Management of temporary pastures involves timely planting, fertilisation, and weed control to maximise yield. Since they are short-lived, careful planning is needed to ensure they are available when required, such as during dry seasons. Temporary pastures are particularly useful for bridging feed gaps and supporting intensive livestock systems.

Fill in the blank: Pastures established for short-term use, often to provide feed during specific seasons, are called _____ pastures.

Box 2.3 Differences between permanent and temporary pastures

Feature	Permanent Pastures	Temporary Pastures (Annual Forages)
Duration	**Long-term**, maintained for many years (typically five or more).	**Short-term**, usually grown for a single season or one to two years, often rotated with cash crops.
Species	A stable **mixture of perennial grasses and legumes** (e.g., Guinea grass, Centrosema).	**Fast-growing annual species** (e.g., Sorghum, Millet, forage maize) or short-lived perennials.
Establishment	High initial cost and effort, focusing on perennial species that are slow to establish.	Quick establishment, typically using seed drilling or broadcasting after the seasonal crop harvest.
Management	Focus on **controlled grazing**, long-term soil health, periodic **reseeding**, and maintenance **fertilization**.	Intensive management focused on **timely planting**, high-dose **fertilization** for rapid growth, and aggressive **weed control**.
Primary Use	Provides a **continuous, reliable feed supply** and ensures **soil protection** against erosion year-round.	Used primarily for **bridging feed gaps** (e.g., during the dry season or early wet season) or providing conserved feed (silage, hay).

Pilot questions 2.3

1. What are permanent pastures?
2. State one practice for sustaining permanent pastures.
3. What are temporary pastures?
4. Give one reason why temporary pastures are useful.
5. Mention one management practice for temporary pastures.

Series Summary

This Series has guided you through the establishment and production of pasture lands, which are essential for ensuring sustainable livestock feeding systems. The focus was on practical steps that enable farmers to create productive pastures and maintain them over time. By examining establishment principles, production practices, and maintenance strategies, you have gained a structured understanding of how to manage pastures effectively.

We began with the principles of pasture establishment, covering site selection, land preparation, species choice, and planting methods. Then we explored pasture production and management, highlighting fertilisation, weed control, and grazing strategies. Finally, we examined the maintenance of permanent and temporary pastures, emphasising practices that sustain productivity and adapt to seasonal changes. In line with the Series Learning Outcomes, you should now be able to explain establishment principles, analyse site and species selection, apply fertilisation and weed control techniques, evaluate grazing strategies, and assess maintenance practices for both permanent and temporary pastures.

Concept Check Questions [Series 2]

Objective questions

1. Which factor is most important when selecting a site for pasture establishment? a. Soil fertility b. Colour of soil c. Presence of weeds d. Distance from market (Linked to SLO 2.2)
2. Which planting method is commonly used for Cynodon dactylon? a. Broadcasting seeds b. Planting stolons or cuttings c. Direct seeding d. Transplanting seedlings (Linked to SLO 2.3)
3. Which nutrient is most critical for vigorous grass growth? a. Nitrogen b. Phosphorus c. Potassium d. Calcium (Linked to SLO 2.4)
4. Which grazing system involves moving animals between paddocks to allow recovery? a. Continuous grazing b. Rotational grazing c. Deferred grazing d. Strip grazing (Linked to SLO 2.5)
5. Which type of pasture is established for short-term use? a. Permanent pasture b. Temporary pasture c. Natural pasture d. Mixed pasture (Linked to SLO 2.6)

Short-answer questions

1. Define site selection in pasture establishment. (Linked to SLO 2.2)
2. State one purpose of land preparation. (Linked to SLO 2.2)
3. Give one example of a tropical grass species used in pastures. (Linked to SLO 2.3)
4. Mention one method of weed control in pasture production. (Linked to SLO 2.4)
5. State one importance of temporary pastures. (Linked to SLO 2.7)

Long-answer questions

1. Explain the principles of pasture establishment, including site selection, land preparation, and species choice. (Linked to SLO 2.1, SLO 2.2, SLO 2.3)
    - Basic response: Pasture establishment involves selecting a suitable site, preparing the land through clearing and ploughing, and choosing species adapted to the environment.
    - Value-added response: Outstanding learners may also discuss soil testing, fertiliser application, and the importance of matching species to intended use such as grazing or cut-and-carry.
2. Evaluate grazing management strategies and their importance in pasture utilisation. (Linked to SLO 2.5)
    - Basic response: Grazing management strategies include continuous, rotational, deferred, and strip grazing. They regulate livestock feeding and prevent overgrazing.
    - Value-added response: Outstanding learners may further explain how rotational grazing enhances pasture recovery, improves forage quality, and supports sustainable livestock production.
3. Differentiate between permanent and temporary pastures, highlighting their management practices. (Linked to SLO 2.6, SLO 2.7)
    - Basic response: Permanent pastures last for many years and require controlled grazing and reseeding, while temporary pastures are short-term and need timely planting and fertilisation.
    - Value-added response: Outstanding learners may expand by discussing how permanent pastures reduce long-term costs, while temporary pastures bridge seasonal feed gaps and support intensive systems.

Answers to Concept Check Questions [Series 2]

Objective questions

1. a. Soil fertility
2. b. Planting stolons or cuttings
3. a. Nitrogen
4. b. Rotational grazing
5. b. Temporary pasture

Short-answer questions

1. Site selection is the process of choosing a suitable location for establishing pasture.
2. To create a fine seedbed and reduce weed competition.
3. Panicum maximum.
4. Manual removal.
5. They provide feed during seasonal shortages.

Long-answer questions (Provided above under each question with basic and value-added responses.)

Answers to Pilot Questions [Series 2]

Part 2.1

1. Site selection is the process of choosing a suitable location for establishing pasture.
2. Soil fertility.
3. To reduce weed competition and enhance seed germination.
4. Panicum maximum.
5. Broadcasting or drilling seeds.

Part 2.2

1. Fertilisation is the application of nutrients to the soil to enhance plant growth.
2. Nitrogen.
3. Weed control is the reduction of unwanted plants that compete with pasture species.
4. Chemical herbicides.
5. Rotational grazing is moving animals between paddocks to allow pasture recovery.

Part 2.3

1. Permanent pastures are grasslands that remain in use for many years without reseeding.
2. Controlled grazing.
3. Temporary pastures are established for short-term use.
4. They bridge feed gaps during dry seasons.
5. Timely planting.

Series 3: Forage Legumes, Fodder Banks, and Shrub Utilisation

Part 3.1 Forage legumes in tropical farming systems

- Sub-Part 3.1.1 Morphological features of forage legumes
- Sub-Part 3.1.2 Roles of forage legumes in soil fertility and livestock nutrition

Part 3.2 Fodder bank technology

- Sub-Part 3.2.1 Establishment of fodder banks
- Sub-Part 3.2.2 Management and utilisation of fodder banks

Part 3.3 Shrubs and tree legumes in pasture systems

- Sub-Part 3.3.1 Adaptation of shrubs and tree legumes
- Sub-Part 3.3.2 Importance of shrubs and trees in dry season feeding and agroforestry

Introduction

Forage legumes, fodder banks, and shrubs are critical components of tropical pasture systems. They not only provide high-quality feed for livestock but also improve soil fertility and ensure feed availability during dry seasons. Farmers who integrate these resources into their systems achieve more sustainable and resilient livestock production.

The aim of this Series is to introduce you to the roles of forage legumes, the technology of fodder banks, and the utilisation of shrubs and tree legumes in pasture systems. It seeks to equip you with practical knowledge for improving feed supply and soil health.

We shall commence this Series by examining forage legumes, focusing on their morphology and their roles in tropical farming systems. Next, we will explore fodder bank technology, considering how fodder banks are established, managed, and utilised. Finally, we will conclude with shrubs and tree legumes, highlighting their adaptation and importance in dry season feeding and agroforestry systems.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** describe the morphological features of forage legumes,
- **SLO 3.2** evaluate the roles of forage legumes in soil fertility and livestock nutrition,
- **SLO 3.3** explain the principles of fodder bank establishment,
- **SLO 3.4** apply management practices for effective utilisation of fodder banks,
- **SLO 3.5** analyse the adaptation features of shrubs and tree legumes, and
- **SLO 3.6** assess the importance of shrubs and tree legumes in dry season feeding and agroforestry systems.

3.1 Forage Legumes in Tropical Farming Systems

3.1.1 Morphological features of forage legumes

Forage legumes are plants from the family Fabaceae that are cultivated primarily for feeding livestock. They are characterised by compound leaves, root nodules, and pods. The **root nodules** contain rhizobia bacteria, which fix atmospheric nitrogen into forms usable by plants, thereby improving soil fertility.

Morphologically, forage legumes may be herbaceous or woody. Their leaves are often trifoliate, though some species have pinnate or simple leaves. Flowers are typically papilionaceous, resembling butterflies, and they develop into pods that split open when mature. These features make legumes highly valuable in tropical farming systems.

Fill in the blank: The bacteria that fix atmospheric nitrogen in legume root nodules are called _____.

Figure 3.1 Morphorogical features of forage legumes

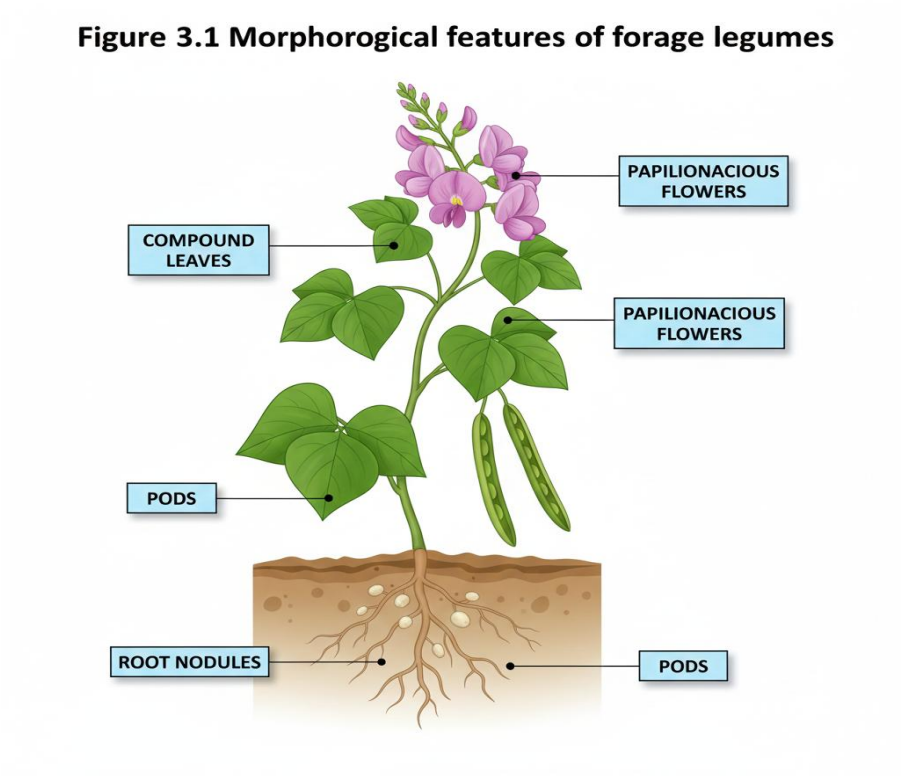

Diagram showing morphological features of forage legumes (compound leaves, root nodules, pods, papilionaceous flowers) Figure 3.1 Morphological features of forage legumes

3.1.2 Roles of forage legumes in soil fertility and livestock nutrition

Forage legumes play multiple roles in tropical farming systems. Their nitrogen-fixing ability enhances soil fertility, reducing dependence on synthetic fertilisers. They also provide high-protein forage, which complements the energy-rich grasses in pastures and improves livestock productivity.

Legumes can also serve as cover crops, suppressing weeds, reducing erosion, and increasing soil organic matter. Shrub and tree legumes such as Leucaena leucocephala are particularly useful as fodder banks, ensuring feed availability during dry seasons.

Fill in the blank: Forage legumes improve soil fertility by fixing _____ from the atmosphere into usable forms.

Box 3.1 Roles of forage legumes in tropical farming systems

Role	Explanation
Nitrogen fixation	Improves soil fertility
High-protein forage	Provides balanced nutrition for livestock
Cover cropping	Suppresses weeds and reduces erosion
Fodder banks	Ensures feed availability during dry seasons

Role	Explanation	Key Benefit
Nitrogen Fixation	Legumes form a symbiotic relationship with **Rhizobia bacteria** in root nodules, converting inert atmospheric nitrogen (N_2) into plant-available ammonium (NH_4^+).	**Improves soil fertility** naturally, reducing reliance on expensive, synthetic nitrogen fertilizers.

Pilot questions 3.1

1. What family do forage legumes belong to?
2. What type of bacteria is found in legume root nodules?
3. What is the typical shape of legume flowers?
4. State one role of forage legumes in tropical farming systems.
5. Give one example of a shrub or tree legume used as a fodder bank.

3.2 Fodder Bank Technology

3.2.1 Establishment of fodder banks

A **fodder bank** is a designated area where high-quality forage species, often legumes and shrubs, are planted and managed specifically to provide feed during periods of scarcity, such as the dry season. Establishing a fodder bank begins with site selection, ensuring fertile soils and good drainage. Land preparation involves clearing, ploughing, and creating a fine seedbed.

Species commonly used include Leucaena leucocephala, Gliricidia sepium, and Stylosanthes guianensis. Planting methods vary depending on the species, with direct seeding, transplanting seedlings, or vegetative propagation being common approaches. Proper spacing is important to maximise yield and facilitate management.

Fill in the blank: A designated area where high-quality forage species are planted to provide feed during scarcity is called a fodder _____.

Figure 3.2 Steps in fodder bank estabisment

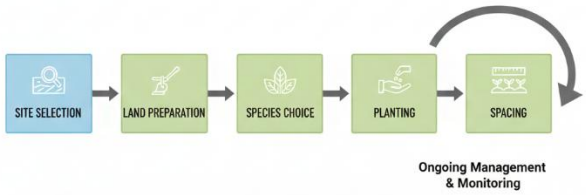

Diagram showing steps in fodder bank establishment (site selection → land preparation → species choice → planting → spacing) Figure 3.2 Steps in fodder bank establishment

3.2.2 Management and utilisation of fodder banks

Effective **management** of fodder banks ensures continuous availability of nutritious forage. Key practices include fertilisation, weed control, and protection from overgrazing. Regular harvesting is recommended to maintain plant vigour and encourage regrowth.

Utilisation involves cutting and carrying forage to livestock or controlled grazing within the fodder bank. Farmers often harvest leaves and tender stems, which are rich in protein, and mix them with grasses to balance livestock diets. Proper utilisation prevents depletion and ensures the fodder bank remains productive for many years.

Fill in the blank: Harvesting leaves and tender stems from fodder banks provides livestock with high-_____ feed.

Box 3.2 Management practices for fodder banks

Practice	Explanation	Impact on Fodder Bank
Fertilisation	Application of specific nutrients, primarily **Phosphorus (P)**, as legumes have a high demand for it, and **Potassium (K)**. Nitrogen	**Replenishes soil nutrients** consumed by harvesting, sustains healthy root

Practice	Explanation	Impact on Fodder Bank
	(N) is often not required due to fixation.	nodulation, and ensures high biomass yield.
Weed Control	Implementing manual weeding or controlled herbicide application, especially during the **establishment phase**, and removing woody perennial weeds.	**Reduces competition** for water, light, and nutrients, allowing the valuable forage species to grow vigorously and dominate the plot.
Controlled Harvesting/Pruning	Harvesting foliage at a specific height and frequency (e.g., pruning every 6–12 weeks during the wet season) to stimulate rapid regrowth.	**Maintains plant vigour**, ensures a supply of young, high-quality, high-protein foliage, and prevents the plants from becoming too woody or tall.
Protection from Overgrazing	Fodder banks should be protected from continuous, direct grazing, typically by fencing, especially when plants are young or recovering.	**Ensures long-term productivity** and persistence of the woody perennials, which are susceptible to damage from excessive defoliation.
Pest and Disease Monitoring	Regular inspection for common pests (e.g., psyllids on *Leucaena*) and fungal diseases that can reduce leaf biomass.	Allows for timely intervention and treatment, minimizing yield loss and maintaining the health of the feed source.

Pilot questions 3.2

1. What is a fodder bank?
2. Name one species commonly used in fodder banks.
3. State one step in establishing a fodder bank.
4. What is the purpose of controlled harvesting in fodder banks?
5. Why is weed control important in fodder bank management?

3.3 Shrubs and Tree Legumes in Pasture Systems

3.3.1 Adaptation of shrubs and tree legumes

Shrubs are woody plants smaller than trees, usually with multiple stems, while **tree legumes** are taller woody plants belonging to the family Fabaceae. Both are highly valued in pasture systems because they adapt well to tropical environments. Their deep root systems enable them to survive drought conditions, and their nitrogen-fixing ability improves soil fertility.

Examples include Leucaena leucocephala and Gliricidia sepium, which are widely used in tropical farming systems. These species tolerate poor soils and irregular rainfall, making them reliable sources of forage during dry seasons.

Fill in the blank: Woody plants belonging to the family Fabaceae that improve soil fertility through nitrogen fixation are called tree _____.

Figure 3.3 Adaptation features of shrubs and tree legumes

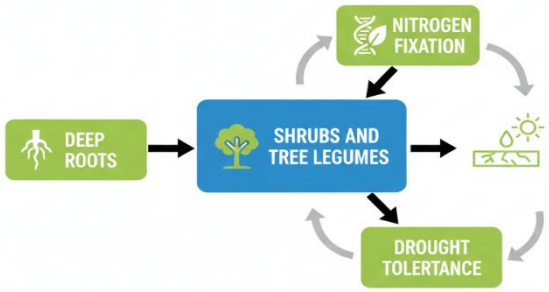

Diagram showing adaptation features of shrubs and tree legumes (deep roots, nitrogen fixation, drought tolerance) Figure 3.3 Adaptation features of shrubs and tree legumes

3.3.2 Importance of shrubs and trees in dry season feeding and agroforestry

Shrubs and trees play multiple roles in pasture systems. They provide high-protein forage, especially during dry seasons when grasses are scarce. Their deep roots stabilise soils and reduce erosion, while their canopy offers shade for animals. In addition, they contribute to **agroforestry systems**, improving soil organic matter and supporting biodiversity.

Tree legumes such as Leucaena are also used in fodder banks, ensuring feed availability throughout the year. Their leaves are palatable and nutritious, making them valuable supplements to grass-based diets.

Fill in the blank: Shrubs and trees are particularly important in pasture systems because they provide high-_____ forage during dry seasons.

Box 3.3 Importance of shrubs and trees in pasture systems

Role	Explanation	Key Benefit
Forage Supply (Browse)	Many tree and shrub legumes (e.g., *Leucaena*, *Gliricidia*) maintain green leaves and high nutritional content, especially **protein**, when herbaceous grasses dry out.	Provides essential **high-protein feed** during the long **dry season**, crucial for maintaining livestock body condition and productivity.
Soil Stabilization	The large, extensive, and **deep root systems** of woody species anchor the soil, particularly on sloped land or areas prone to wind erosion.	Significantly **reduces soil erosion** and helps maintain the physical integrity of the pastureland.
Shade Provision	The tree canopy breaks direct solar radiation and reduces radiant heat load on grazing animals.	Offers **shelter and thermal comfort** for livestock, mitigating **heat stress** which can severely depress appetite, feed intake, and overall production (milk yield, growth).
Agroforestry Contribution	Their leaf litter contributes organic matter to the soil surface, and the deep roots of legumes fix nitrogen, drawing up nutrients from deeper soil profiles.	**Improves soil organic matter**, enhances soil fertility, and contributes to the overall **biodiversity** of the farming system.
Windbreak Effect	The trees act as barriers, reducing wind speed across the pasture.	Lowers the rate of **evapotranspiration** from both the soil and the pasture grasses, conserving moisture and improving grass growth.

Pilot questions 3.3

1. What family do tree legumes belong to?

2. Give one example of a shrub or tree legume used in tropical farming systems.
3. State one adaptation feature of shrubs and tree legumes.
4. Why are shrubs and trees important during dry seasons?
5. Mention one ecological role of shrubs and trees in pasture systems.

Series Summary

This Series has explored the role of forage legumes, fodder banks, and shrubs in tropical pasture systems. The purpose was to highlight how these components contribute to soil fertility, livestock nutrition, and sustainable feed supply. By examining their morphology, establishment, management, and utilisation, you have gained practical insights into how farmers can strengthen livestock production systems.

We began with forage legumes, focusing on their morphological features and their roles in improving soil fertility and providing high-protein forage. Then we studied fodder bank technology, considering how fodder banks are established, managed, and utilised to ensure feed availability during scarcity. Finally, we examined shrubs and tree legumes, emphasising their adaptation features and importance in dry season feeding and agroforestry. In line with the Series Learning Outcomes, you should now be able to describe forage legume morphology, evaluate their roles, explain fodder bank establishment, apply management practices, analyse shrub adaptation, and assess their importance in pasture systems.

Concept Check Questions [Series 3]

Objective questions

1. Which family do forage legumes belong to? a. Poaceae b. Fabaceae c. Solanaceae d. Asteraceae (Linked to SLO 3.1)
2. Which bacteria are found in legume root nodules? a. Azotobacter b. Rhizobia c. Nitrosomonas d. Clostridium (Linked to SLO 3.1)
3. Which species is commonly used in fodder banks? a. Panicum maximum b. Leucaena leucocephala c. Cynodon dactylon d. Zea mays (Linked to SLO 3.3)
4. Which grazing practice ensures fodder banks remain productive? a. Overgrazing b. Controlled harvesting c. Continuous grazing d. Free-range grazing (Linked to SLO 3.4)

5. Which feature enables shrubs and tree legumes to survive drought conditions? a. Shallow roots b. Deep roots c. Broad leaves d. Hollow stems (Linked to SLO 3.5)

Short-answer questions

1. Define forage legumes. (Linked to SLO 3.1)
2. State one role of forage legumes in tropical farming systems. (Linked to SLO 3.2)
3. What is a fodder bank? (Linked to SLO 3.3)
4. Mention one management practice for fodder banks. (Linked to SLO 3.4)
5. State one importance of shrubs and trees in pasture systems. (Linked to SLO 3.6)

Long-answer questions

1. Describe the morphological features of forage legumes and explain their significance. (Linked to SLO 3.1)
    - Basic response: Forage legumes have compound leaves, root nodules, papilionaceous flowers, and pods. These features support nitrogen fixation and provide nutritious forage.
    - Value-added response: Outstanding learners may also explain how these features enhance soil fertility, biodiversity, and resilience in tropical farming systems.
2. Explain the establishment and management of fodder banks. (Linked to SLO 3.3, SLO 3.4)
    - Basic response: Establishment involves site selection, land preparation, species choice, and planting. Management includes fertilisation, weed control, and controlled harvesting.
    - Value-added response: Outstanding learners may expand by discussing species suitability, integration with livestock systems, and long-term sustainability.
3. Assess the importance of shrubs and tree legumes in dry season feeding and agroforestry. (Linked to SLO 3.5, SLO 3.6)
    - Basic response: Shrubs and tree legumes provide high-protein forage, stabilise soils, and offer shade.

- Value-added response: Outstanding learners may further highlight their role in fodder banks, climate resilience, and contributions to agroforestry systems.

Answers to Concept Check Questions [Series 3]

Objective questions

1. b. Fabaceae
2. b. Rhizobia
3. b. Leucaena leucocephala
4. b. Controlled harvesting
5. b. Deep roots

Short-answer questions

1. Forage legumes are plants from the family Fabaceae cultivated primarily for feeding livestock.
2. Nitrogen fixation.
3. A fodder bank is a designated area where high-quality forage species are planted to provide feed during scarcity.
4. Weed control.
5. Providing high-protein forage during dry seasons.

Long-answer questions (Provided above under each question with basic and value-added responses.)

Answers to Pilot Questions [Series 3]

Part 3.1

1. Fabaceae.
2. Rhizobia.
3. Papilionaceous.
4. Nitrogen fixation.
5. Leucaena leucocephala.

Part 3.2

1. A fodder bank is a designated area for planting high-quality forage species.
2. Gliricidia sepium.
3. Site selection.
4. To maintain plant vigour and encourage regrowth.
5. To reduce competition with forage species.

Part 3.3

1. Fabaceae.
2. Leucaena leucocephala.
3. Deep roots.
4. They provide high-protein forage.
5. Soil stabilisation.

Series 4: Seed Production, Harvesting, Processing, and Germplasm Preservation

Part 4.1 Seed production in pasture and forage plants

- Sub-Part 4.1.1 Principles of seed production
- Sub-Part 4.1.2 Factors affecting seed yield and quality

Part 4.2 Seed harvesting and processing

- Sub-Part 4.2.1 Methods of seed harvesting
- Sub-Part 4.2.2 Seed cleaning, drying, and storage

Part 4.3 Germplasm preservation and utilisation

- Sub-Part 4.3.1 Techniques of germplasm preservation
- Sub-Part 4.3.2 Importance of germplasm in pasture improvement

Introduction

Seed production, harvesting, and preservation are vital for sustaining pasture and forage systems. Without reliable seed sources, it becomes difficult to establish or improve pastures. Germplasm preservation further ensures that valuable plant genetic resources are conserved for future use. This Series therefore focuses on the processes that guarantee seed availability, quality, and long-term conservation.

The aim of this Series is to equip you with knowledge of seed production, harvesting, processing, and germplasm preservation in pasture and forage plants. It seeks to provide practical skills for ensuring seed quality and conserving plant genetic resources.

We shall commence this Series by examining the principles of seed production and the factors that influence seed yield and quality. Next, we will explore seed harvesting and processing, including methods of harvesting, cleaning, drying, and storage. Finally, we will conclude with germplasm preservation, highlighting techniques and the importance of conserving genetic resources for pasture improvement.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** explain the principles of seed production in pasture and forage plants,
- **SLO 4.2** analyse the factors affecting seed yield and quality,
- **SLO 4.3** describe methods of seed harvesting,
- **SLO 4.4** apply techniques of seed cleaning, drying, and storage,
- **SLO 4.5** explain techniques of germplasm preservation, and
- **SLO 4.6** evaluate the importance of germplasm in pasture improvement.

4.1 Seed Production in Pasture and Forage Plants

4.1.1 Principles of seed production

Seed production refers to the process of cultivating plants specifically to obtain viable seeds for future planting. In pasture and forage systems, seed production

ensures a continuous supply of quality planting material for establishing and improving pastures.

The principles of seed production include selecting appropriate species, ensuring genetic purity, and providing optimal growing conditions. Proper isolation of seed crops prevents contamination from other varieties, while timely planting and adequate fertilisation enhance seed yield. Farmers must also monitor pests and diseases, as these can significantly reduce seed viability.

Fill in the blank: The process of cultivating plants specifically to obtain viable seeds for future planting is called seed _____.

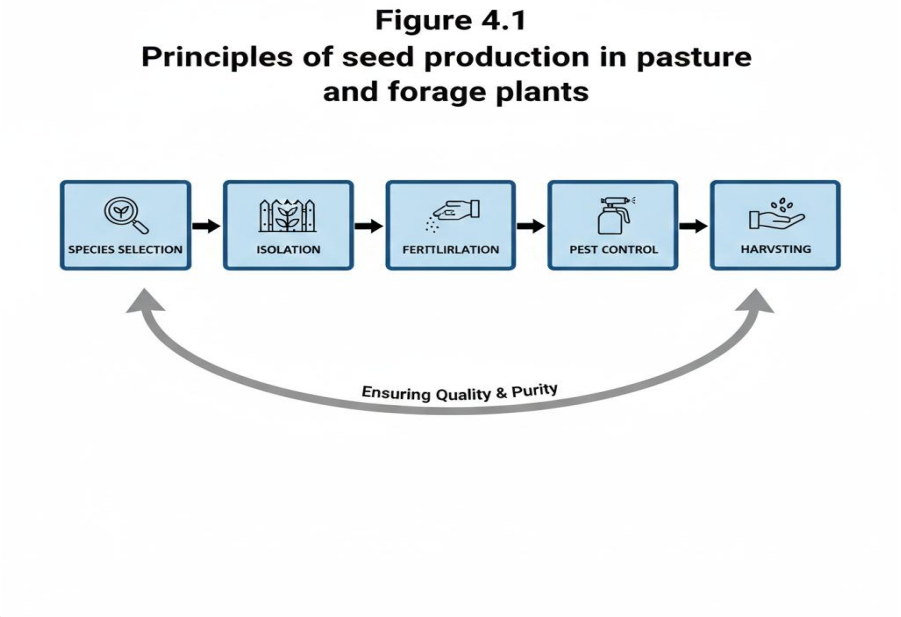

Diagram showing principles of seed production (species selection → isolation → fertilisation → pest control → harvesting) Figure 4.1 Principles of seed production in pasture and forage plants

4.1.2 Factors affecting seed yield and quality

Several factors influence the **yield** and **quality** of seeds in pasture and forage plants:

- **Genetic factors**: The inherent characteristics of the species determine seed size, viability, and productivity.
- **Environmental factors**: Climate, soil fertility, and water availability affect seed development.

- **Management practices**: Proper fertilisation, weed control, and pest management enhance seed yield.
- **Harvesting practices**: Timely harvesting prevents seed loss and ensures high viability.

High-quality seeds are essential for successful pasture establishment, as they germinate quickly and produce vigorous seedlings.

Fill in the blank: The inherent characteristics of a species that determine seed size and viability are called _____ factors.

Table 4.1 Factors affecting seed yield and quality

Factor	Description	Example
Genetic	Inherent traits specific to the species or cultivar being grown, including its natural reproductive potential and maturity timing.	**Seed size and viability** (the ability to germinate) are determined by the plant's genetics. Some species inherently produce lower yields than others.
Environmental	External natural conditions, primarily **climate** (temperature, solar radiation), **soil fertility**, and **water availability** (drought or flooding).	**Inadequate rainfall** during the critical flowering and seed-filling stages will drastically reduce seed setting and cause shriveled, low-quality seeds.
Management	Practices implemented by the grower to support plant health and maximize reproductive output.	**Appropriate fertilization** (especially Phosphorus and Potassium) and timely **weed and pest control** significantly improve flower density and seed yield.
Pollination	The effectiveness of transferring pollen (by wind, insects, or manually) required for fertilization and seed development.	Lack of appropriate **insect pollinators** (e.g., bees) can lead to low seed set, even if the plant is otherwise healthy.
Harvesting	The methods used and the timing of the collection process.	**Timely harvesting** (collecting seeds when mature but before shattering) is crucial to **prevent seed loss** from shattering or damage from improper mechanical collection.

Pilot questions 4.1

1. What is seed production in pasture and forage plants?
2. State one principle of seed production.
3. Name one factor that influences seed yield.
4. What is the importance of isolation in seed production?
5. Why is timely harvesting important for seed quality?

4.2 Seed Harvesting and Processing

4.2.1 Methods of seed harvesting

Seed harvesting is the process of collecting mature seeds from pasture and forage plants. The timing of harvest is critical, as seeds must be collected when they are fully mature but before they are shed or damaged.

Methods include:

- **Manual harvesting**: Seeds are collected by hand, suitable for small-scale production.
- **Mechanical harvesting**: Machines such as seed harvesters or combines are used for large-scale operations.
- **Selective harvesting**: Only mature pods or seed heads are collected, ensuring high viability.

Fill in the blank: The process of collecting mature seeds from pasture and forage plants is called seed _____.

Figure 4.2 Methods of seed harvesting in pasture and forage plants

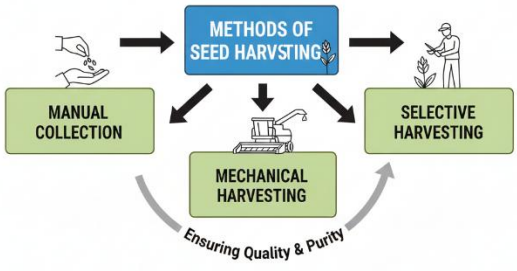

Diagram showing methods of seed harvesting (manual collection, mechanical harvesting, selective harvesting) Figure 4.2 Methods of seed harvesting in pasture and forage plants

4.2.2 Seed cleaning, drying, and storage

After harvesting, seeds must be processed to maintain quality and viability.

- **Seed cleaning**: Removal of debris, chaff, and damaged seeds using sieves or mechanical cleaners.
- **Seed drying**: Seeds are dried to safe moisture levels (usually 8–12%) to prevent mould and deterioration.
- **Seed storage**: Seeds are stored in cool, dry conditions, often in airtight containers, to maintain viability until planting.

Proper processing ensures that seeds remain viable and free from pests and diseases.

Fill in the blank: Seeds are dried to safe moisture levels, usually between 8–_____%, to prevent deterioration.

Box 4.2 Seed processing steps

Step	Explanation	Importance
Cleaning	Involves separating the desired seed from undesirable materials such as debris (chaff, straw, stones), weed seeds, damaged seeds, and immature/shriveled seeds.	**Removes contaminants** that can reduce planting efficiency and purity, and helps prevent the spread of weeds and diseases.
Drying	Reducing the moisture content of the seeds to a specific low level (typically **8% to 12%**, depending on the species).	**Reduces moisture** to safe levels to prevent premature germination, fungal growth, and spoilage during storage.
Storage	Keeping the cleaned and dried seeds in a cool, dark, and dry environment, often in specialized containers (e.g., airtight bags).	**Maintains viability and vigor** until the next planting season, protecting the genetic potential of the seed.

Step	Explanation	Importance
Treatment (Optional)	Applying fungicides, insecticides, or growth regulators to the seed coat.	Protects seeds and young seedlings from soil-borne diseases and pests immediately after planting.
Scarification/Pelleting (Optional)	Treating hard-coated legume seeds (scarification) or coating seeds with protective materials like clay or nutrients (pelleting).	**Enhances germination** (scarification) and improves handling and nutrient delivery during planting (pelleting).

Pilot questions 4.2

1. What is seed harvesting?
2. Name one method of seed harvesting.
3. Why is timing important in seed harvesting?
4. What is the purpose of seed cleaning?
5. At what moisture level are seeds usually dried to prevent deterioration?

4.3 Germplasm Preservation and Utilisation

4.3.1 Techniques of germplasm preservation

Germplasm refers to the genetic material of plants that is preserved for use in breeding, research, and conservation. In pasture and forage systems, germplasm preservation ensures that valuable species and varieties remain available for future generations.

Techniques include:

- **Seed storage**: Storing seeds under controlled conditions of temperature and humidity.
- **Field gene banks**: Maintaining living plants in designated plots for conservation.
- **Cryopreservation**: Storing plant tissues at ultra-low temperatures (often in liquid nitrogen).
- **In vitro conservation**: Preserving plant tissues or cells in laboratory conditions.

Fill in the blank: The genetic material of plants preserved for breeding and conservation is called _____.

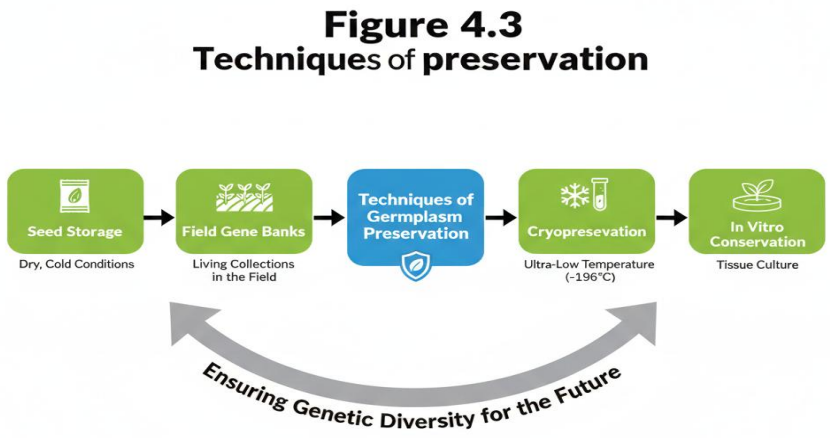

Diagram showing techniques of germplasm preservation (seed storage, field gene banks, cryopreservation, in vitro conservation) Figure 4.3 Techniques of germplasm preservation.

4.3.2 Importance of germplasm in pasture improvement

Germplasm plays a crucial role in pasture improvement. It provides the genetic diversity needed to breed new varieties that are more productive, disease-resistant, and better adapted to changing climates.

Preserved germplasm allows researchers to reintroduce species that may have been lost in farming systems. It also supports sustainable agriculture by ensuring that farmers have access to improved planting materials. In tropical regions, germplasm conservation is vital for maintaining resilience against drought and pests.

Fill in the blank: Germplasm provides the genetic _____ needed to breed new varieties of pasture plants.

Box 4.3 Importance of germplasm in pasture improvement

Importance	Explanation	Impact on Pasture Systems
Genetic Diversity	A broad pool of different genetic material ensures that breeders have a wide variety of traits to select from.	**Enables breeding of improved varieties** that are better yielding, more palatable, or have superior nutritive value than existing varieties.
Disease and Pest Resistance	Germplasm collections often contain genes that confer natural resistance to specific local diseases and insect pests.	Provides the necessary **traits for healthier plants**, reducing the need for chemical treatments and ensuring the persistence of the stand.
Climate Adaptation	Collections include varieties adapted to extreme environmental conditions (e.g., severe drought, high salinity, low fertility).	**Ensures resilience to climate change** by allowing the development of varieties suited to future conditions, such as increased heat and prolonged dry spells.
Sustainable Agriculture	By providing the raw material for continuous genetic improvement, it prevents reliance on a few susceptible varieties.	**Maintains long-term productivity** and prevents genetic erosion, which is the irreversible loss of genetic diversity.
Nutritional Enhancement	Contains varieties with superior nutritional profiles (higher protein, lower anti-nutritional factors, better digestibility).	Allows for the breeding of forages that significantly **improve livestock performance** (growth, milk, meat) without costly feed supplements.

Pilot questions 4.3

1. What is germplasm?
2. Name one technique of germplasm preservation.
3. Why is cryopreservation used in germplasm conservation?
4. State one importance of germplasm in pasture improvement.
5. How does germplasm support sustainable agriculture?

Series Summary

This Series has focused on seed production, harvesting, processing, and germplasm preservation in pasture and forage plants. Its purpose was to highlight how farmers

and researchers can ensure a reliable supply of quality seeds and conserve valuable plant genetic resources for future use. By examining production principles, harvesting and processing methods, and preservation techniques, you have gained practical knowledge essential for sustaining pasture systems.

We began with seed production, covering the principles and factors that influence seed yield and quality. Then we explored harvesting and processing, including methods of collection, cleaning, drying, and storage to maintain seed viability. Finally, we examined germplasm preservation, highlighting techniques such as seed storage, cryopreservation, and in vitro conservation, as well as their importance in pasture improvement. In line with the Series Learning Outcomes, you should now be able to explain seed production principles, analyse yield factors, describe harvesting methods, apply processing techniques, and evaluate germplasm preservation for sustainable pasture development.

Concept Check Questions [Series 4]

Objective questions

1. Which process involves cultivating plants specifically to obtain viable seeds? a. Seed production b. Seed harvesting c. Seed storage d. Seed processing (Linked to SLO 4.1)
2. Which factor refers to the inherent traits of a species that determine seed size and viability? a. Environmental b. Genetic c. Management d. Harvesting (Linked to SLO 4.2)
3. Which method of seed harvesting is most suitable for large-scale operations? a. Manual harvesting b. Mechanical harvesting c. Selective harvesting d. Hand picking (Linked to SLO 4.3)
4. Seeds are usually dried to what moisture level to prevent deterioration? a. 2–4% b. 5–7% c. 8–12% d. 15–20% (Linked to SLO 4.4)
5. Which germplasm preservation technique involves storing plant tissues at ultra-low temperatures? a. Seed storage b. Field gene banks c. Cryopreservation d. In vitro conservation (Linked to SLO 4.5)

Short-answer questions

1. Define seed production in pasture and forage plants. (Linked to SLO 4.1)
2. State one factor that influences seed yield. (Linked to SLO 4.2)
3. What is seed harvesting? (Linked to SLO 4.3)

4. Mention one purpose of seed cleaning. (Linked to SLO 4.4)
5. State one importance of germplasm in pasture improvement. (Linked to SLO 4.6)

Long-answer questions

1. Explain the principles of seed production and factors affecting seed yield and quality. (Linked to SLO 4.1, SLO 4.2)
    - Basic response: Seed production involves species selection, isolation, fertilisation, and pest control. Yield and quality are influenced by genetic, environmental, management, and harvesting factors.
    - Value-added response: Outstanding learners may also discuss the role of seed certification, genetic purity, and adaptation to ecological conditions.
2. Describe methods of seed harvesting and processing in pasture and forage plants. (Linked to SLO 4.3, SLO 4.4)
    - Basic response: Harvesting methods include manual, mechanical, and selective approaches. Processing involves cleaning, drying, and storage.
    - Value-added response: Outstanding learners may expand by explaining how moisture control, pest prevention, and storage facilities improve seed longevity.
3. Assess the importance of germplasm preservation in pasture improvement. (Linked to SLO 4.5, SLO 4.6)
    - Basic response: Germplasm provides genetic diversity, supports breeding, and ensures resilience to diseases and climate change.
    - Value-added response: Outstanding learners may further highlight its role in reintroducing lost species, supporting agroforestry, and ensuring sustainable agriculture.

Answers to Concept Check Questions [Series 4]

Objective questions

1. a. Seed production
2. b. Genetic
3. b. Mechanical harvesting
4. c. 8–12%
5. c. Cryopreservation

Short-answer questions

1. Seed production is the process of cultivating plants specifically to obtain viable seeds for future planting.
2. Genetic factors.
3. Seed harvesting is the process of collecting mature seeds from pasture and forage plants.
4. To remove debris and damaged seeds.
5. Germplasm provides genetic diversity for breeding improved varieties.

Long-answer questions (Provided above under each question with basic and value-added responses.)

Answers to Pilot Questions [Series 4]

Part 4.1

1. Seed production is cultivating plants to obtain viable seeds.
2. Species selection.
3. Genetic factors.
4. Isolation prevents contamination from other varieties.
5. Timely harvesting prevents seed loss and ensures viability.

Part 4.2

1. Seed harvesting is collecting mature seeds from pasture and forage plants.
2. Manual harvesting.
3. To ensure seeds are mature but not lost.
4. To remove debris and chaff.
5. 8–12%.

Part 4.3

1. Germplasm is the genetic material of plants preserved for breeding and conservation.
2. Cryopreservation.
3. To store plant tissues at ultra-low temperatures for long-term preservation.

4. Provides genetic diversity for breeding improved varieties.
5. By ensuring long-term productivity and resilience in farming systems.

Series 5: Range Management, Grazing Systems, and Forage Conservation

Part 5.1 Principles of Range Management

- Sub-Part 5.1.1 Definition and objectives of range management
- Sub-Part 5.1.2 Ecological factors influencing rangelands

Part 5.2 Grazing Systems and Practices

- Sub-Part 5.2.1 Types of grazing systems (continuous, rotational, deferred, strip)
- Sub-Part 5.2.2 Advantages and limitations of grazing systems

Part 5.3 Forage Conservation Techniques

- Sub-Part 5.3.1 Hay and silage making
- Sub-Part 5.3.2 Storage and utilisation of conserved forage

Introduction

Livestock production in tropical regions often faces challenges of feed scarcity, especially during dry seasons. Managing rangelands effectively and conserving forage are therefore essential for ensuring a steady supply of nutritious feed. Without proper management, rangelands may degrade, and livestock productivity may decline. This Series builds on earlier discussions of pasture establishment and utilisation, now focusing on how to manage grazing and conserve forage for long-term sustainability.

The aim of this Series is to equip you with knowledge and skills in range management, grazing systems, and forage conservation, enabling you to sustain productive rangelands and secure feed resources throughout the year.

We shall commence this Series by examining the principles of range management, including its definition, objectives, and ecological factors. Next, we will explore grazing systems and practices, considering their types, advantages, and limitations. Finally, we will conclude with forage conservation techniques, focusing on hay and silage making, as well as storage and utilisation methods.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** define the principles and objectives of range management,
- **SLO 5.2** explain ecological factors influencing rangeland productivity,
- **SLO 5.3** describe different types of grazing systems,
- **SLO 5.4** analyse the advantages and limitations of grazing systems,
- **SLO 5.5** demonstrate techniques of hay and silage making, and
- **SLO 5.6** apply methods of storage and utilisation of conserved forage.

5.1 Principles of Range Management

5.1.1 Definition and objectives of range management

Range management refers to the planned use and care of rangelands to ensure their sustainable productivity. Rangelands are areas of land that provide forage for livestock and wildlife, often dominated by grasses, legumes, shrubs, and trees.

The objectives of range management include:

- Maintaining ecological balance between plants, animals, and the environment.
- Preventing overgrazing and land degradation.
- Ensuring continuous supply of forage for livestock.
- Conserving soil and water resources.
- Supporting biodiversity and sustainable livelihoods.

Fill in the blank: The planned use and care of rangelands to ensure sustainable productivity is called range _____.

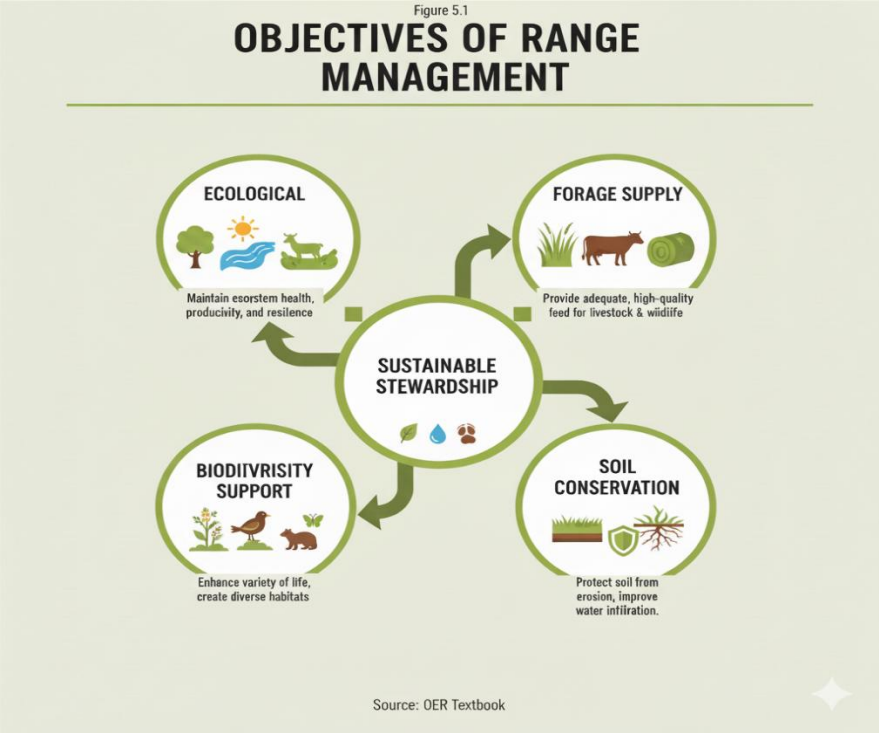

Diagram showing objectives of range management (ecological balance, forage supply, soil conservation, biodiversity support) Figure 5.1 Objectives of range management.

5.1.2 Ecological factors influencing rangelands

Rangeland productivity is influenced by several ecological factors:

- **Climate**: Rainfall and temperature determine the growth and survival of forage species.
- **Soil fertility**: Nutrient-rich soils support vigorous plant growth, while poor soils limit productivity.
- **Vegetation type**: The composition of grasses, legumes, shrubs, and trees affects forage quality and availability.
- **Topography**: Slope and drainage influence soil erosion and water retention.
- **Human activities**: Overgrazing, deforestation, and poor management practices can degrade rangelands.

Fill in the blank: Rainfall and temperature are examples of _____ factors influencing rangeland productivity.

Table 5.1 Ecological factors influencing rangelands

Factor	Influence	Example
Climate	Determines growth and survival	Rainfall, temperature
Soil fertility	Affects plant vigour	Nutrient levels
Vegetation type	Influences forage quality	Grass-legume mix
Topography	Impacts erosion and drainage	Slopes, valleys
Human activities	Can degrade rangelands	Overgrazing, deforestation

Pilot questions 5.1

1. What is range management?
2. State one objective of range management.
3. Name one ecological factor influencing rangelands.
4. Why is soil fertility important in rangeland productivity?
5. Give one example of human activity that can degrade rangelands.

5.2 Grazing Systems and Practices

5.2.1 Types of grazing systems

Grazing systems are organised methods of managing how livestock feed on pastures. The choice of system depends on pasture type, livestock numbers, and management goals.

The main types include:

- **Continuous grazing**: Animals graze the same area throughout the season.
- **Rotational grazing**: Animals are moved between paddocks to allow pasture recovery.
- **Deferred grazing**: Grazing is delayed to allow plants to mature before animals feed.
- **Strip grazing**: Animals graze a small strip at a time, controlled by fencing.

Fill in the blank: Moving animals between paddocks to allow pasture recovery is called _____ grazing.

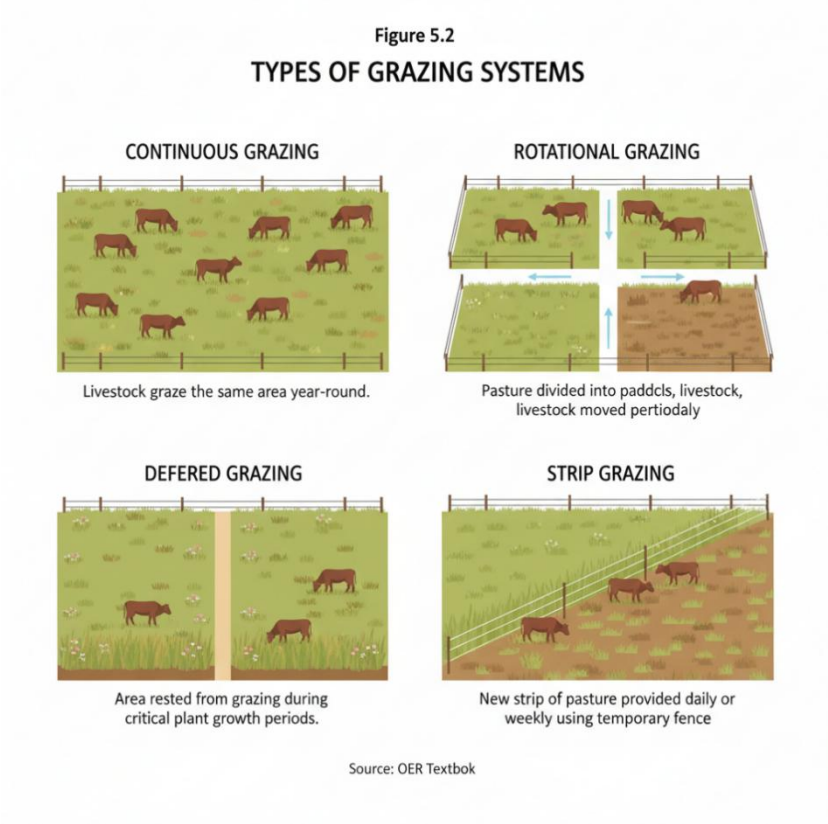

Diagram showing types of grazing systems (continuous, rotational, deferred, strip)
Figure 5.2 Types of grazing systems

5.2.2 Advantages and limitations of grazing systems

Each grazing system has strengths and weaknesses:

- **Continuous grazing**
  - Advantages: Simple, low cost, minimal labour.
  - Limitations: Risk of overgrazing, uneven pasture use.
- **Rotational grazing**
  - Advantages: Promotes pasture recovery, improves forage quality, supports sustainability.
  - Limitations: Requires fencing, labour, and planning.
- **Deferred grazing**
  - Advantages: Allows seed production and plant maturity.
  - Limitations: Reduced forage availability during deferment.

- **Strip grazing**
    - Advantages: Efficient pasture use, reduces wastage.
    - Limitations: Requires movable fencing and close supervision.

Fill in the blank: Rotational grazing improves forage quality but requires more _____ and planning.

Box 5.2 Advantages and limitations of grazing systems

Grazing system	Advantages	Limitations
Continuous	Simple, low cost	Risk of overgrazing
Rotational	Promotes recovery, improves quality	Requires fencing and labour
Deferred	Allows seed production	Reduced forage availability
Strip	Efficient pasture use	Needs movable fencing

Pilot questions 5.2

1. What is a grazing system?
2. Name one type of grazing system.
3. State one advantage of rotational grazing.
4. Mention one limitation of continuous grazing.
5. Why is strip grazing considered efficient?

5.3 Forage Conservation Techniques

5.3.1 Hay and silage making

Forage conservation refers to the preservation of excess forage during periods of abundance for use during feed scarcity, especially in dry seasons. Two common methods are **hay making** and **silage making**.

- **Hay making**: Involves cutting forage (usually grasses or legumes), drying it to safe moisture levels (about 15–20%), and storing it for later use. Hay is lightweight, easy to transport, and suitable for long-term storage.

- **Silage making**: Involves storing green forage in airtight conditions (such as silos or pits) where it ferments to produce a moist, palatable feed. Silage retains more nutrients than hay and is particularly useful for dairy cattle.

Fill in the blank: Preserving green forage in airtight conditions to allow fermentation is called _____ making.

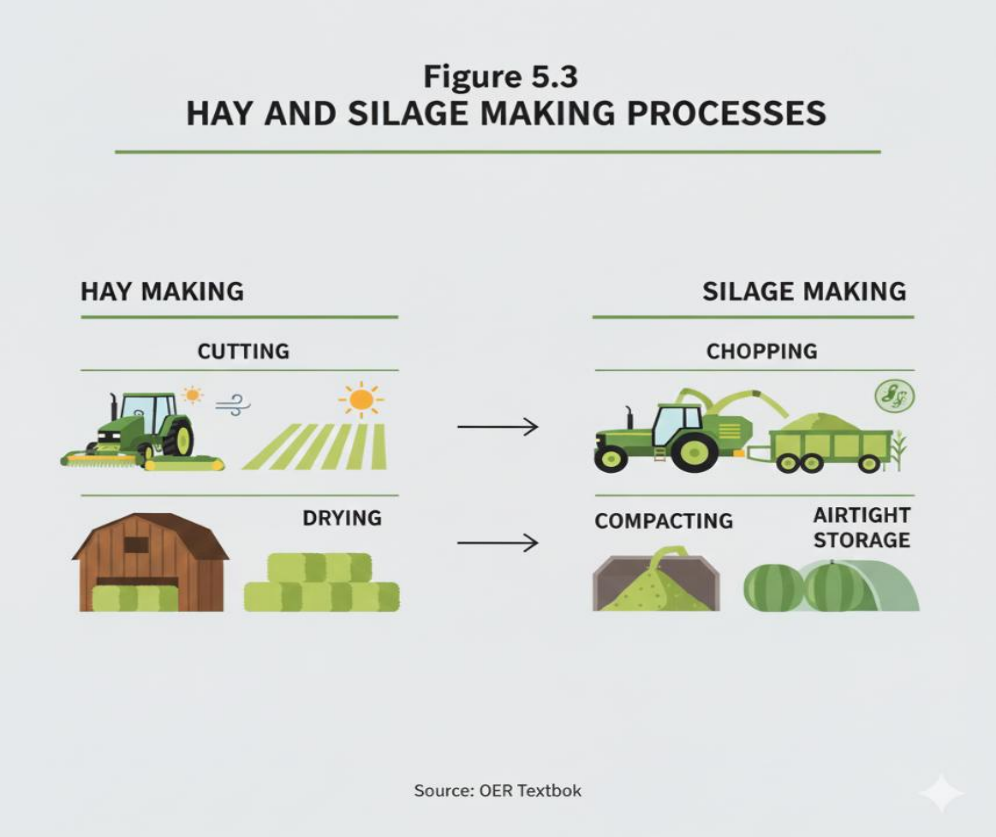

Diagram showing hay and silage making (cutting, drying, storage for hay; chopping, compacting, airtight storage for silage) Figure 5.3 Hay and silage making processes

5.3.2 Storage and utilisation of conserved forage

Once conserved, forage must be stored properly to maintain quality and prevent spoilage.

- **Storage of hay**: Hay should be stored in dry, well-ventilated areas, preferably on raised platforms to avoid moisture damage.
- **Storage of silage**: Silage must remain airtight to prevent mould growth and nutrient loss. Covering silos or pits with plastic sheets is common practice.

- **Utilisation**: Conserved forage is fed to livestock during dry seasons or when pastures are insufficient. Mixing hay or silage with fresh forage improves diet balance.

Fill in the blank: Conserved forage is particularly important during _____ seasons when pastures are insufficient.

Box 5.3 Storage and utilisation of conserved forage

Conserved forage	Storage method	Utilisation
Hay	Dry, ventilated, raised platforms	Fed during scarcity, mixed with fresh forage
Silage	Airtight silos or pits	Palatable feed, especially for dairy cattle

Pilot questions 5.3

1. What is forage conservation?
2. Define hay making.
3. Define silage making.
4. State one method of storing hay.
5. Why is conserved forage important during dry seasons?

Series Summary

This Series has focused on **range management, grazing systems, and forage conservation**, which are central to sustaining livestock production in tropical environments. The purpose was to highlight how rangelands can be managed responsibly, how grazing systems can be applied to balance forage use and recovery, and how forage can be conserved to ensure feed availability during scarcity.

We began with the principles of range management, covering its definition, objectives, and the ecological factors that influence rangeland productivity. Then we explored grazing systems and practices, examining the types of systems such as continuous, rotational, deferred, and strip grazing, alongside their advantages and limitations. Finally, we studied forage conservation techniques, focusing on hay and silage making, as well as storage and utilisation methods. In line with the Series Learning Outcomes, you should now be able to define range management,

explain ecological factors, describe grazing systems, analyse their strengths and weaknesses, and apply forage conservation techniques effectively.

Concept Check Questions [Series 5]

Objective questions

1. Range management refers to: a. The planned use and care of rangelands b. The harvesting of seeds c. The conservation of forests d. The cultivation of crops (Linked to SLO 5.1)
2. Which ecological factor directly influences rangeland productivity? a. Soil fertility b. Market distance c. Labour availability d. Farm size (Linked to SLO 5.2)
3. Moving animals between paddocks to allow pasture recovery is called: a. Continuous grazing b. Rotational grazing c. Deferred grazing d. Strip grazing (Linked to SLO 5.3)
4. Which grazing system is simple and low cost but risks overgrazing? a. Rotational grazing b. Continuous grazing c. Strip grazing d. Deferred grazing (Linked to SLO 5.4)
5. Preserving green forage in airtight conditions to allow fermentation is called: a. Hay making b. Silage making c. Composting d. Mulching (Linked to SLO 5.5)

Short-answer questions

1. Define range management. (Linked to SLO 5.1)
2. State one ecological factor influencing rangelands. (Linked to SLO 5.2)
3. Name one type of grazing system. (Linked to SLO 5.3)
4. Mention one limitation of continuous grazing. (Linked to SLO 5.4)
5. State one importance of forage conservation. (Linked to SLO 5.6)

Long-answer questions

1. Explain the principles and objectives of range management, including ecological factors influencing rangelands. (Linked to SLO 5.1, SLO 5.2)
    - Basic response: Range management involves planned use of rangelands to sustain productivity, with objectives such as ecological balance and forage supply.

- Value-added response: Outstanding learners may also discuss soil and water conservation, biodiversity support, and resilience against degradation.

2. Describe the types of grazing systems and analyse their advantages and limitations. (Linked to SLO 5.3, SLO 5.4)
    - Basic response: Grazing systems include continuous, rotational, deferred, and strip grazing, each with strengths and weaknesses.
    - Value-added response: Outstanding learners may expand by explaining how rotational grazing enhances sustainability and strip grazing reduces wastage.
3. Demonstrate forage conservation techniques and explain their importance in livestock feeding. (Linked to SLO 5.5, SLO 5.6)
    - Basic response: Forage conservation involves hay and silage making, with proper storage and utilisation during scarcity.
    - Value-added response: Outstanding learners may further highlight nutrient retention in silage, long-term storage benefits of hay, and their role in bridging seasonal feed gaps.

Answers to Concept Check Questions [Series 5]

Objective questions

1. a. The planned use and care of rangelands
2. a. Soil fertility
3. b. Rotational grazing
4. b. Continuous grazing
5. b. Silage making

Short-answer questions

1. Range management is the planned use and care of rangelands to ensure sustainable productivity.
2. Climate.
3. Deferred grazing.
4. Risk of overgrazing.
5. Provides feed during dry seasons.

Long-answer questions (Provided above under each question with basic and value-added responses.)

Answers to Pilot Questions [Series 5]

Part 5.1

1. Range management is the planned use and care of rangelands.
2. Ensuring continuous forage supply.
3. Climate.
4. Soil fertility supports vigorous plant growth.
5. Overgrazing.

Part 5.2

1. A grazing system is an organised method of managing livestock feeding on pastures.
2. Rotational grazing.
3. Promotes pasture recovery.
4. Risk of overgrazing.
5. It reduces wastage.

Part 5.3

1. Forage conservation is the preservation of excess forage for use during scarcity.
2. Hay making is drying forage to safe moisture levels for storage.
3. Silage making is fermenting green forage in airtight conditions.
4. Store hay in dry, ventilated areas.
5. It ensures feed availability during dry seasons.