La-Net

AGE 102

PRACTICAL FARM WORK 1

Acquiring hands-on skills and knowledge for efficient and sustainable farm practices.

CROP PRODUCTION | ANIMAL HUSBANDRY | SOIL MANAGEMENT | FARM MAINTENANCE | SAFETY & TEAMWORK

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Course code: AGE 102

Course title: Practical Farm Work 1

Course credit load: 2 Units

Series 1: Crop Production Skills and Farmland Preparation

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Introduction

Crop production is the backbone of agriculture and the foundation upon which food security, rural livelihoods, and agro-industrial development rest. Before a seed can be planted or a harvest realised, a farmer must make a series of informed decisions about land selection, soil preparation, and the sequence of operations that create the conditions for plant growth. Developing competent, ethical, and scientifically grounded skills in these foundational operations is the purpose of this Series.

The aim of this Series is to equip you with the knowledge and practical skills required for crop production and farmland preparation, from understanding the categories and importance of crops to selecting suitable farmland, clearing, tilling, and amending the soil in preparation for planting.

We shall commence this Series by introducing the importance, categories, and production cycle of crops. Next, we will examine the criteria for farmland selection and soil and topographic assessment. Following that, we will cover land clearing methods, tillage practices, and soil amendment. Finally, we will wrap up with the practical tools, steps, safety practices, and ethics of farmland preparation.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** explain the importance of crop production and identify the main categories of crops and their uses (Linked to Part 1.1),
- **SLO 1.2** describe the full crop production cycle from land preparation to harvest (Linked to Part 1.1),
- **SLO 1.3** identify and apply the criteria used to select a suitable farmland (Linked to Part 1.2),
- **SLO 1.4** conduct a basic soil assessment and evaluate soil fertility for crop production (Linked to Part 1.2),
- **SLO 1.5** explain how topography, drainage, and accessibility influence farmland suitability (Linked to Part 1.2),

- **SLO 1.6** describe the methods of land clearing and explain when each is appropriate (Linked to Part 1.3),
- **SLO 1.7** explain the types of tillage and their purposes in crop production (Linked to Part 1.3),
- **SLO 1.8** describe soil amendment practices and explain how seedbeds are prepared (Linked to Part 1.3), and
- **SLO 1.9** demonstrate competent and ethical use of farm tools and equipment in preparing a farm plot (Linked to Part 1.4).

1.1 Introduction to Crop Production

1.1.1 Importance of crop production in agriculture

Crop production is the branch of agriculture concerned with growing plants for food, feed, fibre, fuel, and industrial raw materials. It is the primary source of food for the human population, providing the carbohydrates, proteins, vitamins, and minerals that sustain life. Beyond food, crops supply raw materials for textiles (cotton, jute), pharmaceuticals (neem, aloe vera), biofuels (sugarcane, soybean), and industrial products (rubber, palm oil). In Nigeria, crop production accounts for a substantial share of agricultural GDP and employs the majority of the rural population.

Crop production also underpins national food security, foreign exchange earnings through agricultural exports, and the supply of raw materials for agro-processing industries. Students acquiring crop production skills are therefore not only developing personal livelihoods but contributing to broader national development goals. The ethical dimension of crop production, including sustainable land use, minimising chemical inputs, and protecting soil health for future generations, is an integral part of professional agricultural practice that this course emphasises from the outset.

Fill in the blank: Crop production is the branch of agriculture concerned with growing plants for food, feed, fibre, fuel, and ________ raw materials.

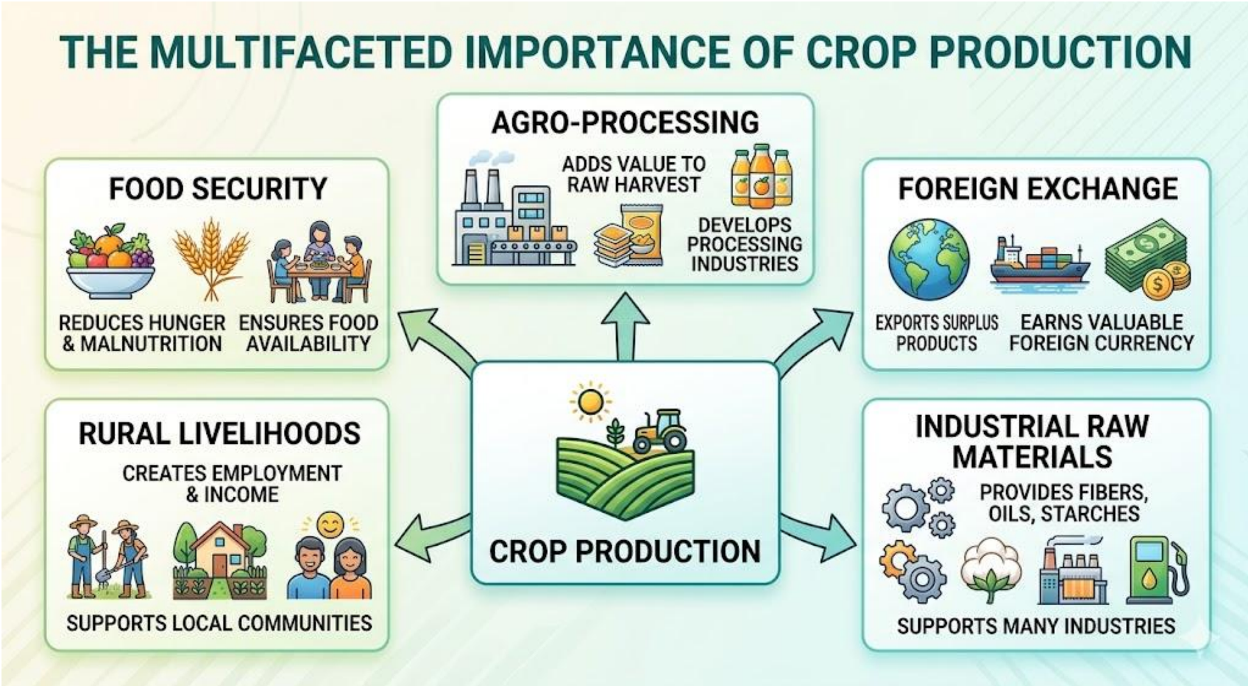

Figure 1.1: Diagram showing the multiple uses and importance of crop production in food, industry, and livelihoods

1.1.2 Categories of crops and their uses

Crops are classified by their botanical nature and primary use. **Cereals** (maize, rice, sorghum, millet, wheat) are the most widely grown food crops and the primary source of dietary energy for most Nigerians. **Legumes** (cowpea, groundnut, soybean, pigeon pea) fix atmospheric nitrogen and provide dietary protein. **Root and tuber crops** (cassava, yam, sweet potato, cocoyam) are important carbohydrate staples and raw materials for starch and flour production.

Vegetables (tomato, pepper, okra, leafy vegetables) supply vitamins and minerals and are high-value cash crops. **Tree crops and fruits** (oil palm, cocoa, rubber, citrus, mango) provide long-term income and industrial raw materials. **Fibre crops** (cotton, jute, kenaf) supply textile industries. Understanding crop categories allows a farmer to plan rotations that optimise soil health, match crops to land capability, and diversify income sources throughout the farming calendar.

Fill in the blank: ________ such as cowpea, groundnut, and soybean fix atmospheric nitrogen and provide dietary protein, making them valuable in both nutrition and soil fertility management.

Crop Category	Examples	Primary Uses
Cereals	Rice, Wheat, Maize, Sorghum, Millet	Staple food, source of carbohydrates, bread, porridge, beer brewing
Legumes	Beans, Peas, Lentils, Chickpeas, Soybeans, Groundnuts	Protein source, soil nitrogen fixation, edible seeds, oil extraction
Root and Tuber Crops	Yam, Cassava, Potato, Cocoyam, Sweet Potato	Carbohydrate-rich staple foods, starch production, animal feed
Vegetables	Tomato, Onion, Carrot, Spinach, Pepper	Vitamins and minerals, culinary uses, fresh consumption
Tree Crops	Cocoa, Coffee, Oil Palm, Mango, Orange	Cash crops, beverages, oils, fruits, export commodities
Fibre Crops	Cotton, Jute, Kenaf, Flax, Sisal	Textile production, ropes, mats, industrial uses

Table 1.1: Categories of crops, examples, and their primary uses

1.1.3 Overview of the crop production cycle

The crop production cycle is the sequence of operations from land preparation to post-harvest handling that must be followed in the correct order for crop production to succeed. The cycle begins with **land selection and preparation** (clearing, tillage, amendment), proceeds through **planting operations** (seed selection, sowing or transplanting at the correct spacing and depth), and continues through **crop establishment and cultural practices** (fertilisation, weeding, irrigation, pest and disease management).

The cycle concludes with harvesting at the correct stage of crop maturity, followed by post-harvest operations including threshing, drying, grading, and storage. Each stage is linked to the next; a mistake at the land preparation stage, such as poor drainage or inadequate soil amendment, propagates through the entire cycle and reduces final yield. The crop production cycle also has a temporal dimension: operations must be timed to match seasonal rainfall patterns, temperature regimes, and market demand. Understanding the cycle as a whole is essential before beginning any individual operation.

Fill in the blank: The crop production cycle begins with land selection and preparation and ends with ________ operations including threshing, drying, grading, and storage.

Figure 1.2: Circular diagram showing the stages of the crop production cycle from land preparation through planting, cultural practices, harvesting, and post-harvest operations

Pilot questions 1.1

1. State three reasons why crop production is important to Nigeria.
2. Name four categories of crops and give two examples of each.
3. List the main stages of the crop production cycle in correct order.
4. Why is land preparation considered the most critical stage of the crop production cycle?

5. Explain what is meant by the temporal dimension of the crop production cycle.

1.2 Farmland Selection and Assessment

1.2.1 Criteria for selecting a suitable farmland

Farmland selection is one of the most consequential decisions in crop production because the land determines the crop types that can be grown, the inputs required, and the likely yield achievable. Key selection criteria include: soil type and texture (loamy soils are preferred for most crops because they balance water retention and drainage), soil depth (deep soils allow unrestricted root development), soil pH (most crops thrive between pH 5.5 and 7.0), and the absence of harmful levels of salinity, waterlogging, or toxic elements.

Other important criteria are land history (previous crops, pesticide use, weed seed bank), proximity to markets and infrastructure (roads, water supply, storage facilities), availability of labour and farm inputs, land tenure security (the farmer must have reliable access and legal right to use the land for a sufficient period to recover their investment), and exposure to agroclimatic risks such as flooding, drought, or erosion-prone slopes. A preliminary site visit combined with simple soil tests enables an informed selection decision before any investment is made in land clearing or inputs.

Fill in the blank: ________ soils are preferred for most crops because they balance water retention and drainage, supporting good root development and consistent moisture supply.

1.2.2 Soil assessment and fertility evaluation

Soil assessment determines whether the physical, chemical, and biological properties of the soil can support the intended crop. A simple field assessment begins with observation of the soil colour (dark soils are generally rich in organic matter), texture (the feel test: sandy soils feel gritty, clay soils feel sticky, loam feels smooth and slightly sticky), and structure (well-structured soils crumble easily and have visible pores). Waterlogging is assessed by observing whether water stands on the surface or drains quickly after simulated rainfall.

Soil fertility evaluation involves assessing nutrient status, which in the field can be approximated by observing the vigour of existing vegetation (dense, dark green vegetation indicates reasonable fertility) and by using simple soil test kits that measure pH, nitrogen, phosphorus, and potassium. Laboratory analysis of soil samples provides more precise results and guides fertiliser recommendations. Organic matter content is a key fertility indicator: soils with more than 2 per cent organic matter generally support good crop production without heavy fertiliser inputs. The results of soil assessment directly inform decisions on soil amendment before planting.

Fill in the blank: Soils with more than ________ per cent organic matter generally support good crop production and require less fertiliser input to achieve satisfactory yields.

Plate 1.1: A student performing a simple field soil texture test by rolling a moist soil sample between the palms to determine whether it is sandy, loamy, or clayey

1.2.3 Topography, drainage, and accessibility

Topography refers to the physical configuration of the land surface including slope, aspect, and elevation. Gently sloping land (2 to 5 per cent slope) is preferred for most arable crops because it allows natural drainage without excessive erosion. Steeply sloping land (above 15 per cent) is prone to surface runoff, sheet erosion, and nutrient loss, and requires expensive terracing or contour farming to be used safely. Flat or depressional land may accumulate water and become waterlogged, requiring drainage infrastructure before it can support most crops.

Drainage quality determines how quickly excess water leaves the soil after rain; poorly drained soils become anaerobic, impairing root respiration and promoting root rots and waterlogging stress in most crops except lowland rice. Accessibility refers to the ease of reaching the land with farm inputs (fertiliser, seeds, machinery) and removing outputs (harvested produce) to markets. Land that is physically fertile but inaccessible during the rainy season, when roads become impassable, loses much of its productive value because timely operations cannot be conducted and produce cannot be marketed. All three factors must be assessed together as part of integrated farmland suitability evaluation.

Fill in the blank: Gently sloping land of _________ to 5 per cent slope is preferred for arable crops because it provides natural drainage without causing significant surface erosion.

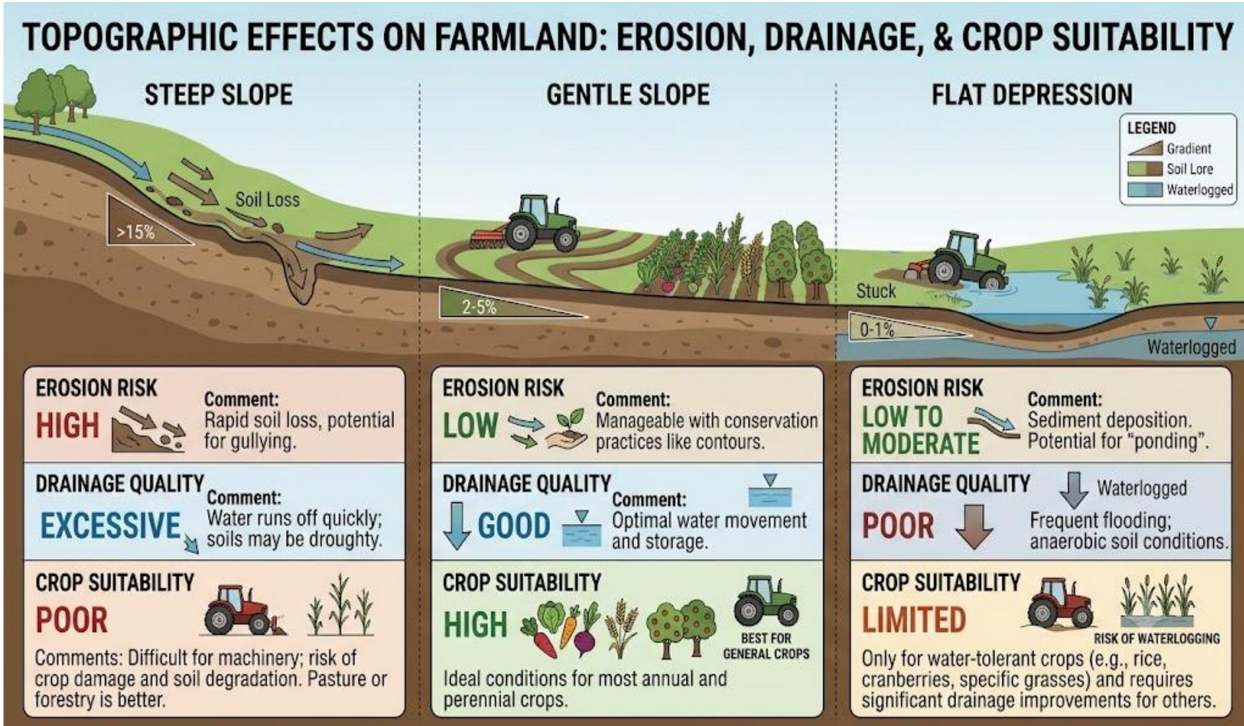

Figure 1.3: Diagram showing the relationship between topographic slope, drainage quality, and farmland suitability for different crop types

Pilot questions 1.2

1. List five criteria used to select a suitable farmland for crop production.
2. Why is land tenure security an important criterion in farmland selection?
3. Describe how a student can assess soil texture in the field without laboratory equipment.
4. What does soil organic matter content indicate about soil fertility?
5. Explain why steep slopes are unsuitable for most arable crop production.

1.3 Land Clearing and Pre-planting Operations

1.3.1 Methods of land clearing

Land clearing is the removal of existing vegetation and debris from selected farmland to allow tillage and planting. The three main methods are **manual clearing** (using cutlasses, hoes, and axes to cut and remove vegetation by hand), **mechanical clearing** (using bulldozers, tractors with brush cutters, or disc ploughs to clear and incorporate vegetation), and **chemical clearing** (applying herbicides to kill vegetation before tillage). In smallholder Nigerian agriculture, manual clearing with cutlass and hoe is the most common method.

Slash-and-burn clearing, in which cut vegetation is allowed to dry and then burned, has traditionally been practised in forest zones but is now discouraged because it destroys soil organic matter, kills beneficial soil organisms, contributes to air pollution, and accelerates forest loss. Where burning is unavoidable, the ash provides a short-term potassium and calcium benefit to the soil. Cut vegetation that is not burned should be composted or incorporated as green manure to return organic matter to the soil. The method of clearing chosen depends on farm size, terrain, available equipment, labour supply, and cost.

Fill in the blank: Slash-and-burn clearing is discouraged because it destroys soil ________ matter, kills beneficial soil organisms, and contributes to deforestation.

Plate 1.2: Students manually clearing farm vegetation using cutlasses and axes as part of practical farmland preparation

1.3.2 Tillage practices and their purposes

Tillage is the mechanical manipulation of the soil to create a suitable seedbed, control weeds, incorporate organic matter, and improve soil structure. **Primary tillage** (ploughing) is the initial deep disturbance of the soil, typically to a depth of 20 to 30 cm, using a mouldboard plough, disc plough, or ridging plough. It breaks up compacted layers, buries surface vegetation and residues, and creates a rough surface that weathers before secondary tillage. **Secondary tillage** (harrowing) refines the soil surface to a fine tilth suitable for seeding.

Zero tillage (no-till) is a conservation practice in which the soil is not disturbed and crops are planted directly into the previous crop residue; it conserves soil moisture, reduces erosion, and builds organic matter but requires effective weed control through herbicides or mulching. Minimum tillage involves limited soil disturbance sufficient to create a planting zone without full ploughing. For smallholder farmers in Nigeria, hoe tillage (making ridges or mounds with a hand hoe) is the most widely practised method; ridges improve drainage, concentrate soil organic matter, and are especially suited to root crops such as yam and cassava.

Fill in the blank: ________ tillage involves the initial deep disturbance of the soil to a depth of 20 to 30 cm using a plough, creating a rough surface that weathers before secondary tillage.

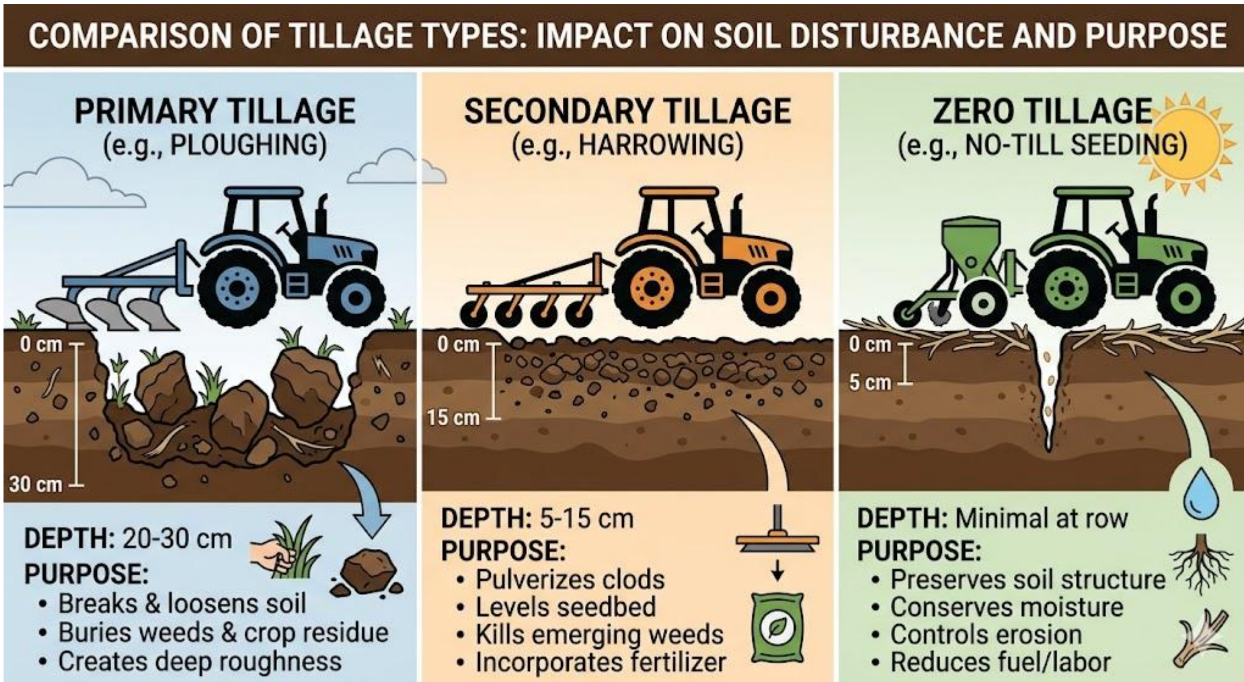

Figure 1.4: Diagram comparing primary tillage (ploughing), secondary tillage (harrowing), and zero tillage in terms of soil disturbance and purpose

1.3.3 Soil amendment and bed preparation

Soil amendment involves adding materials to the soil to improve its physical, chemical, or biological properties before planting. Organic amendments include farmyard manure, compost, and green manure crops, which improve soil structure, water retention, and biological activity while supplying slow-release nutrients. Inorganic amendments include lime (calcium carbonate or calcium hydroxide) applied to raise soil pH in acidic soils, gypsum applied to improve the structure of saline-sodic soils, and synthetic fertilisers applied as basal dressings to supply the nutrients most limiting to early crop growth.

Seedbed preparation is the final pre-planting operation, creating the physical conditions in which seeds can germinate and establish successfully. A good seedbed is fine-textured, firm enough to provide good seed-to-soil contact, moist but not waterlogged, free of large clods and debris, and at an appropriate depth for the crop. Ridges and mounds are traditional seedbeds for root crops; flat seedbeds are used for cereals and legumes seeded by broadcasting or drilling; raised beds improve drainage and root aeration in low-lying or heavy-clay areas. Amendment materials are incorporated during tillage so they are evenly distributed through the seedbed zone.

Fill in the blank: ________ is applied to acidic soils during soil amendment to raise the pH to a range suitable for most food crops.

Pilot questions 1.3

1. Name the three main methods of land clearing and state one advantage and one disadvantage of each.
2. Why is slash-and-burn clearing discouraged in modern agricultural practice?
3. Distinguish between primary tillage and secondary tillage.
4. Explain the advantages of zero tillage over conventional tillage.
5. State three characteristics of a well-prepared seedbed.

1.4 Practical Skills in Farmland Preparation

1.4.1 Tools and equipment for land preparation

Hand tools are the primary implements used for farmland preparation by smallholder farmers in Nigeria. The **cutlass** (machete) is used for vegetation clearing; the **hoe** is used for tillage, ridging, weeding, and seedbed preparation; the **axe** is used for cutting woody vegetation and stumps; the **rake** is used for gathering cleared debris and smoothing seedbeds; and the **wheelbarrow** is used for transporting manure, soil, and harvested produce.

Animal-drawn implements include the ox plough, disc harrow, and ridger, which multiply the area a farmer can prepare compared with hand tools. Mechanised equipment includes tractors fitted with mouldboard ploughs, disc ploughs, and disc harrows for large-scale operations. All tools must be properly maintained: cutting edges sharpened regularly, wooden handles checked for cracks and replaced as needed, metal parts oiled to prevent rust, and tools cleaned and stored securely after use. Poorly maintained tools are less efficient, cause operator fatigue and injury, and have shorter working lives, increasing the cost of farm operations.

Fill in the blank: The ________ is the most versatile hand tool used in Nigerian smallholder farming, employed for tillage, ridging, weeding, and seedbed preparation.

Plate 1.4: Common farm hand tools laid out for a practical session including cutlass, hoe, rake, axe, and wheelbarrow

1.4.2 Practical steps in preparing a farm plot

Preparing a farm plot follows a logical sequence of steps that must be performed in the correct order. Step 1: **demarcation** — mark the boundaries of the plot using pegs and string or ridging. Step 2: **clearing** — remove vegetation using cutlass, axe, or mechanical means. Step 3: **primary tillage** — plough or hoe-till the cleared area to the required depth, incorporating surface residues. Step 4: **amendment** — apply and incorporate manure, compost, lime, or basal fertiliser as indicated by soil assessment.

Step 5: **secondary tillage** — harrow or hoe the surface to create a fine, uniform tilth. Step 6: **seedbed formation** — make ridges, mounds, raised beds, or flat beds according to the crop to be planted. Step 7: **final inspection** — check that the plot is free of large debris and clods, the seedbed is at the correct depth and firmness, drainage channels are in place, and plot boundaries are clearly marked. Each step should be completed before the next begins, and the completed plot should be planted as soon as possible to prevent weed re-establishment and moisture loss from the disturbed soil surface.

Fill in the blank: The first practical step in preparing a farm plot is ________, which involves marking the plot boundaries using pegs and string before any vegetation is cleared.

Figure 1.5: Step-by-step flowchart showing the seven practical steps of farm plot preparation from demarcation to final inspection

1.4.3 Safety, ethics, and good farm practices

Safety on the farm is a non-negotiable professional obligation. When using cutting tools such as cutlasses and axes, students must maintain a safe working distance from other operators, always cut away from the body, ensure tools are sharp (blunt tools require excessive force and are more likely to slip), and wear appropriate protective clothing including boots, gloves, and long trousers. When operating in the sun, rest breaks, adequate hydration, and sun protection reduce the risk of heat exhaustion.

Ethical farm practices encompass responsible land use and stewardship. Students must avoid clearing vegetation beyond the designated farm plot, dispose of cleared material responsibly (compost rather than burn where possible), avoid contaminating water sources with agrochemicals, return borrowed tools cleaned and in good condition, and respect the property and crops of neighbouring farms. Good farm practices also include keeping accurate records of operations performed (dates, inputs applied, observations made), which builds the evidence base for farm decision-making and supports the agricultural extension and evaluation objectives of this course.

Fill in the blank: Students using cutting tools must always cut ________ from the body and maintain a safe working distance from other operators to prevent injury.

Safety & Ethics Criteria	**Key Practices**
Tool use	Handle hoes, cutlasses, and other farm tools carefully; store them properly after use.
Protective clothing	Wear boots, gloves, hats, and long sleeves to prevent injuries, bites, and sunburn.
Waste disposal	Dispose of plastics, chemical containers, and organic waste responsibly; avoid littering.
Record keeping	Keep accurate notes on land preparation activities, inputs used, and observations.
Ethical conduct	Respect shared tools, avoid damaging crops or property, and work cooperatively.
Environmental care	Prevent soil erosion, conserve water, and protect biodiversity during farm work.

Box 1.2: Safety rules and ethical good farm practices for practical farmland preparation

Pilot questions 1.4

1. Name five hand tools used in farmland preparation and state the function of each.
2. Why is regular maintenance of farm tools important?
3. List the seven steps of farm plot preparation in the correct order.
4. State three safety rules that must be observed when using cutting tools on the farm.

5. Give two examples of ethical responsibilities of a student farmer during practical farm work.

Series Summary

This Series has introduced the foundational knowledge and practical skills required for crop production and farmland preparation. We began by establishing the importance of crop production in food security, national development, and livelihoods, categorising crops by their type and use, and describing the crop production cycle as a sequential and temporally structured set of operations. We then examined the criteria for farmland selection, practical methods of soil assessment and fertility evaluation, and the influence of topography, drainage, and accessibility on land suitability.

Following that, we covered the three methods of land clearing, primary and secondary tillage and conservation alternatives, and soil amendment and seedbed preparation practices. Finally, we identified the tools and equipment used in land preparation, described the seven-step sequence for preparing a farm plot, and emphasised the safety rules, ethical responsibilities, and good practice standards expected of every student during practical farm work. By completing this Series, you should now be able to achieve all nine Series Learning Outcomes (SLO 1.1 to SLO 1.9).

Glossary of Terms

- **Arable crop:** a crop grown on tilled land in an annual or short-season production system, as distinct from perennial tree crops; examples include maize, cassava, cowpea, and tomato.
- **Basal dressing:** the application of fertiliser to the soil before or at planting, incorporated during tillage or placed in the planting hole, to supply nutrients to the crop during early establishment.
- **Compost:** decomposed organic material produced by the controlled biological breakdown of crop residues, kitchen waste, or animal manure; used as a soil amendment to improve structure, fertility, and biological activity.

- **Conservation tillage:** tillage practices that minimise soil disturbance and maintain crop residues on the surface to reduce erosion, conserve moisture, and build organic matter; includes zero tillage and minimum tillage.
- **Crop rotation:** the practice of growing different crop species in sequence on the same land over successive seasons to manage soil fertility, break pest and disease cycles, and reduce weed pressure.
- **Farmyard manure:** a mixture of animal dung, urine, and bedding material that has been composted or partially decomposed; applied as a soil amendment to improve fertility and organic matter content.
- **Green manure:** a crop grown specifically to be incorporated into the soil while still green to improve soil organic matter, nitrogen content, and structure; legumes are the most common green manures.
- **Harrowing:** secondary tillage using a harrow implement to break up clods, level the soil surface, and create a fine seedbed after primary tillage (ploughing).
- **Land tenure:** the legal and customary arrangements governing who has the right to use, manage, and benefit from a piece of land; secure tenure is essential for long-term agricultural investment.
- **Loamy soil:** a soil texture class with a balanced mixture of sand, silt, and clay particles that provides good drainage, water retention, aeration, and nutrient-holding capacity; generally the most productive soil texture for crop production.
- **Mouldboard plough:** a primary tillage implement that cuts, lifts, and inverts a furrow slice of soil, burying surface vegetation and residues and exposing subsoil to weathering.
- **pH (soil):** a measure of soil acidity or alkalinity on a scale of 0 to 14; pH 7 is neutral, below 7 is acidic, above 7 is alkaline; most crops prefer a pH between 5.5 and 7.0.
- **Primary tillage:** the initial deep disturbance of the soil (ploughing) to a depth of 20 to 30 cm that breaks compacted layers, buries residues, and prepares the land for secondary tillage.
- **Ridging:** a tillage operation that forms raised rows of soil (ridges) separated by furrows; improves drainage, concentrates organic matter, and is particularly suited to root crops such as yam and cassava.

- **Secondary tillage:** tillage operations performed after primary tillage to refine the seedbed; includes harrowing, rotavating, and levelling to create a fine, uniform tilth suitable for sowing.
- **Seedbed:** the soil layer prepared and conditioned to provide the physical conditions (fineness, firmness, moisture, depth) required for seed germination and early seedling establishment.
- **Slash-and-burn:** a land clearing method in which vegetation is cut, allowed to dry, and then burned; not recommended in modern practice because it destroys soil organic matter and contributes to deforestation.
- **Soil fertility:** the capacity of a soil to supply the nutrients, water, and physical conditions required by crops to achieve their productive potential.
- **Tilth:** the physical condition of the soil after tillage, describing its texture, structure, and suitability as a seedbed; a fine tilth has small, uniform crumbs with good pore space.
- **Zero tillage (no-till):** a conservation practice in which crops are planted directly into untilled soil with minimal disturbance; conserves moisture, reduces erosion, and builds organic matter over time.

Concept Check Questions [Series 1]

Objective Questions

1. Crop production is the branch of agriculture concerned with growing plants for food, feed, fibre, fuel, and ________ raw materials. (Linked to SLO 1.1)
2. Most crops thrive in a soil pH range of ________ to 7.0. (Linked to SLO 1.3)
3. The initial deep disturbance of the soil to 20 to 30 cm depth is called ________ tillage. (Linked to SLO 1.7)
4. A conservation practice in which crops are planted directly into untilled soil is called ________ tillage. (Linked to SLO 1.7)
5. The first practical step in preparing a farm plot is ________, which involves marking the plot boundaries. (Linked to SLO 1.9)

Short-Answer Questions

6. Explain why farmland selection is one of the most consequential decisions in crop production. (Linked to SLO 1.3)
7. Describe how a student can assess soil texture in the field without laboratory equipment. (Linked to SLO 1.4)
8. Distinguish between primary tillage and secondary tillage and explain the purpose of each. (Linked to SLO 1.7)
9. State three characteristics of a well-prepared seedbed and explain why each is important. (Linked to SLO 1.8)
10. State three safety rules that must be observed when using cutting tools during practical farm work. (Linked to SLO 1.9)

Long-Answer Questions

11. Analyse the criteria used for farmland selection and explain how soil assessment, topography, drainage, and accessibility together determine the suitability of a piece of land for crop production. (Linked to SLOs 1.3, 1.4, 1.5)
12. Discuss the pre-planting operations required to prepare a farmland for crop production, explaining the methods of land clearing, the types of tillage, the role of soil amendment, and the characteristics of a good seedbed. (Linked to SLOs 1.6, 1.7, 1.8)

13. Evaluate the practical skills, safety standards, and ethical responsibilities required of an agricultural student during farmland preparation, describing the tools used, the sequence of operations, and the good farm practices expected. (Linked to SLOs 1.8, 1.9)

Answers to Concept Check Questions [Series 1]

Objective Questions

1. Industrial.
2. 5.5.
3. Primary.
4. Zero.
5. Demarcation.

Short-Answer Questions

6. Farmland selection determines the crop types that can be grown, the inputs required, and the likely yield; a poor choice of land imposes costs and constraints that persist throughout the production cycle, including insufficient drainage, inappropriate pH, shallow soils that restrict root growth, or poor accessibility that prevents timely operations; getting the selection right is therefore the highest-leverage decision in the crop production process.
7. The feel test: take a moist soil sample and roll it between the palms; sandy soil feels gritty and will not form a ribbon; clay soil feels sticky and smooth and forms a long, plastic ribbon; loam feels smooth and slightly sticky and forms a short ribbon that crumbles; silt feels silky or floury when dry and slightly plastic when wet.
8. Primary tillage (ploughing) is the initial deep disturbance of the soil to 20 to 30 cm, breaking compacted layers, burying surface residues, and creating a rough surface that weathers; secondary tillage (harrowing) refines the rough ploughed surface into a fine, uniform tilth by breaking clods and levelling the surface in preparation for seeding.
9. Any three: fine-textured (provides good seed-to-soil contact for uniform germination); firm but not compacted (allows root penetration while preventing seed movement); moist but not waterlogged (provides germination moisture without causing anaerobic conditions); free of large

clods and debris (prevents physical barriers to seedling emergence); correct depth for the crop (ensures seeds are placed at the optimal depth for the species).

10. Any three: always cut away from the body; maintain a safe working distance from other operators when swinging cutting tools; keep cutting edges sharp to reduce the force required and the risk of slipping; wear protective clothing including boots, long trousers, and gloves; inspect the tool handle for cracks before use.

Long-Answer Questions

11. Basic response: Key farmland selection criteria include soil type and texture (loam preferred), soil depth, pH (5.5 to 7.0 for most crops), drainage, land history, market proximity, labour availability, and tenure security. Soil assessment uses the feel test and simple test kits to evaluate texture, pH, and nutrient status. Topography assessment checks slope (2 to 5 per cent preferred for arable crops, above 15 per cent erosion-prone) and drainage. Accessibility ensures timely input delivery and produce marketing.
12. Value-added response: Farmland suitability is not a binary yes/no but a profile of opportunities and constraints that must be matched to the crop, the available inputs, and the farmer's resources. A student farmer who conducts a thorough pre-selection assessment avoids costly mistakes that cannot be corrected once operations begin; a poorly drained plot identified before clearing can be drained before investment is made, while one identified after planting may result in total crop failure. Developing systematic assessment habits early in a farming career is therefore one of the most valuable professional investments an agriculture student can make.
13. Basic response: Land clearing methods: manual (cutlass, axe — low cost, labour-intensive), mechanical (tractors — fast, high cost), chemical (herbicides — effective but requires skill). Slash-and-burn is discouraged due to organic matter loss and forest damage. Primary tillage (ploughing to 20 to 30 cm) breaks compacted layers; secondary tillage (harrowing) creates fine tilth. Soil amendment: organic (manure, compost) improves structure and biology; inorganic (lime, basal fertiliser) corrects pH and nutrient deficiencies. A good seedbed is fine, firm, moist, and free of debris.
14. Value-added response: The choice of clearing method should match the scale, terrain, vegetation type, and available resources. Manual clearing is appropriate for small plots and forest margins where machinery cannot operate; mechanical clearing for large open areas; chemical clearing where vegetation is dense and labour costs are high. Conservation alternatives to burning (composting cut material, incorporating green manure) represent best practice that should become habitual for agriculture students. The combination of organic and inorganic soil amendment,

guided by soil assessment results, is always more effective and more economical than blanket fertiliser application without knowledge of the soil's starting condition.

15. Basic response: Hand tools: cutlass (clearing), hoe (tillage, ridging, weeding), axe (woody vegetation), rake (debris removal, seedbed smoothing), wheelbarrow (transport). Seven steps: demarcation, clearing, primary tillage, soil amendment, secondary tillage, seedbed formation, final inspection. Safety: cut away from body, safe distance between operators, sharp tools, protective clothing. Ethics: responsible waste disposal, no contamination of water sources, record keeping, respect for neighbouring farms.
16. Value-added response: The practical skills developed in farmland preparation are the foundation on which all subsequent crop production skills are built. A student who can systematically and safely prepare a well-structured seedbed has already demonstrated competence in observation, tool use, sequencing, and applied agronomy. The ethical dimensions, including responsible land use, waste management, and accurate record keeping, reflect the professional standards expected of agricultural graduates who will serve as role models and change agents in their communities.

Answers to Pilot Questions [Series 1]

Part 1.1: Introduction to Crop Production

1. Any three: crop production is the primary source of food for the population; it contributes substantially to agricultural GDP and rural employment; it supplies raw materials for agro-processing industries; it earns foreign exchange through agricultural exports; it supports food security and poverty reduction.
2. Any four categories with two examples each: cereals (maize, rice); legumes (cowpea, groundnut); roots and tubers (cassava, yam); vegetables (tomato, okra); tree crops (oil palm, cocoa); fibre crops (cotton, jute).
3. Land selection and preparation, planting operations (seed selection and sowing), crop establishment and cultural practices (fertilisation, weeding, irrigation, pest management), harvesting, post-harvest operations (threshing, drying, grading, storage).
4. Land preparation is considered most critical because mistakes at this stage, such as poor drainage, incorrect pH, or inadequate seedbed preparation, propagate through the entire production cycle and reduce the final yield; unlike errors at later stages (such as missing a weeding), poor land preparation cannot easily be corrected once the crop is established.

5. The temporal dimension refers to the fact that each crop production operation must be timed to match seasonal rainfall patterns, temperature regimes, and market demand; sowing must coincide with the onset of rains, harvesting must occur at the correct stage of crop maturity, and produce must reach markets when demand and prices are favourable.

Part 1.2: Farmland Selection and Assessment

1. Any five: soil type and texture (loam preferred); soil depth (unrestricted root development); soil pH (5.5 to 7.0 for most crops); drainage quality; land history (previous crops and weed seed bank); proximity to markets and infrastructure; labour and input availability; land tenure security; agroclimatic risk (flooding, drought, erosion).
2. Land tenure security ensures that the farmer has reliable access and legal right to use the land for a sufficient period to recover the cost of investments made in clearing, amendment, and crop establishment; without tenure security, farmers are reluctant to make long-term improvements such as drainage infrastructure or perennial crop planting.
3. The feel test: take a moist soil sample, roll it between the palms; sandy soil feels gritty and will not form a ribbon or ball; clay soil feels sticky and smooth and forms a long plastic ribbon; loam feels smooth and slightly sticky and forms a short ribbon that crumbles; silt feels silky when dry and slightly plastic when wet.
4. Soil organic matter content indicates overall soil biological activity, nutrient-holding capacity, and structural quality; soils above 2 per cent organic matter generally have active microbial populations, good water retention, and adequate slow-release nutrient supply, requiring lower fertiliser inputs to achieve satisfactory crop yields.
5. Steep slopes above 15 per cent cause rapid surface runoff that carries away topsoil nutrients (sheet erosion), reduces water infiltration and soil moisture, makes mechanised operations dangerous or impossible, and requires expensive terracing or contour farming to prevent severe land degradation.

Part 1.3: Land Clearing and Pre-planting Operations

1. Manual: advantage — low cost, suitable for small plots and inaccessible terrain; disadvantage — labour-intensive and slow. Mechanical: advantage — fast and efficient for large areas; disadvantage — high cost and can compact or damage soil. Chemical: advantage — effective against dense vegetation with minimal soil disturbance; disadvantage — requires skill, protective equipment, and can contaminate water if misused.

2. Slash-and-burn destroys soil organic matter, killing beneficial soil organisms and reducing long-term fertility; it contributes to air pollution through smoke emissions; it accelerates deforestation and loss of biodiversity; and the ash-derived fertility boost is short-lived and followed by rapid soil degradation if not followed by proper land management.
3. Primary tillage (ploughing) is the initial deep disturbance of the soil to 20 to 30 cm that breaks compacted layers, buries surface residues, and creates a rough surface; secondary tillage (harrowing) refines the rough ploughed surface into a fine, uniform tilth suitable for seeding by breaking clods and levelling the surface.
4. Zero tillage conserves soil moisture by maintaining surface residues that reduce evaporation; reduces soil erosion by eliminating the exposed, disturbed surface produced by conventional tillage; builds soil organic matter over time through residue accumulation; and saves fuel and labour costs. However, it requires effective weed control through herbicides or mulching.
5. Any three: fine-textured with small uniform crumbs; firm enough to provide good seed-to-soil contact; moist but not waterlogged; free of large clods and debris; correct depth for the crop; level surface for uniform seeding depth; good drainage to prevent waterlogging.

Part 1.4: Practical Skills in Farmland Preparation

1. Cutlass: vegetation clearing. Hoe: tillage, ridging, weeding, seedbed preparation. Axe: cutting woody vegetation and stumps. Rake: gathering debris and smoothing seedbeds. Wheelbarrow: transporting manure, soil, and harvested produce.
2. Properly maintained tools are more efficient (requiring less physical effort), safer to use (sharp tools are less likely to slip), have longer working lives (reducing replacement costs), and produce better quality work; poorly maintained tools increase operator fatigue and injury risk and raise the long-term cost of farm operations.
3. Demarcation, clearing, primary tillage, soil amendment, secondary tillage, seedbed formation, final inspection.
4. Any three: always cut away from the body; maintain a safe working distance from other operators; keep cutting edges sharp; wear protective clothing (boots, long trousers, gloves); inspect tool handles for cracks before use; rest and hydrate regularly when working in the sun.
5. Any two: dispose of cleared vegetation responsibly by composting rather than burning where possible; avoid clearing vegetation beyond the designated farm plot boundaries; avoid contaminating water sources with agrochemicals; return borrowed tools cleaned and in good condition; keep accurate records of operations performed and inputs applied; respect the property and crops of neighbouring farms.

References and Attributions [Series 1]

Textual References (Books and External Sources)

- Brady, N. C., & Weil, R. R. (2016). The nature and properties of soils (15th ed.). Pearson Education.
- Fageria, N. K., Baligar, V. C., & Clark, R. B. (2006). Physiology of crop production. Food Products Press.
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- Oluwole, S. O. (2006). Principles of crop production in West Africa. Concept Publications.
- FAO (Food and Agriculture Organization of the United Nations). (2015). Soil and water conservation practices: Fact sheet. FAO.
- FAO (Food and Agriculture Organization of the United Nations). (2025). Guidelines for sustainable agriculture. FAO.

Figures, Plates, Tables, and Boxes

- Figure 1.1: Importance of crop production diagram Attribution: AI generated using prompt "Generate a diagram showing crop production at the centre with arrows to food security, industrial raw materials, foreign exchange, rural livelihoods, and agro-processing." Suggested OER search string: "importance of crop production diagram food security livelihoods OER".
- Table 1.1: Crop categories and uses Attribution: AI generated using prompt "Generate a table listing crop categories including cereals, legumes, roots and tubers, vegetables, tree crops, and fibre crops with examples and primary uses." Suggested OER search string: "crop categories uses cereals legumes roots vegetables tree crops table OER".
- Figure 1.2: Crop production cycle circular diagram Attribution: AI generated using prompt "Generate a circular flowchart showing the crop production cycle from land preparation through planting, cultural practices, harvesting, and post-harvest operations." Suggested OER search string: "crop production cycle stages circular diagram OER".
- Box 1.1: Farmland selection criteria checklist Attribution: AI generated using prompt "Generate a checklist box listing key criteria for farmland selection including soil type, depth, pH, drainage, land history, market proximity, and land tenure." Suggested OER search string: "farmland selection criteria checklist soil pH drainage land tenure OER".

- Plate 1.1: Student performing field soil texture test Attribution: AI generated using prompt "Generate an image of a student performing a field soil texture test by rolling moist soil between their palms." Suggested OER search string: "student soil texture test field assessment loam clay sandy OER image".
- Figure 1.3: Topography and farmland suitability diagram Attribution: AI generated using prompt "Generate a cross-section diagram showing steep slope, gentle slope, and flat depression with erosion risk, drainage quality, and crop suitability annotated." Suggested OER search string: "topography slope drainage farmland suitability cross-section diagram OER".
- Plate 1.2: Students manually clearing farm vegetation Attribution: AI generated using prompt "Generate an image showing agricultural students manually clearing farm vegetation using cutlasses and axes." Suggested OER search string: "students manual land clearing cutlass farmland preparation OER image".
- Figure 1.4: Tillage types comparison diagram Attribution: AI generated using prompt "Generate a three-panel diagram comparing primary tillage, secondary tillage, and zero tillage showing soil disturbance depth and purpose." Suggested OER search string: "tillage types primary secondary zero tillage comparison diagram OER".
- Plate 1.3: Prepared farm ridges and seedbeds Attribution: AI generated using prompt "Generate an image showing neatly prepared farm ridges and seedbeds on a student practical farm plot ready for planting." Suggested OER search string: "prepared farm ridges seedbeds student practical farm plot OER image".
- Plate 1.4: Common farm hand tools for practical session Attribution: AI generated using prompt "Generate an image showing common farm hand tools including cutlass, hoe, rake, axe, and wheelbarrow laid out for a practical session." Suggested OER search string: "farm hand tools cutlass hoe rake axe wheelbarrow practical session OER image".
- Figure 1.5: Farm plot preparation steps flowchart Attribution: AI generated using prompt "Generate a numbered flowchart showing seven steps of farm plot preparation: demarcation, clearing, primary tillage, soil amendment, secondary tillage, seedbed formation, and final inspection." Suggested OER search string: "farm plot preparation steps flowchart demarcation tillage seedbed OER".
- Box 1.2: Safety rules and ethical good farm practices Attribution: AI generated using prompt "Generate a text box listing key safety rules and ethical practices for students during practical farmland preparation." Suggested OER search string: "farm safety rules ethics good practices students practical OER".

Course code: AGE 102

Course title: Practical Farm Work 1

Course credit load: 2 Units

Series 2: Cultural Practices, Harvesting, and Storage Techniques

- **Part 2.1: Planting Operations and Crop Establishment**
  - Sub Part 2.1.1: Seed selection, treatment, and sowing methods
  - Sub Part 2.1.2: Planting density, spacing, and depth
  - Sub Part 2.1.3: Transplanting techniques and seedling management
- **Part 2.2: Cultural Practices During the Growing Season**
  - Sub Part 2.2.1: Fertilisation: types, timing, and application methods
  - Sub Part 2.2.2: Weeding methods and weed management strategies
  - Sub Part 2.2.3: Irrigation, mulching, and staking
- **Part 2.3: Harvesting Principles and Practices**
  - Sub Part 2.3.1: Determining crop maturity and harvest timing
  - Sub Part 2.3.2: Harvesting methods and tools for different crops
  - Sub Part 2.3.3: Post-harvest handling: threshing, drying, and grading
- **Part 2.4: Storage Techniques and Post-harvest Management**
  - Sub Part 2.4.1: Importance of proper storage and common storage losses
  - Sub Part 2.4.2: Traditional and modern storage structures and methods
  - Sub Part 2.4.3: Preservation techniques for crop products

Introduction

The preparation of farmland, covered in Series 1, creates the conditions for crop growth. What happens from the moment of planting through to the safe storage of the harvested product determines whether all that preparatory effort is translated into food, income, and raw materials, or lost to poor agronomic practice and post-harvest mismanagement. Cultural practices, harvesting, and storage are the operational heart of practical crop production, and proficiency in these skills is central to the objectives of this course.

The aim of this Series is to equip you with the practical knowledge and skills required for crop planting and establishment, the cultural management practices that support crop growth, the principles and techniques of harvesting different crop types, and the storage and preservation methods that protect harvested produce from loss.

We shall commence this Series by examining planting operations and crop establishment. Next, we will study the cultural practices applied during the growing season. Following that, we will cover harvesting principles, methods, and post-harvest handling. Finally, we will wrap up with storage structures, methods, and preservation techniques for crop products.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** describe seed selection and treatment methods and explain the main sowing techniques (Linked to Part 2.1),
- **SLO 2.2** explain the principles of planting density, spacing, and depth for different crops (Linked to Part 2.1),
- **SLO 2.3** demonstrate correct transplanting techniques and seedling management (Linked to Part 2.1),
- **SLO 2.4** describe the types, timing, and methods of fertiliser application in crop production (Linked to Part 2.2),
- **SLO 2.5** explain weeding methods and weed management strategies (Linked to Part 2.2),

- **SLO 2.6** describe irrigation, mulching, and staking practices and explain their roles in crop production (Linked to Part 2.2),
- **SLO 2.7** explain how to determine crop maturity and harvest timing for different crops (Linked to Part 2.3),
- **SLO 2.8** describe harvesting methods and post-harvest handling procedures (Linked to Part 2.3), and
- **SLO 2.9** identify and explain the storage structures, methods, and preservation techniques used for crop products (Linked to Part 2.4).

2.1 Planting Operations and Crop Establishment

2.1.1 Seed selection, treatment, and sowing methods

Seed selection is the first and most consequential planting decision. Good seed must be genetically pure (from the correct variety), physically intact (no broken or shrivelled seeds), free of seed-borne pathogens and pests, and capable of high germination and vigour. Improved varieties certified by agricultural seed agencies generally outperform farm-saved seed in yield potential, uniformity, and disease resistance. A simple germination test — placing a sample of seeds on moist paper and counting those that germinate after five to seven days — reveals germination percentage before field planting.

Seed treatment before sowing protects against soil-borne pathogens and seed-borne diseases, improves germination uniformity, and may supply early-season nutrients. Common treatments include fungicide dressing (thiram, mancozeb) to prevent damping-off, insecticide dressing (imidacloprid) to protect against soil insects, and rhizobium inoculation for legume seeds to enhance nitrogen fixation. Sowing methods include broadcasting (scattering seed uniformly over the seedbed, used for dense crops such as rice and cover crops), drilling (placing seed in continuous furrows at a set depth and spacing), and placing (dropping seeds individually into prepared holes, used for large-seeded crops such as maize and cowpea).

Fill in the blank: A simple ________ test, conducted by placing seeds on moist paper for five to seven days, reveals the germination percentage of a seed lot before field planting.

Seed Treatment Method	Agents Commonly Used	Problems Prevented
Fungicide dressing	Thiram, Carbendazim, Mancozeb, Tebuconazole, Trichoderma (bio-agent)	Seed-borne and soil-borne fungal diseases (e.g., damping-off, root rot, smuts)
Insecticide dressing	Imidacloprid, Chlorpyriphos, Thiamethoxam	Early-season insect pests (thrips, aphids, leafhoppers, white grubs)
Rhizobium inoculation	Rhizobium strains specific to legumes (soybean, cowpea, groundnut)	Poor nodulation, low nitrogen fixation, reduced legume growth

Table 2.1: Common seed treatment methods, the agents used, and the problems they prevent

2.1.2 Planting density, spacing, and depth

Planting density is the number of plants per unit area and is one of the most important determinants of crop yield and quality. Too high a density causes competition among plants for light, water, and nutrients, producing thin, weak plants with reduced individual yields; too low a density wastes land and allows excessive weed growth between plants. Optimal density is crop-specific: maize is typically planted at 53,000 to 67,000 plants per hectare; cowpea at 100,000 to 150,000; cassava at 10,000 to 12,500 cuttings per hectare.

Planting spacing is expressed as the distance between rows (inter-row) and between plants within a row (intra-row). For maize, a common spacing is 75 cm between rows and 25 to 30 cm within rows with two seeds per hole, later thinned to one. Planting depth must place the seed in moist soil at a depth where soil temperature and oxygen are adequate for germination; as a general rule, seeds are planted at a depth of two to three times their diameter. Very small seeds (onion, tomato) are sown shallowly (0.5 to 1 cm); large seeds (maize, cowpea) are sown at 3 to 5 cm; tuber crops (yam) are planted at 7 to 10 cm.

Fill in the blank: Seeds are generally planted at a depth of ________ to three times their diameter to ensure placement in moist, well-aerated soil with adequate temperature for germination.

Crop	Spacing	Planting Density (per hectare)	Planting Depth
Maize	75 cm between rows × 25 cm between plants	~53,000 plants/ha	3–5 cm
Cowpea	60 cm between rows × 20 cm between plants	~83,000 plants/ha	3–5 cm
Cassava	1 m × 1 m	~10,000 plants/ha	5–10 cm (stem cuttings)
Yam	1 m × 1 m	~10,000 plants/ha	10–15 cm (seed yam setts)
Tomato	75 cm between rows × 45 cm between plants	~29,000 plants/ha	1–2 cm

Table 2.2: Recommended planting spacing and density for selected Nigerian food crops Sample

2.1.3 Transplanting techniques and seedling management

Transplanting involves raising seedlings in a protected nursery environment and then moving them to the main field at an appropriate age. It is used for crops that benefit from an extended nursery period (tomato, pepper, onion, cabbage, rice in flooded paddies) or whose seeds are too small for reliable direct field sowing. A well-managed nursery provides optimal moisture, temperature, and nutrition for uniform germination and early growth, allowing the production of vigorous, uniform transplants that establish quickly in the field.

Transplanting should be done in the late afternoon or on a cloudy day to reduce transplant shock from water stress. Seedlings should be watered thoroughly before lifting, the root ball should be kept intact where possible (plug transplants minimise root disturbance), and transplants should be placed at the same depth as they grew in the nursery. After transplanting, irrigation should be applied immediately and daily for the first five to seven days until plants are established. Transplant mortality above 10 per cent indicates problems with transplant technique, nursery quality, or post-transplant care that must be diagnosed and corrected.

Fill in the blank: Transplanting should be done in the late ________ or on a cloudy day to reduce water stress and transplant shock in newly moved seedlings.

Plate 2.1: A student transplanting tomato seedlings from a nursery tray into prepared field ridges during a practical farm session

Pilot questions 2.1

1. State three characteristics of good quality seed for field planting.
2. What is seed priming and how does it improve field performance?
3. Explain the effect of too high a planting density on crop performance.
4. State the recommended planting depth guideline for seeds in relation to seed size.
5. Describe three practices that reduce transplant shock when moving seedlings from nursery to field.

2.2 Cultural Practices During the Growing Season

2.2.1 Fertilisation: types, timing, and application methods

Fertiliser is any material added to the soil or applied to plants to supply nutrients that are deficient or unavailable in sufficient quantities for maximum crop production. **Organic fertilisers** (compost, farmyard manure, green manure, crop residues) supply nutrients slowly as organic matter decomposes, improve soil structure and biological activity, and have no risk of causing salt injury when correctly applied. **Inorganic (mineral) fertilisers** supply nutrients in immediately available form and can be formulated to match crop demand precisely.

Fertiliser application timing is as important as the choice of fertiliser. Basal application occurs at or before planting and supplies nutrients for early establishment; nitrogen-rich fertilisers (urea, CAN) applied basally on sandy soils are at high risk of leaching loss and are better applied as split top-dressings when the crop has an established root system. Top-dressing is the application of fertiliser to established crops; nitrogen top-dressing at specific growth stages (tillering in cereals, first flowering in legumes) matches supply to peak demand. Fertiliser can be broadcast over the surface, placed in bands alongside rows, or applied through irrigation water (fertigation).

Fill in the blank: The application of fertiliser to established crops at specific growth stages is called ________ and matches nutrient supply to the period of peak crop demand.

Fertiliser	Nutrient Content	Recommended Timing	Application Method
NPK 15:15:15	Balanced mix of Nitrogen (15%), Phosphorus (15%), Potassium (15%)	At planting or early growth stage	Band placement or broadcasting near root zone
Urea	High Nitrogen (46%)	Top dressing during vegetative growth	Broadcasting or side dressing; avoid direct seed contact
SSP (Single Superphosphate)	Phosphorus (16–20%), Calcium, Sulphur	At planting for root development	Band placement in furrows or hills

Farmyard manure	Organic matter, Nitrogen, Phosphorus, Potassium (low concentration)	Before planting during land preparation	Broadcasting and incorporation into soil
Compost	Organic matter, micronutrients, improves soil structure	Before planting or as mulch during crop growth	Broadcasting, mulching, or incorporation into soil

Table 2.3: Common fertiliser types, their nutrient content, application timing, and method for Nigerian food crops

2.2.2 Weeding methods and weed management strategies

Weeds are plants growing where they are not wanted; they compete with crops for light, water, nutrients, and space, and can harbour pests and diseases. The critical period of weed competition is the first four to eight weeks after planting for most annual crops; weeds establishing during this window cause the greatest yield loss. Weed management is not the complete elimination of weeds (which is neither economically feasible nor ecologically desirable) but keeping weed populations below the economic threshold at which competition reduces yield.

Weeding methods include manual weeding with a hoe or hand pulling (most common in smallholder agriculture; thorough but labour-intensive), mechanical weeding with inter-row cultivators or wheel hoes (faster but requires appropriate row spacing and equipment), and chemical weeding with herbicides (pre-emergent herbicides applied to the soil before crop emergence to prevent weed germination; post-emergent herbicides applied to growing weeds). Cultural weed control strategies include crop rotation (disrupts weed life cycles), mulching (suppresses weed germination by blocking light), dense planting (competitive canopy closure), and the use of cover crops that smother weeds between seasons.

Fill in the blank: The first ________ to eight weeks after planting is the critical period of weed competition during which uncontrolled weeds cause the greatest crop yield loss.

Plate 2.2: Students weeding a maize plot using hoes during the critical weed competition period shortly after crop emergence

2.2.3 Irrigation, mulching, and staking

Irrigation is the artificial supply of water to crops when rainfall is insufficient, irregular, or absent. For practical farm work in Nigeria, small-scale irrigation methods include watering can application (for nurseries and small plots), bucket drip systems (slow water delivery through simple drip points at each plant), and furrow irrigation (water flowing along furrows between ridges). Irrigation should be applied in the early morning or late evening to minimise evaporation loss; over-irrigation causes waterlogging and root disease, while under-irrigation causes water stress and reduced yield.

Mulching is the application of organic or synthetic materials to the soil surface around crops. Organic mulches (grass, straw, leaves, crop residues) conserve soil moisture by reducing evaporation, moderate soil temperature, suppress weed germination, and decompose to add organic matter. A mulch layer of 5 to 10 cm is effective for most crops. **Staking** involves providing physical support to climbing or tall crops (yam, tomato, long-season cowpea, cucumber) using wooden stakes, bamboo poles, or trellises; it keeps foliage off the ground, improves air circulation, reduces disease, and makes harvesting easier.

Fill in the blank: ________ applied to the soil surface around crops conserves soil moisture, suppresses weed growth, moderates soil temperature, and adds organic matter as it decomposes.

Plate 2.3: Staked tomato plants and mulched beds on a practical student farm plot showing combined use of staking and mulching

Pilot questions 2.2

1. Distinguish between organic and inorganic fertilisers and give one advantage of each.
2. What is meant by basal application and top-dressing of fertiliser?
3. Explain the concept of the critical period of weed competition.
4. Compare manual weeding and chemical weeding in terms of cost, effectiveness, and practicality.
5. State two benefits of mulching for crop production.

2.3 Harvesting Principles and Practices

2.3.1 Determining crop maturity and harvest timing

Harvesting at the correct stage of maturity is critical for maximising yield, quality, and storage life. **Physiological maturity** is the stage at which the crop has achieved its maximum dry weight and nutritional content; it is the appropriate harvest point for grain crops (maize, sorghum, cowpea) where dry grain is the target product. **Horticultural maturity** is the stage at which the crop has the quality attributes (size, colour, texture, flavour) desired by the market, which may occur before or after physiological maturity depending on the crop and intended use.

Maturity indicators vary by crop. Maize grain maturity is indicated by the formation of a black layer at the base of the kernel (black layer test) and by the moisture content dropping below 30 per cent. Cassava roots can be harvested from 8 to 24 months depending on variety and intended use; roots that are fibrous or bitter indicate over-maturity. Tomato colour change from green to red (or yellow in some varieties) indicates harvest readiness for fresh markets. Cowpea pods turn yellow and dry when physiologically mature. Yam tubers are ready when the aerial parts yellow and die back. Understanding maturity indicators allows harvest to be timed to avoid both premature harvest (low yield and quality) and over-maturity (field losses, poor storage).

Fill in the blank: ________ maturity is the stage at which a grain crop has achieved its maximum dry weight and is the appropriate harvest point for crops where dry grain is the intended product.

🌾 Crop	Maturity Indicators	Harvest Timing
Maize	Kernels harden, husks dry, silk turns brown	90–120 days after planting
Cowpea	Pods turn brown/dry, seeds harden	75–100 days after planting
Cassava	Leaves yellow and fall, tubers swell	9–12 months after planting
Tomato	Fruits change from green to red, firm texture	70–90 days after transplanting
Yam	Vines yellow and dry, tubers fully developed	8–10 months after planting

Table 2.4: Maturity indicators and harvest timing for selected Nigerian food crops

2.3.2 Harvesting methods and tools for different crops

Harvesting method depends on the crop, scale of operation, available equipment, and the required product form. **Manual harvesting** is the most common method in Nigerian smallholder farming. Cereals (maize, sorghum) are harvested by hand-stripping cobs or cutting stalks with a cutlass. Legumes (cowpea, groundnut) are uprooted or pods are hand-picked. Root crops (cassava, yam) are dug with a hoe or fork, taking care to avoid damaging roots. Vegetables and fruits are hand-picked at the appropriate stage of maturity.

Harvesting tools include the cutlass (for cutting cereal stalks and cassava stems), the hoe and digging fork (for lifting root crops and groundnuts), harvesting knives and secateurs (for vegetables and fruits), and harvesting baskets and sacks for collecting and transporting produce from the field. Post-harvest field handling must minimise physical damage: rough handling of freshly harvested produce causes bruising that accelerates decay. Produce should be harvested during the cooler parts of the day, placed in the shade immediately after harvest, and transported to the handling facility as soon as possible to prevent deterioration from field heat.

Fill in the blank: Freshly harvested produce should be moved into the ________ immediately after harvest and transported to the handling facility quickly to prevent quality loss from field heat.

2.3.3 Post-harvest handling: threshing, drying, and grading

Threshing is the separation of the grain from the rest of the plant (stalk, pod, or cob). Manual threshing methods include beating sheaves against a hard surface, treading with feet or animal hooves, and hand-shelling of maize cobs. Mechanical threshers (pedal-operated or engine-driven) dramatically increase throughput and reduce physical damage to grain. Threshing must be followed immediately by winnowing, the removal of chaff and other light debris by exposing the grain to a wind current (natural or from a fan).

Drying reduces grain moisture content to safe storage levels: below 13 per cent for cereals, below 10 per cent for groundnuts, and below 8 per cent for cowpea to prevent mould growth and mycotoxin contamination. Sun drying on raised platforms or tarpaulins is the most common method; grain should be spread in thin layers, stirred frequently, and protected from rain and contamination. Grading involves sorting the harvested product by size, colour, weight, and freedom from defects, broken seeds, and foreign matter to meet market standards. Well-graded produce commands higher prices, reduces post-harvest losses, and facilitates standardised packaging.

Fill in the blank: Cereal grain must be dried to below ________ per cent moisture content before storage to prevent mould growth and mycotoxin contamination.

Plate 2.5: Freshly threshed grain being sun-dried on a raised platform and winnowed by students during a post-harvest practical session

Pilot questions 2.3

1. Distinguish between physiological maturity and horticultural maturity with one example of each.
2. State two maturity indicators for maize grain.
3. Name three harvesting tools used for different crops and state which crop each is used for.
4. Explain why freshly harvested produce should be moved to shade immediately after harvest.
5. Describe the process of winnowing and explain its purpose in post-harvest handling.

2.4 Storage Techniques and Post-harvest Management

2.4.1 Importance of proper storage and common storage losses

Storage is the preservation of harvested produce from the time of harvest until it is consumed, processed, or sold. Proper storage is essential because crops are harvested seasonally but consumed continuously throughout the year; without adequate storage, seasonal surpluses lead to price collapses and waste, while seasonal deficits cause food insecurity and high food prices. In Nigeria, post-harvest losses across all food crops are estimated at 20 to 40 per cent of total production, representing a major economic loss equivalent to billions of naira annually.

Common causes of storage losses include moisture (high grain moisture promotes mould and mycotoxin growth), insects (weevils, grain borers, and bean beetles are the most destructive grain storage pests in Nigeria), rodents (rats and mice consume and contaminate stored produce), and poor storage structures (leaking roofs, inadequate ventilation, and contact with damp floors). Physiological losses also occur through respiration and metabolic activity of living produce. Understanding the causes of storage losses is the first step to selecting appropriate storage methods and protective treatments.

Fill in the blank: In Nigeria, post-harvest losses across food crops are estimated at 20 to ________ per cent of total production, representing a major economic and food security challenge.

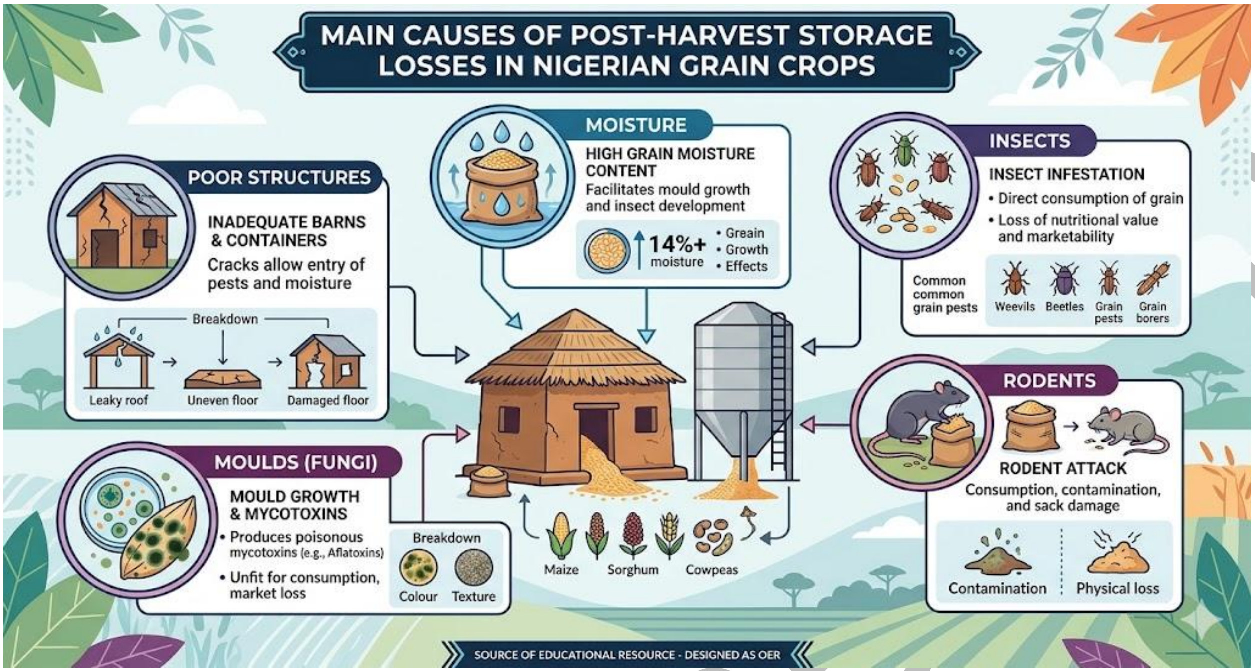


Figure 2.1: Diagram showing the main causes of post-harvest storage losses in Nigerian grain crops

2.4.2 Traditional and modern storage structures and methods

Traditional storage structures used in Nigerian smallholder agriculture include **cribs and barns** (open-sided wooden or bamboo structures that store maize on the cob with good air circulation), **mud granaries** (sealed clay structures used for small grain storage in the savanna zone), **underground pits** (used for yam and cassava storage in some communities), and **woven baskets and gourds** (used for household-scale storage of seeds and dried produce). Traditional structures are low-cost but generally provide inadequate protection against insects and rodents.

Modern improved storage structures and methods include hermetic storage bags (airtight polythene bags that create a modified atmosphere lethal to insects without chemical treatment; PICS bags and SuperGrain bags are widely promoted in Nigeria), metal silos (cylindrical galvanised steel bins providing rodent- and moisture-proof storage at small to medium scale), and warehouses with palletised bag storage and fumigation capability for large-scale commercial storage. Refrigerated cold storage is used for perishable produce (vegetables, fruits, tubers). Improved storage consistently reduces losses by 50 to 90 per cent compared with traditional methods.

Fill in the blank: Hermetic storage ________ create a modified atmosphere inside that becomes lethal to grain-damaging insects without the use of chemical pesticides.

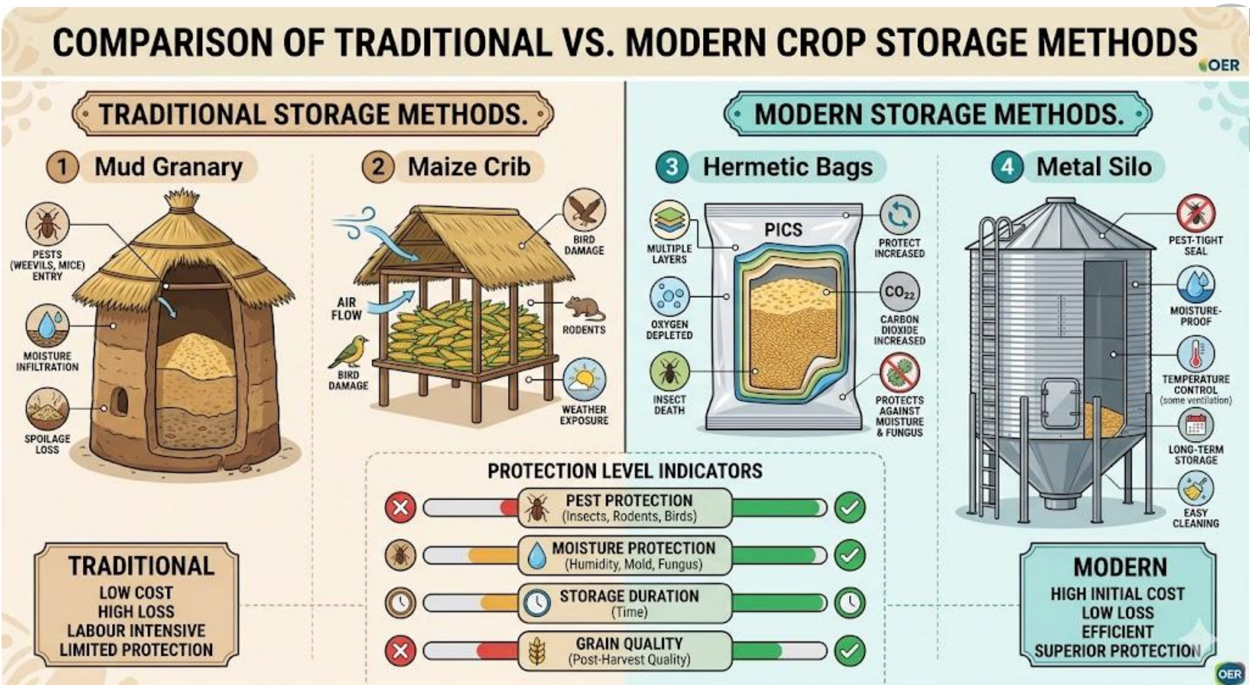


Figure 2.2: Diagram comparing traditional storage structures (mud granary, crib) with modern methods (hermetic bags, metal silo) in terms of protection against insects, moisture, and rodents

2.4.3 Preservation techniques for crop products

Chemical preservation of stored grain involves applying approved insecticides (pirimiphos-methyl, deltamethrin, spinosad) as admixture treatments or surface sprays to protect against storage insects. Fumigation using aluminium phosphide (phosphine gas) is used for large-scale grain storage to eliminate insects in sealed stores. Chemical treatments must be applied at the correct dose, only to produce intended for non-immediate human consumption, and with strict adherence to re-entry intervals and personal protective equipment requirements.

Physical and natural preservation methods are increasingly important as alternatives to synthetic chemicals. Hermetic storage eliminates insects without chemicals. Ash admixture (mixing grain with wood ash) creates a dust that clogs the spiracles of insects, killing them without toxic residues. Dried neem leaves, chilli powder, and other plant materials have documented insect-repellent properties and are used in traditional grain storage. For processed crop products (cassava flour, palm oil, dried vegetables), preservation involves controlling moisture content during drying, packaging in airtight containers, and storing away from heat, light, and humidity. Fermentation is used to preserve perishable products such as locust beans (iru) and cassava (fufu, garri).

Fill in the blank: Mixing grain with wood ________ is a traditional preservation method that kills storage insects by clogging their breathing pores without leaving toxic chemical residues.

Preservation Method	Type	Agents / Materials Used	Pest Targets
Insecticide admixture	Chemical	Actellic Super, Malathion, Permethrin powders	Grain weevils, beetles, moth larvae
Fumigation	Chemical	Aluminium phosphide tablets, carbon dioxide	Hidden insects, internal feeders (weevils, borers)
Hermetic storage	Natural/Physical	Airtight bags (e.g., PICS bags), sealed drums	All insect pests (oxygen deprivation)
Ash application	Natural	Wood ash mixed with grains	Weevils, beetles (repels and suffocates)
Neem leaves/powder	Natural	Neem seed powder, neem leaves	Weevils, beetles, moths (repellent and anti-feedant)
Chilli powder	Natural	Ground chilli mixed with grains	Weevils, beetles (repellent, irritant)

Box 2.1: Summary of chemical and natural preservation methods for stored crop products

Pilot questions 2.4

6. State three main causes of post-harvest storage losses in Nigerian grain crops.
7. Describe two traditional storage structures used in Nigeria and state one limitation of each.
8. What are hermetic storage bags and how do they protect grain without chemical pesticides?
9. Explain the role of moisture control in preventing post-harvest losses during storage.
10. Name two traditional or natural preservation methods for stored grain and explain how each works.

Series Summary

This Series has covered the operational core of practical crop production from planting through to safe storage of the harvested product. We began with planting operations, examining seed selection and treatment, sowing methods, the principles of planting density, spacing, and depth for different crops, and the transplanting techniques and seedling management practices that ensure successful crop establishment. We then studied the cultural practices applied during the growing season, including fertiliser types, timing, and application methods, weeding strategies with their critical period implications, and the supporting practices of irrigation, mulching, and staking.

Following that, we covered harvesting principles, learning to distinguish physiological from horticultural maturity, identifying maturity indicators for key Nigerian crops, describing manual harvesting tools and methods, and explaining post-harvest handling procedures including threshing, winnowing, drying to safe moisture levels, and grading. Finally, we examined the importance of proper storage, the causes of storage losses in Nigerian grain crops, the range of traditional and modern storage structures, and the chemical and natural preservation techniques available to protect harvested produce. By completing this Series, you should now be able to achieve all nine Series Learning Outcomes (SLO 2.1 to SLO 2.9).

Glossary of Terms

- **Basal application:** the application of fertiliser to the soil before or at planting, incorporated during tillage or placed in the planting hole, to supply nutrients during early crop establishment.
- **Black layer test:** a method of assessing maize grain maturity by inspecting the base of the kernel for the formation of a black abscission layer, which forms when the grain reaches physiological maturity.
- **Broadcasting:** a sowing method in which seed is scattered uniformly over the seedbed surface by hand or mechanically; used for dense crops such as rice and cover crops.

- **Critical period of weed competition:** the period of early crop growth (typically four to eight weeks after planting) during which uncontrolled weed competition causes the greatest reduction in final crop yield.
- **Fertigation:** the application of fertiliser through an irrigation system, supplying soluble nutrients directly to the root zone in the irrigation water.
- **Fumigation:** the treatment of sealed storage structures with a toxic gas (phosphine from aluminium phosphide) to kill insects in stored grain; requires certified operators and strict safety protocols.
- **Grading:** the sorting of harvested produce by size, colour, weight, and quality to meet market or processing standards; well-graded produce commands higher prices.
- **Hermetic storage:** an airtight storage system (bag, silo, or container) that creates a modified atmosphere through the respiration of grain and any insects present, eventually becoming lethal to insects without chemical treatment.
- **Horticultural maturity:** the stage of crop development at which the product has the size, colour, texture, or flavour desired by the consumer or market, which may differ from physiological maturity.
- **Inorganic fertiliser:** a manufactured mineral fertiliser supplying nutrients in immediately available form; examples include urea (N), single superphosphate (P), muriate of potash (K), and compound NPK fertilisers.
- **Mulching:** the application of organic or synthetic material to the soil surface around growing crops to conserve moisture, suppress weeds, moderate soil temperature, and add organic matter as the material decomposes.
- **PICS bags:** Purdue Improved Crop Storage bags; triple-layer hermetic polythene bags developed for small-scale grain storage, widely promoted in Nigeria as a low-cost alternative to insecticide treatment.
- **Physiological maturity:** the stage of crop development at which the plant has completed grain filling and achieved maximum dry weight; the appropriate harvest point for grain crops.
- **Rhizobium inoculation:** the treatment of legume seeds with a preparation containing Rhizobium bacteria before planting, to ensure effective nitrogen fixation in the root nodules of the crop.

- **Staking:** the provision of physical support to climbing or tall crops using wooden stakes, bamboo poles, or trellises; prevents lodging, improves canopy air circulation, and facilitates harvesting.
- **Threshing:** the post-harvest operation of separating grain from the rest of the plant material (stalks, pods, cobs); performed manually or with mechanical threshers.
- **Top-dressing:** the application of fertiliser (usually nitrogen) to an established growing crop, timed to coincide with a period of peak nutrient demand.
- **Transplanting:** the process of moving seedlings grown in a nursery to the main field; used for crops with small seeds or those requiring an extended nursery period.
- **Winnowing:** the separation of grain from chaff and light debris by exposing the threshed grain to a current of air, allowing the heavier grain to fall while the lighter chaff is blown away.

Concept Check Questions [Series 2]

Objective Questions

1. Seeds are generally sown at a depth of two to ________ times their diameter. (Linked to SLO 2.2)
2. The application of fertiliser to an established crop at peak demand stages is called ________. (Linked to SLO 2.4)
3. The first four to eight weeks after planting is known as the ________ period of weed competition. (Linked to SLO 2.5)
4. Cereal grain must be dried to below ________ per cent moisture content before safe storage. (Linked to SLO 2.8)
5. PICS bags are a type of ________ storage bag that protects grain without chemical pesticides. (Linked to SLO 2.9)

Short-Answer Questions

1. Explain why seed treatment before planting is important and name two types of seed treatment. (Linked to SLO 2.1)

2. Describe three cultural practices used to manage weed populations in a maize crop. (Linked to SLO 2.5)
3. Explain what physiological maturity means and give two indicators that maize grain has reached physiological maturity. (Linked to SLO 2.7)
4. State three causes of post-harvest storage losses in Nigerian grain crops and explain how each can be prevented. (Linked to SLO 2.9)
5. Explain how hermetic storage bags protect grain from insect damage without using chemical insecticides. (Linked to SLO 2.9)

Long-Answer Questions

1. Analyse the planting and crop establishment operations for a selected Nigerian food crop, explaining seed selection and treatment, sowing method, planting density and depth, and where applicable, transplanting procedure. (Linked to SLOs 2.1, 2.2, 2.3)
2. Discuss the cultural management practices required during the growing season of a crop, covering fertilisation, weed management, irrigation, mulching, and staking, and explaining the agronomic rationale for each practice. (Linked to SLOs 2.4, 2.5, 2.6)
3. Evaluate the post-harvest management of a Nigerian grain crop from harvest to storage, explaining how maturity is determined, the harvesting method used, post-harvest handling including threshing and drying, and the storage structure and preservation method selected. (Linked to SLOs 2.7, 2.8, 2.9)

Answers to Concept Check Questions [Series 2]

Objective Questions

1. Three.
2. Top-dressing.
3. Critical.
4. 13.
5. Hermetic.

Short-Answer Questions

1. Seed treatment before planting is important because it protects seeds and seedlings from soil-borne pathogens and seed-borne diseases, improves germination uniformity, and may supply early-season nutrients. Two types: fungicide dressing (e.g. thiram applied to seed surfaces to prevent damping-off); rhizobium inoculation (applying Rhizobium bacteria to legume seeds to ensure effective nitrogen fixation).
2. Any three: manual weeding with hoe during the critical period (first four to eight weeks after planting); mulching with organic materials to suppress weed germination by blocking light; application of a pre-emergent herbicide (e.g. atrazine) before crop emergence to prevent weed establishment; crop rotation to break the weed seed bank of species adapted to the previous crop.
3. Physiological maturity is the stage at which the crop has completed grain filling and achieved its maximum dry weight; two indicators for maize: (1) the black layer test, where a distinct black abscission layer forms at the base of the kernel; (2) grain moisture content drops below 30 per cent; (3) the husk turns brown and papery and can easily be peeled back.
4. Any three with prevention: high moisture (prevent by drying grain to below 13 per cent before storage); insect pests such as weevils and grain borers (prevent by insecticide admixture treatment or hermetic storage); rodents (prevent by storing in rodent-proof metal bins or sealed structures raised off the ground); fungal moulds and mycotoxins (prevent by drying to safe moisture levels and ensuring good store ventilation).
5. Hermetic storage bags (e.g. PICS bags) are triple-layer airtight polythene bags that, when properly sealed with grain inside, prevent the entry of new oxygen; insects already inside and in the grain respire and consume the available oxygen while releasing carbon dioxide; the resulting low-oxygen, high-carbon-dioxide modified atmosphere becomes lethal to insects within two to three weeks without any chemical application.

Long-Answer Questions

1. Basic response (using maize as example): Select certified improved seed with high germination (above 85 per cent); treat with fungicide (thiram) and insecticide (imidacloprid) dressing before planting; sow by placing at 75 cm by 25 to 30 cm spacing, 3 to 5 cm deep, two seeds per hole; thin to one plant per stand after establishment; target 53,000 to 67,000 plants/ha.
2. Value-added response: The choice of variety is the single highest-leverage seed decision: an improved open-pollinated variety or hybrid suited to the local agro-ecology, with resistance to the major diseases of the area, will outperform a well-treated but poorly adapted variety.

Students should practise the germination test before every planting season to avoid sowing seed with poor germination potential; this simple 5-day test saves the cost of replanting and the time lost to a failed stand.

3. Basic response: Fertilisation: apply NPK 15:15:15 at planting as basal dressing; top-dress with urea at four to six weeks (tillering). Weed management: weed twice during the critical period (two and four weeks after planting) using a hoe; apply atrazine pre-emergent if available. Irrigation: apply water during flowering and grain filling if rainfall is inadequate. Mulching: apply 5 to 10 cm of grass or straw mulch around plants. Staking not required for maize.
4. Value-added response: Each cultural practice has an economic optimum: the benefit of each additional unit of input must exceed its cost. For smallholder farmers, this means prioritising the two or three practices with the greatest yield impact per naira spent. In most situations, timely weeding during the critical period and a single targeted nitrogen top-dressing provide the best return on investment. Practices such as mulching, which require significant labour, are most valuable in the dry season or where moisture stress is a primary yield-limiting factor.
5. Basic response (using cowpea as example): Harvest when pods turn yellow-brown and dry; use the black-pod colour change as the primary indicator; hand-pick ripe pods in successive harvests or harvest all at once when 80 per cent of pods are ripe; sun-dry threshed grain to below 10 per cent moisture; grade by removing broken seeds and debris; store in PICS hermetic bags or treat with pirimiphos-methyl admixture in sealed jute bags.
6. Value-added response: Post-harvest losses in cowpea are among the highest of any Nigerian grain crop because the cowpea weevil (Callosobruchus maculatus) can multiply rapidly in stored grain, destroying the entire stock within three months if untreated. The choice between hermetic storage (zero chemical cost but requires airtight discipline) and insecticide admixture (reliable but requires correct dose and safety precautions) should be made based on the farmer's scale of operation and access to inputs. For smallholder women processors who store cowpea for household consumption, PICS bags represent the safest and most practical option.

Answers to Pilot Questions [Series 2]

Part 2.1: Planting Operations and Crop Establishment

1. Any three: genetically pure (correct variety); physically intact (no broken or shrivelled seeds); free of seed-borne pathogens and pests; high germination percentage (above 85 per cent); high vigour (rapid, uniform germination under field conditions); from a certified seed source.
2. Seed priming is the controlled partial hydration of seeds before planting, allowing pre-germination metabolic activity to begin without radicle emergence; it improves germination speed and uniformity, synchronises seedling emergence, and improves performance under stress conditions such as limited soil moisture; it is done by soaking seeds in water for a specified time, then re-drying to original weight before sowing.
3. Too high a planting density causes inter-plant competition for light (producing etiolated, weak stems), water, and nutrients; individual plant yield and grain size decline; susceptibility to lodging (falling over) increases; micro-climate within the canopy becomes humid, increasing disease pressure; overall yield per hectare may decrease beyond the critical density threshold.
4. Seeds are generally sown at a depth of two to three times their diameter; this ensures placement in the moist, warm soil zone required for germination while ensuring the seedling has sufficient energy reserves (cotyledons) to reach the soil surface; very small seeds (tomato, onion) are sown shallowly at 0.5 to 1 cm; large seeds (maize, cowpea) at 3 to 5 cm.
5. Any three: water seedlings thoroughly in the nursery before lifting to ensure turgid tissues; transplant in the late afternoon or on a cloudy day to reduce water stress; keep the root ball intact (use plug trays to avoid root damage); plant at the same depth as in the nursery; irrigate immediately after transplanting and daily for five to seven days; shade transplants with palm fronds or leaves for the first two to three days.

Part 2.2: Cultural Practices During the Growing Season

1. Organic fertilisers (compost, farmyard manure) supply nutrients slowly as organic matter decomposes, improve soil structure and biology, and have no salt injury risk; advantage: long-term soil health improvement. Inorganic fertilisers (urea, NPK) supply nutrients in immediately available form and can be formulated precisely; advantage: rapid nutrient supply matched to peak crop demand.

2. Basal application is the placement of fertiliser in the soil at or before planting (incorporated during tillage or placed in the planting hole or furrow) to supply nutrients for early establishment; top-dressing is the application of fertiliser to an established growing crop, usually on the soil surface or incorporated shallowly, timed to coincide with a period of peak demand such as tillering in cereals or first flowering in legumes.
3. The critical period of weed competition is the period of early crop growth (typically four to eight weeks after planting for most annual crops) during which uncontrolled weed competition causes the greatest reduction in final crop yield; weeds establishing before this period suppress the crop's ability to develop a competitive canopy; after this period, the crop canopy closes and suppresses further weed establishment, reducing the incremental yield loss from late-season weeds.
4. Manual weeding: low cost per operation, no chemical input required, suitable for small plots; effective if done at the right time; labour-intensive and time-dependent, may be delayed if labour is unavailable during the critical period. Chemical weeding: fast and effective over large areas, allows timely weed control regardless of labour availability; requires capital investment for herbicide purchase, sprayer, and protective equipment; risk of crop injury from wrong product or dose; requires skill in product selection and application.
5. Any two: conserves soil moisture by reducing surface evaporation, reducing irrigation frequency and drought stress; suppresses weed germination and growth by blocking light, reducing weeding labour; moderates soil temperature, protecting roots from heat stress in the dry season; decomposes to add organic matter and nutrients to the soil over time.

Part 2.3: Harvesting Principles and Practices

1. Physiological maturity: the stage at which the crop has completed grain filling and achieved maximum dry weight; appropriate harvest point for grain crops (example: maize harvested at physiological maturity when the black layer forms and moisture drops below 30 per cent). Horticultural maturity: the stage at which the produce has the quality attributes desired by the consumer or market (example: tomato harvested at horticultural maturity when the skin turns from green to red for fresh market sale, which is before physiological seed maturity).
2. Any two: formation of the black layer at the base of the kernel; grain moisture content dropping below 30 per cent; the husk turns brown and papery and can be peeled back easily from the cob.
3. Any three with crops: cutlass (maize — cutting stalks; cassava — cutting stems at harvest); hoe or digging fork (yam, cassava — lifting tubers from soil; groundnut — lifting plants);

harvesting knife or secateurs (tomato, pepper, cucumber — cutting fruit from the plant); harvesting basket or sack (all crops — collecting and transporting produce from the field).

4. Field heat rapidly accelerates the respiration rate and metabolic deterioration of harvested produce, reducing shelf life; bruising from rough handling in direct sunlight promotes rapid fungal and bacterial decay; moving produce into the shade immediately reduces temperature, slows respiration and deterioration, and preserves quality until it can be transported to the handling or processing facility.
5. Winnowing is the separation of grain from chaff and other light debris after threshing; it is performed by pouring the threshed mixture from a height in a wind current or in front of a fan, which blows the lighter chaff away while the heavier grain falls into the collection container; its purpose is to remove non-grain material that would increase bulk, harbour insects and moisture, and reduce the market grade and value of the stored grain.

Part 2.4: Storage Techniques and Post-harvest Management

1. Any three: high moisture content of grain (promotes mould and mycotoxin growth); insect pests (weevils, grain borers, bean beetles consume and contaminate grain); rodents (consume and contaminate stored produce); fungal moulds (grow on moist grain, producing mycotoxins harmful to human and animal health); poor storage structures (leaking roofs, damp floors, inadequate ventilation).
2. Any two with limitation: mud granary — low cost and widely available; limitation: can crack and allow moisture or insect entry, limited protection against rodents. Maize crib (open-sided wooden structure) — good ventilation for cob storage; limitation: poor protection against rodents and insects if not treated. Underground pit — low cost; limitation: risk of flooding, poor ventilation, and difficulty accessing produce.
3. Hermetic storage bags (e.g. PICS bags) are triple-layer airtight polythene bags that, when sealed, prevent the entry of oxygen; insects and grain inside consume the available oxygen through respiration and release carbon dioxide; the resulting low-oxygen, high-carbon-dioxide atmosphere becomes lethal to all life stages of storage insects within two to three weeks, protecting grain without any chemical treatment.
4. High moisture in stored grain supports the growth of mould fungi (especially Aspergillus species) that produce mycotoxins harmful to humans and livestock; it also promotes insect reproduction; drying grain to safe moisture levels (below 13 per cent for cereals) before storage stops mould growth and slows insect development; maintaining dry conditions in the

store (sealed roof, ventilation, pallets off damp floor) prevents re-absorption of moisture during storage.

5. Any two: Ash admixture — mixing grain with wood ash creates a fine dust that clogs the spiracles (breathing pores) of storage insects, asphyxiating them without toxic chemical residues; particularly effective against weevils and bean beetles. Dried neem leaves — neem leaves contain azadirachtin and other compounds that repel and disrupt the reproduction of storage insects; dried leaves are mixed with grain or placed around stored bags to reduce insect infestation.

References and Attributions [Series 2]

Textual References (Books and External Sources)

- Purseglove, J. W. (1972). Tropical crops: Monocotyledons. Longman.
- Onwueme, I. C., & Sinha, T. D. (1991). Field crop production in tropical Africa. CTA.
- Oluwatosin, G. A., Adeyemo, A. J., & Oke, A. O. (2014). Agricultural science for West African schools and colleges. Evans Brothers.
- IITA (International Institute of Tropical Agriculture). (2010). Cowpea production and storage. IITA Briefs.
- FAO (Food and Agriculture Organization of the United Nations). (2011). Global food losses and food waste. FAO.
- FAO (Food and Agriculture Organization of the United Nations). (2025). Guidelines for sustainable agriculture. FAO.

Figures, Plates, Tables, and Boxes

- Table 2.1: Seed treatment methods table Attribution: AI generated using prompt "Generate a table listing seed treatment methods including fungicide dressing, insecticide dressing, and rhizobium inoculation with agents and problems prevented." Suggested OER search string: "seed treatment methods fungicide insecticide rhizobium inoculation table OER".
- Table 2.2: Planting spacing and density table Attribution: AI generated using prompt "Generate a table showing recommended planting spacing, density, and depth for Nigerian food crops including maize, cowpea, cassava, yam, and tomato." Suggested OER search string: "planting spacing density depth Nigerian food crops table OER".
- Plate 2.1: Student transplanting tomato seedlings Attribution: AI generated using prompt "Generate an image of a student transplanting young tomato seedlings from a nursery tray into prepared field ridges during a practical farm session." Suggested OER search string: "student transplanting tomato seedlings nursery field ridges practical OER image".
- Table 2.3: Fertiliser types and application table Attribution: AI generated using prompt "Generate a table of common fertilisers used in Nigerian crop production with nutrient content, timing, and application method." Suggested OER search string: "fertiliser types nutrient content timing application Nigerian crops table OER".

- Plate 2.2: Students weeding a maize plot Attribution: AI generated using prompt "Generate an image of agricultural students manually weeding between maize rows using hoes during the critical weed competition period." Suggested OER search string: "students weeding maize rows hoes critical period weed competition OER image".
- Plate 2.3: Staked tomato plants and mulched beds Attribution: AI generated using prompt "Generate an image showing staked tomato plants supported by wooden stakes and mulched soil around their bases on a student practical farm plot." Suggested OER search string: "staked tomato plants mulched beds student practical farm plot OER image".
- Table 2.4: Crop maturity indicators and harvest timing Attribution: AI generated using prompt "Generate a table showing maturity indicators and harvest timing for Nigerian food crops including maize, cowpea, cassava, tomato, and yam." Suggested OER search string: "crop maturity indicators harvest timing Nigerian food crops table OER".
- Plate 2.4: Students harvesting maize cobs Attribution: AI generated using prompt "Generate an image of agricultural students manually harvesting maize cobs by hand-stripping from stalks during a practical farm session." Suggested OER search string: "students harvesting maize cobs hand-stripping practical farm OER image".
- Plate 2.5: Grain sun-drying and winnowing Attribution: AI generated using prompt "Generate an image showing threshed grain spread on a raised drying platform for sun drying and students winnowing grain to remove chaff." Suggested OER search string: "threshed grain sun drying winnowing raised platform students practical OER image".
- Figure 2.1: Post-harvest storage losses causes diagram Attribution: AI generated using prompt "Generate a diagram showing the main causes of post-harvest storage losses in Nigerian grain crops including moisture, insects, rodents, moulds, and poor structures." Suggested OER search string: "post-harvest storage losses causes Nigerian grain crops diagram OER".
- Figure 2.2: Traditional vs modern storage structures comparison Attribution: AI generated using prompt "Generate a comparison diagram showing traditional storage structures versus modern hermetic bags and metal silos with protection level indicators." Suggested OER search string: "traditional modern storage structures hermetic bags metal silo comparison OER diagram".
- Box 2.1: Grain preservation methods summary Attribution: AI generated using prompt "Generate a text box listing chemical and natural preservation methods for stored crop products including insecticide admixture, fumigation, hermetic storage, ash, neem, and chilli." Suggested OER search string: "grain storage preservation methods chemical natural hermetic ash neem OER".

Course code: AGE 102

Course title: Practical Farm Work 1

Course credit load: 2 Units

Series 3: Identification and Preservation of Weeds, Pests, and Diseases

- **Part 3.1: Weed Collection, Identification, and Preservation**
    - Sub Part 3.1.1: Importance of weed identification in crop production
    - Sub Part 3.1.2: Methods of collecting and pressing weed specimens
    - Sub Part 3.1.3: Techniques for preserving and mounting weed specimens
- **Part 3.2: Identification of Common Crop Pests**
    - Sub Part 3.2.1: Categories and characteristics of crop pests
    - Sub Part 3.2.2: Field identification of common insect pests and their damage
    - Sub Part 3.2.3: Collection and preservation of insect pest specimens
- **Part 3.3: Identification of Crop Diseases**
    - Sub Part 3.3.1: Categories of crop diseases and their causal agents
    - Sub Part 3.3.2: Field identification of common crop diseases by symptoms
    - Sub Part 3.3.3: Collection and preservation of disease specimens
- **Part 3.4: Integrated Pest and Disease Management**
    - Sub Part 3.4.1: Principles of Integrated Pest Management (IPM)
    - Sub Part 3.4.2: Cultural, biological, and chemical control methods
    - Sub Part 3.4.3: Practical application of IPM on the farm

Introduction

A farmer who cannot identify the weeds, pests, and diseases affecting a crop cannot manage them effectively. Misidentification leads to the wrong control measure being applied, wasting resources and potentially worsening the problem. Conversely, accurate identification of a pest or disease at its earliest stage allows timely, targeted, and cost-effective intervention. Developing the skills to collect, identify, and preserve specimens of weeds, pests, and diseases is therefore a foundational practical competency of this course.

The aim of this Series is to equip you with the practical skills of field identification of common weeds, insect pests, and crop diseases in the local farming environment, the techniques of collecting and preserving specimens for study and reference, and the principles and methods of integrated pest and disease management.

We shall commence this Series by examining weed identification, collection, and preservation. Next, we will study the identification and preservation of insect pest specimens. Following that, we will cover disease identification by symptoms and the collection of disease specimens. Finally, we will wrap up with the principles and practical application of integrated pest and disease management on the farm.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** explain the importance of weed identification and describe the categories of weeds found on Nigerian farms (Linked to Part 3.1),
- **SLO 3.2** collect and press weed specimens correctly and preserve them in a herbarium (Linked to Part 3.1),
- **SLO 3.3** identify the categories of crop pests and describe their general characteristics (Linked to Part 3.2),
- **SLO 3.4** identify common insect pests by their appearance and the damage symptoms they cause (Linked to Part 3.2),

- **SLO 3.5** collect, kill, and preserve insect pest specimens for study (Linked to Part 3.2),
- **SLO 3.6** identify the categories of crop diseases and their causal agents (Linked to Part 3.3),
- **SLO 3.7** identify common crop diseases by their field symptoms (Linked to Part 3.3),
- **SLO 3.8** describe the principles of Integrated Pest Management (IPM) (Linked to Part 3.4), and
- **SLO 3.9** apply cultural, biological, and chemical control methods appropriately in an IPM programme (Linked to Part 3.4).

3.1 Weed Collection, Identification, and Preservation

3.1.1 Importance of weed identification in crop production

Weeds are plants growing where they are not wanted; they compete with crops for light, water, nutrients, and space, and can harbour crop pests and diseases. Accurate identification of weed species is important because different weed species require different management strategies: annual grasses (e.g. spear grass, Imperata cylindrica) are controlled differently from perennial sedges (e.g. nutgrass, Cyperus rotundus), which have underground tubers that regrow after cutting; and broadleaved weeds (e.g. Tridax procumbens) respond to different herbicides than grasses and sedges.

Weed identification also reveals the farming history and soil conditions of a plot. The presence of nutgrass (Cyperus rotundus) indicates a previously cultivated, disturbed soil. Striga (witchweed), a parasitic weed that attaches to the roots of cereals, indicates a history of cereal cultivation and depleted soil fertility. Identifying the dominant weed species before planting allows the farmer to select the most effective control strategy and, where herbicides are to be used, to choose a product with the correct spectrum of activity. Building a local weed specimen collection enriches this identification capacity over successive seasons.

Fill in the blank: ________ is a parasitic weed that attaches to the roots of cereal crops and is an indicator of a history of continuous cereal cultivation and declining soil fertility.

Plate 3.1: Common Nigerian farm weeds including spear grass, nutgrass, Tridax, and Striga displayed for identification during a practical session

3.1.2 Methods of collecting and pressing weed specimens

Collecting weed specimens for identification and preservation requires systematic field work. The specimen should include the complete plant where possible: roots, stem, leaves, flowers, and seeds, as all parts may be needed for identification. Specimens are collected using a hand trowel or digging fork to lift the entire plant including the root system, then placed in a polythene bag with a small amount of moist paper to prevent wilting during transport to the pressing station. Each specimen should be labelled immediately with collection location, date, habitat, and a field number.

Plant pressing involves placing the fresh specimen between sheets of absorbent paper (newspaper is suitable) within a plant press or between heavy boards weighted with a brick or stone. The specimen should be arranged to display all diagnostic features: spread leaves to show upper and lower surfaces, straighten the stem, and position flowers and seeds visibly. Paper is changed every 24 to 48 hours for the first week to remove moisture and prevent mould. Full pressing and drying takes seven to fourteen days depending on the thickness of the plant material. Well-pressed specimens retain their morphological features indefinitely when properly stored.

Fill in the blank: When pressing a weed specimen, the absorbent paper must be changed every 24 to ________ hours during the first week to remove moisture and prevent mould growth on the specimen.

Plate 3.2: Students pressing weed specimens between sheets of newspaper in a plant press during a practical herbarium session

3.1.3 Techniques for preserving and mounting weed specimens

Mounting is the permanent attachment of a dried, pressed plant specimen to a herbarium sheet (a sheet of stiff white card, typically A3 or foolscap size). The dried specimen is attached using strips of archival tape or thin strips of paper and white glue applied across the stem and major branches at several points. Roots, flowers, and loose seeds that detach during drying are placed in a small paper envelope (packet) glued to the herbarium sheet alongside the mounted specimen.

A herbarium label is attached to the bottom right corner of the sheet and must include: the scientific name and family of the weed, the common name in English and the local language, the collection location (village, local government area, state), date of collection, habitat description (e.g. cultivated field margin, roadside), name of collector, and a unique accession number. The completed herbarium sheet is stored flat in a herbarium cabinet or folder, interleaved with mothballs (naphthalene) or camphor to deter insect damage to the dried specimens. A well-maintained student herbarium becomes a permanent reference collection for weed identification in subsequent seasons.

Fill in the blank: A herbarium ________ attached to the bottom right corner of the mounting sheet records the scientific name, collection location, date, habitat, and collector for each preserved specimen.

Plate 3.3: A completed herbarium sheet showing a mounted weed specimen with label and packet of loose plant parts

Pilot questions 3.1

1. Explain why accurate weed identification is important before selecting a weed control method.
2. What does the presence of Striga on a farm indicate about the farming history and soil conditions?
3. Describe the correct procedure for collecting a weed specimen in the field.
4. Explain why absorbent paper must be changed frequently during the first week of pressing.
5. List the information that must appear on a herbarium label.

3.2 Identification of Common Crop Pests

3.2.1 Categories and characteristics of crop pests

Crop pests are organisms that cause economic damage to agricultural crops. They are classified by their biological nature into: **insect pests** (the most numerous and economically important category, including beetles, bugs, caterpillars, aphids, and flies), **nematodes** (microscopic roundworms that attack roots, causing galls, stunting, and wilting), **rodents** (rats and mice that damage crops in the field and in storage), **birds** (grain eaters such as quelea and sparrows that devastate ripening cereal crops), and **larger vertebrates** (monkeys, cattle, and other animals that invade farms).

Insects are further classified by their feeding mode: chewing insects (caterpillars, beetles, grasshoppers) consume plant tissue visibly; piercing-sucking insects (aphids, whiteflies, mealybugs, thrips) insert mouthparts into plant cells and extract sap, causing distortion, yellowing, and wilting; boring insects (stem borers, pod borers) tunnel into stems, fruits, or grain; and gall-forming insects stimulate abnormal plant growth. Understanding the feeding mode of the pest is essential for selecting the appropriate control measure: systemic insecticides are effective against sucking pests but may not reach boring insects that feed inside plant tissues.

Fill in the blank: ________ insects such as aphids and whiteflies insert their mouthparts into plant cells to extract sap, causing yellowing, wilting, and distortion of plant tissue.

Pest Category	Examples	Damage Type
Chewing insects	Caterpillars, Grasshoppers, Beetles	Bite and remove plant tissues (leaves, stems, fruits) causing defoliation and reduced photosynthesis
Sucking insects	Aphids, Whiteflies, Thrips, Leafhoppers	Pierce and suck plant sap, leading to wilting, stunted growth, and transmission of viral diseases
Boring insects	Stem borers (maize), Fruit borers (tomato), Coffee berry borer	Tunnel into stems, fruits, or seeds, weakening plants and destroying edible parts
Nematodes	Root-knot nematodes, Cyst nematodes	Attack roots, causing galls, poor nutrient uptake, stunted growth, and yield loss
Rodents	Rats, Mice	Gnaw on seeds, roots, and stored grains; contaminate food with droppings
Birds	Quelea birds, Sparrows	Peck at grains and fruits, reducing harvest and causing significant field losses

Table 3.1: Categories of crop pests, their characteristics, examples, and types of crop damage caused

3.2.2 Field identification of common insect pests and their damage

Stem borers (Busseola fusca, Sesamia calamistis) are major pests of maize and sorghum; they are identified by the presence of dead hearts (central shoot dying while outer leaves remain green) in young plants and stem tunnelling with frass (insect excrement) in older plants. **Aphids** are small, soft-bodied sucking insects that cluster on young shoots and leaves, causing curling, yellowing, and stunting; they also transmit plant viruses. **Pod borers** (Maruca vitrata) attack legume flower buds and pods, causing characteristic holes in pods and damaged seed.

Cassava mealybug (Phenacoccus manihoti) covers cassava growing tips and young leaves with a white waxy secretion, causing stunted growth and typical bunchy top symptoms. **Termites** attack crop roots, kill seedlings, and tunnel into woody stems; mud tunnels on plant stems are a characteristic sign of termite activity. **Grasshoppers and locusts** consume foliage and can defoliate crops entirely during outbreaks. When identifying pest damage, students should note the plant part affected, the type of damage (holes, tunnels, discolouration, wilting), the presence of the pest itself or its frass, and the crop growth stage at which damage first appeared.

Fill in the blank: Dead ________ in young maize plants, where the central shoot dies while outer leaves remain green, is a characteristic symptom of stem borer infestation.

3.2.3 Collection and preservation of insect pest specimens

Collecting insect specimens requires different methods depending on the insect's size and behaviour. Small insects (aphids, thrips) are collected by brushing them into a vial of 70 per cent ethanol using a fine paintbrush. Larger insects (beetles, grasshoppers, caterpillars) are collected by hand or with an insect net (sweep net) and killed in a killing jar containing a small piece of cotton wool soaked in ethyl acetate or chloroform. Larvae and soft-bodied insects are best preserved in 70 per cent ethanol rather than dry-mounted, as drying causes them to shrivel and lose their morphological features.

Dry-mounting involves relaxing stiff collected insects in a relaxing box (a sealed container with a moist layer at the base) until their joints are flexible, then mounting them on insect pins pushed through the thorax at the correct angle and position for each insect order. Wings of moths and butterflies are spread on a spreading board and pinned flat to dry. Labels on insect pins record the collection data: date, location, plant host, and collector name. Pinned specimens are stored in an insect collection box with naphthalene to deter other insects from damaging the collection. Mounted specimens allow detailed examination of diagnostic features under a hand lens or dissecting microscope.

Fill in the blank: Small soft-bodied insects such as aphids and thrips are best preserved in ________ per cent ethanol rather than dry-mounted, because drying causes them to shrivel and lose their shape.

Plate 3.5: Students mounting collected insect specimens on insect pins in a collection box during a practical entomology session

Pilot questions 3.2

1. Name five categories of crop pests and give one example of each.
2. Distinguish between chewing and piercing-sucking insects in terms of their feeding mode and the type of damage they cause.
3. Describe three field symptoms that indicate stem borer infestation in a maize crop.
4. How are small soft-bodied insects such as aphids and thrips collected and preserved?
5. Explain the purpose of a relaxing box in insect specimen preparation.

3.3 Identification of Crop Diseases

3.3.1 Categories of crop diseases and their causal agents

Crop diseases are abnormal conditions of plants caused by pathogens or environmental factors that interfere with normal plant growth and development. The four main categories of infectious crop diseases are: **fungal diseases** (the most common category; fungi cause blights, rusts, smuts, rots, wilts, and leaf spots), **bacterial diseases** (caused by bacteria; typically produce water-soaked lesions, blights, wilts, and rots with a foul odour), **viral diseases** (caused by plant viruses, usually transmitted by insect vectors; produce mosaic patterns, yellowing, distortion, and stunting), and **nematode diseases** (root knot nematodes produce galls on roots).

Non-infectious (abiotic) disorders are caused by environmental factors including nutrient deficiencies, waterlogging, drought, temperature extremes, pesticide toxicity, and soil pH problems; they produce symptoms that can resemble infectious diseases but cannot be transmitted from plant to plant. Distinguishing infectious from non-infectious disorders is the first critical step in disease diagnosis: infectious diseases typically show a disease gradient (more severe near the source of infection) and spread progressively through the crop, while abiotic disorders tend to affect all plants in a zone uniformly. Accurate causal categorisation determines whether chemical, biological, or management interventions are appropriate.

Fill in the blank: ________ diseases caused by plant viruses are typically transmitted by insect vectors and produce symptoms including mosaic patterns, leaf yellowing, distortion, and plant stunting.

Disease Category	Causal Agents	Transmission Routes	Nigerian Crop Examples
Fungal diseases	Fungi (e.g., *Fusarium*, *Phytophthora*, *Aspergillus*)	Spores via wind, rain splash, soil, infected seed	Maize (leaf blight), Cassava (root rot), Tomato (early blight)
Bacterial diseases	Bacteria (e.g., *Xanthomonas*, *Pseudomonas*, *Ralstonia*)	Water, soil, contaminated tools, insect vectors	Tomato (bacterial wilt), Cassava (bacterial blight), Cowpea (bacterial pustule)
Viral diseases	Viruses (e.g., CMV, TMV, Cassava mosaic virus)	Insect vectors (whiteflies, aphids), infected seed, mechanical injury	Cassava (mosaic disease), Cowpea (mosaic virus), Tomato (leaf curl virus)
Nematode diseases	Plant-parasitic nematodes (e.g., *Meloidogyne* spp.)	Soil, infected planting material	Yam (root-knot nematodes), Tomato (root galls), Cowpea (nematode damage)

Abiotic disorders	Non-living factors (nutrient deficiency, drought, salinity, chemical toxicity)	Environmental stress, poor soil fertility, mismanagement	Maize (nitrogen deficiency), Tomato (blossom end rot), Cassava (drought stress)

Table 3.2: Categories of crop diseases, their causal agents, transmission routes, and examples of diseases in Nigerian crops

3.3.2 Field identification of common crop diseases by symptoms

Accurate field diagnosis of crop diseases requires systematic observation of symptoms: the plant parts affected, the appearance of lesions (colour, size, shape, margins), the presence of fungal structures (spores, mycelium), odour, and the pattern of disease distribution in the crop. **Maize streak virus** produces characteristic yellow streaks running parallel to the leaf veins; it is transmitted by leafhoppers and is one of the most important viral diseases of maize in Nigeria. **Cassava mosaic disease** (caused by Cassava Mosaic Begomoviruses) produces mosaic chlorosis on leaves with distortion and reduction in leaf size.

Groundnut leaf spot (Cercospora arachidicola, Cercosporidium personatum) produces circular brown spots on leaves, causing defoliation and yield loss. **Cowpea bacterial blight** (Xanthomonas vignicola) causes water-soaked lesions that turn brown and angular, with yellow halos. **Root rots** of yam and cassava (Pythium, Phytophthora) cause soft, brown, foul-smelling decay of storage roots. Damping-off (Pythium, Rhizoctonia) kills seedlings at soil level, leaving a characteristic brown constriction at the stem base. When observing disease symptoms, students should record the plant part affected, the symptom type, the percentage of plants affected, and any visible pathogen structures.

Fill in the blank: Maize ________ virus produces characteristic yellow streaks parallel to the leaf veins and is transmitted by leafhopper insects in Nigerian maize fields.

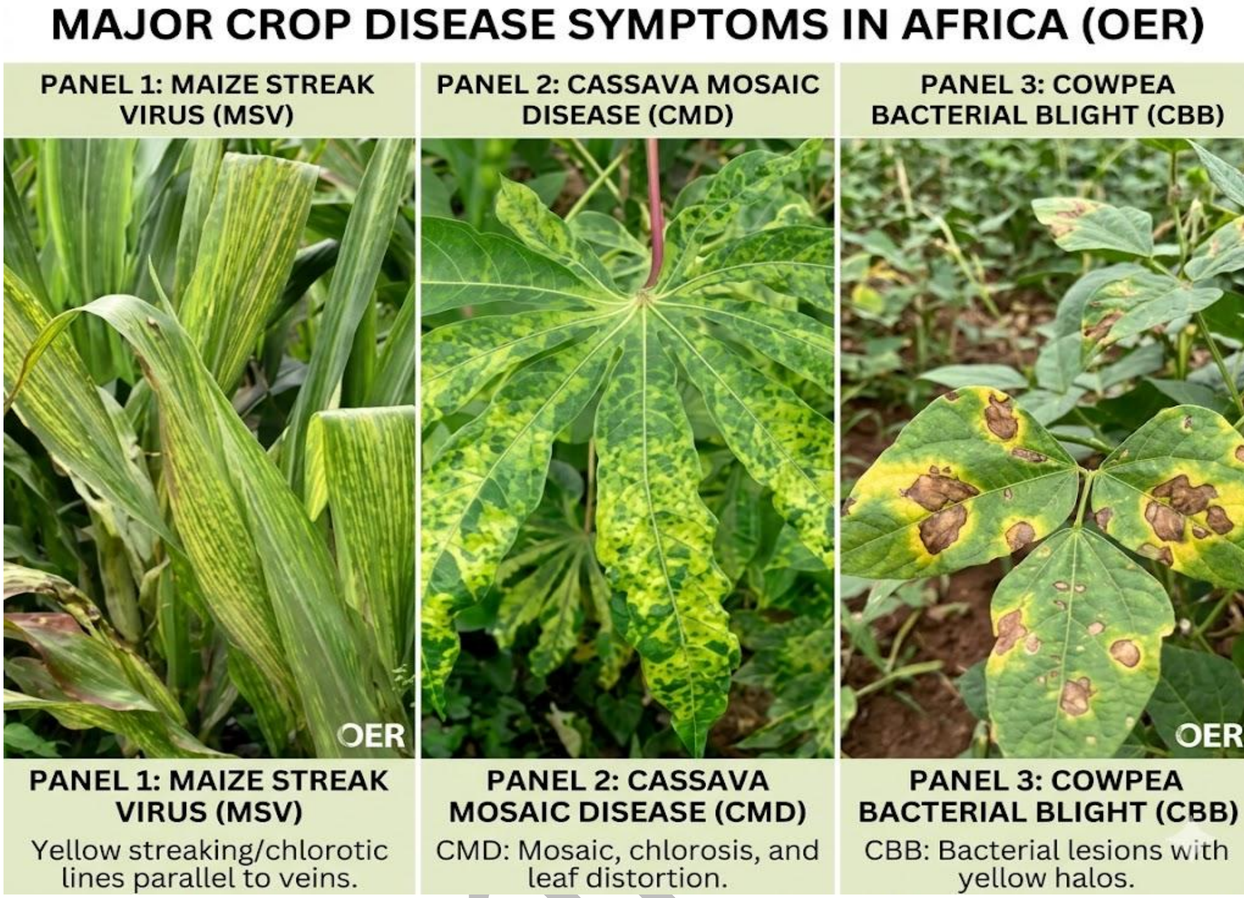


Plate 3.6: Field photographs showing maize streak virus symptoms, cassava mosaic disease, and cowpea bacterial blight for student disease identification

3.3.3 Collection and preservation of disease specimens

Collecting disease specimens for study and reference requires careful selection of representative samples showing clear, typical symptoms. Specimens should be collected from plants in the active disease stage (not from severely wilted or desiccated plants where symptoms may be obscured). For fungal diseases, specimens showing sporulation (powdery or rusty masses on leaf surfaces) are most useful for identification. For viral diseases, young symptomatic leaves showing characteristic mosaic or streak patterns should be collected.

Leaf and stem specimens are pressed and dried using the same herbarium technique described for weeds in Part 3.1, with the symptomatic tissue carefully positioned to display the lesions clearly. For root diseases, affected root sections are washed, cut to display internal symptoms, and either preserved in 70 per cent ethanol in labelled vials or photographed in detail before pressing. Disease specimen labels must record: crop species and variety, disease name and causal agent if known, symptom description, collection date and location, percentage of plants affected, and weather conditions at collection. Photographs taken in the field supplement pressed specimens and are invaluable for future reference.

Fill in the blank: For fungal disease specimens, material showing ________ (visible spore masses on the leaf surface) is most useful for identification and should be prioritised for collection.

Plate 3.7: A mounted disease specimen sheet showing groundnut leaf spot with herbarium label and field photograph attached

Pilot questions 3.3

1. Name the four categories of infectious crop diseases and give one Nigerian crop example of each.
2. Distinguish between infectious and non-infectious crop disorders and explain how to tell them apart in the field.
3. Describe the symptoms of maize streak virus and explain how it is transmitted.

4. Describe the symptoms of damping-off disease in crop seedlings.
5. What information must be recorded on a disease specimen label?

3.4 Integrated Pest and Disease Management

3.4.1 Principles of Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is a science-based, ecologically sensitive approach to pest management that combines multiple control methods in a coordinated programme to keep pest and disease populations below the economic injury level, while minimising harm to human health, beneficial organisms, and the environment. IPM is not the complete elimination of pests (which is neither achievable nor desirable, since low pest populations support populations of natural enemies), but their management at economically and ecologically acceptable levels.

The IPM decision-making process follows four steps: (1) monitoring and scouting (regular field inspections to detect pests and diseases at the earliest possible stage); (2) identification (accurately determining the pest or disease responsible for the observed damage); (3) action threshold assessment (determining whether the pest population or disease incidence has reached the economic threshold at which intervention is justified); and (4) selecting and applying the most appropriate combination of control methods. Chemical pesticides are used in IPM only as a last resort when other methods are insufficient and the economic threshold has been crossed.

Fill in the blank: In IPM, chemical pesticides are used only as a ________ resort when pest populations exceed the economic threshold and other control methods have proven insufficient.

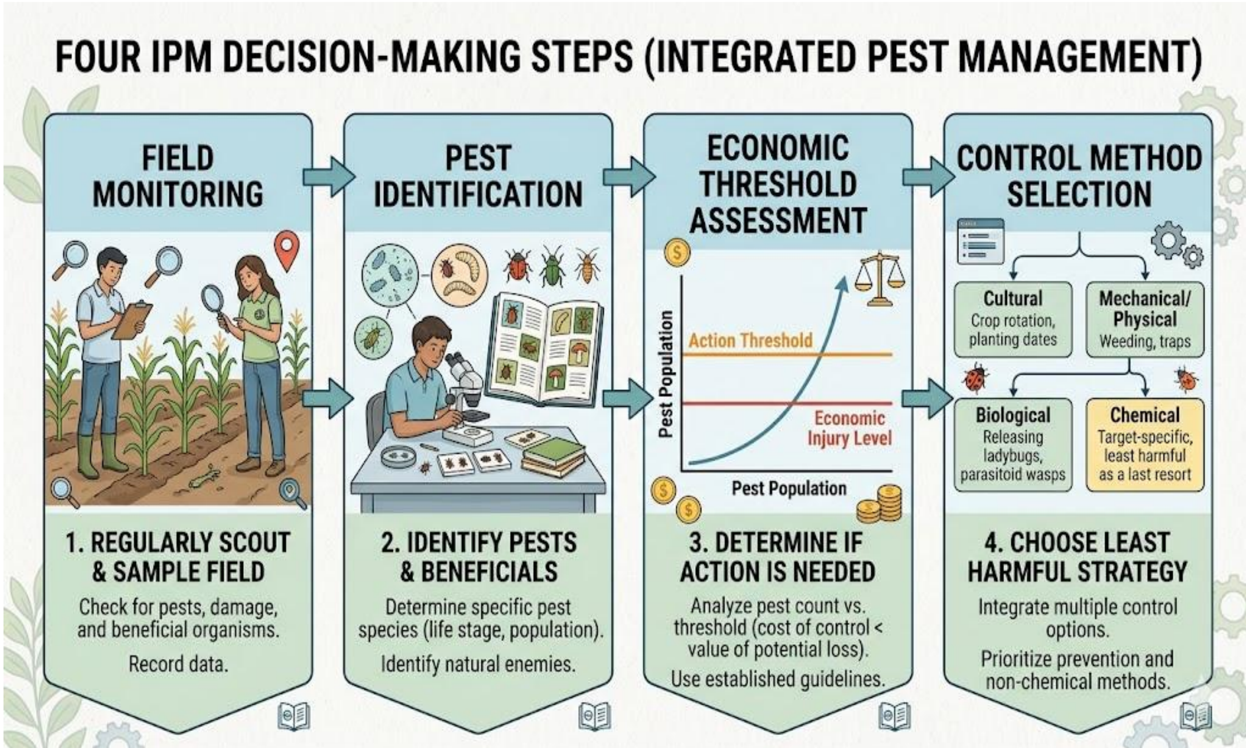


Figure 3.1: Diagram showing the four steps of the IPM decision-making process from field monitoring to control method selection

3.4.2 Cultural, biological, and chemical control methods

Cultural control methods manipulate the crop environment to make it less favourable to pests and diseases. They include crop rotation (breaks host-specific pest and disease cycles), resistant varieties (genetic resistance to specific pests and diseases is the most cost-effective and environmentally safe control method), timely planting (avoiding peak pest populations by manipulating planting date), field sanitation (removing crop residues that harbour overwintering pests), proper plant spacing (improving air circulation to reduce fungal disease), and intercropping (disrupting pest host location and supporting natural enemy populations).

Biological control uses living organisms (parasitoids, predators, and pathogens) to suppress pest populations. Examples include **Trichogramma** wasps (parasitoids of lepidopteran eggs), ladybirds (predators of aphids), and **Bacillus thuringiensis** (a bacterial pathogen toxic to caterpillars, available as a commercial biopesticide). **Chemical control** uses synthetic or natural pesticides to kill or repel pests; it should be targeted (the correct product for the identified pest), timed (applied when pests are most vulnerable), and at the minimum effective dose to preserve natural enemies and prevent resistance development.

Fill in the blank: ________ varieties, which carry genetic resistance to specific pests or diseases, are the most cost-effective and environmentally safe long-term crop protection strategy.

Control Method	Cost	Environmental Impact	Effectiveness	Suitability for Smallholder Farmers
Cultural control	Low (uses local practices like crop rotation, sanitation, resistant varieties)	Very low; eco-friendly and sustainable	Moderate; depends on proper timing and consistency	Highly suitable — affordable and easy to implement
Biological control	Moderate (requires beneficial organisms like predators, parasitoids, or biopesticides)	Low; safe for environment and non-target species	High when properly managed; long-term control	Suitable with training and access to bio-agents
Chemical control	High (cost of pesticides and protective gear)	High; risk of pollution and health hazards	Very high; rapid action and broad-spectrum	Limited suitability — effective but costly and risky without guidance

Table 3.3: Comparison of cultural, biological, and chemical pest control methods by cost, environmental impact, and effectiveness

3.4.3 Practical application of IPM on the farm

Implementing IPM on a student farm plot begins before the crop is planted, with the selection of a resistant or tolerant variety and appropriate crop rotation. During the growing season, students conduct weekly scouting of the plot, examining at least ten plants at five randomly selected points across the plot, recording the pest species observed, their population density, the plant parts and growth stages affected, and any natural enemy activity. A simple scouting record sheet is completed after each inspection.

When a pest or disease is detected, the first response is to check whether the economic threshold has been exceeded: for stem borers in maize, for example, control is warranted when more than 30 per cent of plants show dead hearts at the vegetative stage, or more than 20 per cent show stem tunnelling at flowering. Below the threshold, natural enemy populations and crop tolerance are allowed to operate. Above the threshold, the least-disruptive effective method is applied first: removing and destroying affected plants, applying neem extract or biopesticide, or, if necessary, a targeted synthetic pesticide application. All control actions and their outcomes are recorded in the farm diary.

Fill in the blank: During IPM scouting, students examine at least ________ plants at five randomly selected points across the plot to assess pest populations and disease incidence.

Plate 3.8: A student completing a pest scouting record sheet while inspecting a maize plot during an IPM practical session

Pilot questions 3.4

1. Define Integrated Pest Management and explain its main objective.
2. List the four steps of the IPM decision-making process.

3. Give two examples of cultural control methods and explain how each reduces pest or disease damage.
4. What is biological control and give one Nigerian example of a biological control agent?
5. Explain what an economic threshold is and why it is important in IPM decision-making.

Series Summary

This Series has developed the skills of identification, collection, and preservation of weeds, pests, and diseases, which are the diagnostic foundation of sound crop protection practice. We began with weeds, explaining why accurate weed identification matters, describing the collection and pressing procedure for weed specimens, and explaining the mounting and labelling requirements for a herbarium collection. We then examined crop pests, classifying them by biological category and feeding mode, describing the field identification of common insect pests by their damage symptoms, and explaining the procedures for collecting and preserving insect specimens.

Following that, we covered crop diseases, categorising them by causal agent, explaining how to distinguish infectious from non-infectious disorders, describing the symptoms of common diseases of Nigerian food crops, and explaining how disease specimens are collected and mounted. Finally, we established the principles of Integrated Pest Management, described the cultural, biological, and chemical control methods available, and outlined the practical IPM process for a student farm plot including weekly scouting, economic threshold assessment, and targeted intervention. By completing this Series, you should now be able to achieve all nine Series Learning Outcomes (SLO 3.1 to SLO 3.9).

Glossary of Terms

- **Accession number:** a unique identifier assigned to each specimen in a herbarium or insect collection to allow retrieval and cross-referencing with collection data records.
- **Abiotic disorder:** a non-infectious plant disorder caused by an environmental factor such as nutrient deficiency, waterlogging, drought, or temperature extreme, rather than by a pathogen.
- **Bacillus thuringiensis (Bt):** a naturally occurring soil bacterium that produces protein crystals toxic to caterpillars and other insect larvae; available as a commercial biopesticide compatible with IPM programmes.
- **Biological control:** the use of living organisms (parasitoids, predators, or pathogens) to suppress pest or disease populations below economically damaging levels.
- **Biopesticide:** a pesticide derived from natural materials including microorganisms, plant extracts, or minerals; generally more environmentally safe than synthetic chemical pesticides.
- **Cultural control:** pest management practices that manipulate the crop environment (rotation, resistant varieties, sanitation, planting date) to reduce pest and disease populations without chemical inputs.
- **Damping-off:** a seedling disease caused by soil fungi (Pythium, Rhizoctonia) that kills seedlings at the soil line, leaving a characteristic brown constriction at the base of the stem.
- **Dead heart:** a symptom of stem borer infestation in young maize or sorghum plants, in which the central (youngest) leaf shoot dies and turns brown while the outer leaves remain green.
- **Economic injury level:** the pest population density or disease incidence at which crop losses equal the cost of applying a control measure; management intervention is justified at or above this level.
- **Economic threshold:** the pest population level at which management action should be taken to prevent the pest from reaching the economic injury level; slightly below the economic injury level to allow time for intervention.
- **Frass:** the excrement and feeding debris produced by insect larvae, particularly boring insects; visible inside stems, pods, or grain as a powdery or granular material.
- **Herbarium:** a systematic collection of dried, pressed, and mounted plant specimens, each labelled with collection data, used as a reference for plant identification.

- **Integrated Pest Management (IPM):** a science-based approach that combines multiple pest control methods in a coordinated programme to keep pest populations below economic thresholds while minimising environmental and health impacts.
- **Killing jar:** a sealed container holding an insect-killing agent (ethyl acetate or chloroform on cotton wool) used to kill collected insect specimens quickly without damaging their morphological features.
- **Mosaic:** a viral disease symptom characterised by an irregular pattern of normal green and pale yellow-green areas on infected leaves, producing a mosaic-like appearance.
- **Nematode:** a microscopic roundworm; plant-parasitic nematodes attack crop roots, causing galls, stunting, wilting, and entry points for fungal and bacterial pathogens.
- **Plant press:** a device consisting of two flat boards with ventilating boards and absorbent paper layers used to press and dry plant specimens for herbarium mounting.
- **Relaxing box:** a sealed humid chamber used to restore flexibility to dried insect specimens before mounting, preventing breakage during pinning and wing-spreading.
- **Sporulation:** the production of spores by a fungal pathogen on the surface of infected plant tissue; visible sporulation (powdery, rusty, or mouldy masses) is an important aid to fungal disease identification.
- **Striga (witchweed):** a genus of parasitic plants that attach to the roots of cereal crops (maize, sorghum, millet) and extract water and nutrients, causing severe yield loss; indicates history of continuous cereal cultivation.
- **Sweep net:** an insect collection net with a sturdy frame and fine mesh bag used to sweep through vegetation to collect insects for identification and study.
- **Systemic insecticide:** an insecticide absorbed by the plant and transported throughout its tissues; effective against sucking insects that feed on plant sap but may not control boring insects feeding inside tissues.

Concept Check Questions [Series 3]

Objective Questions

1. ________ is a parasitic weed that attaches to cereal roots and indicates a history of continuous cereal cultivation. (Linked to SLO 3.1)
2. The feeding mode of aphids and whiteflies is described as piercing-________. (Linked to SLO 3.3)
3. Dead heart in young maize is a symptom caused by ________ borer infestation. (Linked to SLO 3.4)
4. Maize streak virus is transmitted by ________ insects. (Linked to SLO 3.7)
5. In IPM, chemical pesticides are used as a ________ resort after other methods have been considered. (Linked to SLO 3.8)

Short-Answer Questions

1. Explain why different weed species require different control methods and give one example. (Linked to SLO 3.1)
2. Describe the correct procedure for pressing a collected weed specimen. (Linked to SLO 3.2)
3. Distinguish between chewing and piercing-sucking insects in terms of feeding mode and damage type. (Linked to SLO 3.3)
4. Explain the difference between infectious and non-infectious crop disorders and how each is identified in the field. (Linked to SLO 3.6)
5. List the four steps of the IPM decision-making process and explain the role of the economic threshold. (Linked to SLO 3.8)

Long-Answer Questions

1. Analyse the practical skills required for collecting, pressing, and preserving weed specimens for a student herbarium, explaining the field collection procedure, the pressing and drying technique, and the mounting and labelling requirements. (Linked to SLOs 3.1, 3.2)
2. Discuss the identification of common crop pests and diseases found on Nigerian farms, describing the categories of pests by feeding mode, the field symptoms of key insect pests and diseases of Nigerian food crops, and the methods of preserving insect and disease specimens. (Linked to SLOs 3.3, 3.4, 3.6, 3.7)

3. Evaluate the Integrated Pest Management approach as a strategy for crop protection, explaining its principles, the four decision-making steps, the cultural, biological, and chemical control methods available, and how IPM is implemented practically on a student farm plot. (Linked to SLOs 3.8, 3.9)

Answers to Concept Check Questions [Series 3]

Objective Questions

1. Striga (witchweed).
2. Sucking.
3. Stem.
4. Leafhopper.
5. Last.

Short-Answer Questions

1. Different weed species have different morphology, life cycles, and physiology that determine their response to control measures; annual grasses (e.g. spear grass) are controlled by regular hoeing before they set seed, while perennial sedges with underground tubers (e.g. nutgrass) regrow after cutting and require repeated tillage or herbicides with soil activity; broadleaved weeds respond to broadleaf-selective herbicides that are harmless to grass crops, while grass weeds in broadleaf crops are controlled by grass-selective herbicides.
2. Place the fresh specimen between sheets of absorbent paper (newspaper), arranging leaves to display upper and lower surfaces, straightening the stem, and positioning flowers and seeds; place within a plant press or between heavy boards and apply firm pressure with weights; change the absorbent paper every 24 to 48 hours for the first week to remove moisture; continue pressing for seven to fourteen days until completely dry; the dried specimen is then ready for mounting on a herbarium sheet.
3. Chewing insects (caterpillars, beetles, grasshoppers) have mandibles that cut and consume plant tissue, producing visible holes, notched leaf margins, skeletonised leaves, or completely defoliated plants; the damage is external and visible. Piercing-sucking insects (aphids, whiteflies, mealybugs, thrips) insert needle-like mouthparts into plant cells to extract sap,

producing yellowing, wilting, leaf curling, stunting, and honeydew deposits; they may also transmit plant viruses.

4. Infectious disorders are caused by pathogens (fungi, bacteria, viruses, nematodes) that can spread from plant to plant; they typically show a disease gradient (more severe near the infection source), spread progressively through the crop, and show characteristic lesion types or pathogen structures. Non-infectious (abiotic) disorders are caused by environmental factors and cannot spread between plants; they tend to affect all plants in a zone uniformly, without a progressive spread pattern, and may follow soil or drainage patterns.
5. The four steps are: (1) monitoring and scouting, (2) accurate pest identification, (3) economic threshold assessment, and (4) selection and application of control methods. The economic threshold is the pest population density or disease incidence at which control action must be taken to prevent losses that exceed the cost of intervention; below the threshold, no intervention is taken and natural enemies are allowed to operate; above it, the least-disruptive effective control method is applied.

Long-Answer Questions

1. Basic response: Field collection — dig the complete plant (root, stem, leaves, flowers, seeds), bag immediately with moist paper, label with location, date, habitat, and field number. Pressing — arrange specimen between newspaper sheets in a press, change paper every 24 to 48 hours for the first week, press for 7 to 14 days. Mounting — attach dried specimen to herbarium sheet with archival tape and glue; loose parts in an envelope; label at bottom right with scientific name, common names, collection data, habitat, collector, and accession number; store with naphthalene.
2. Value-added response: A student herbarium serves not only as a practical exercise but as a permanent reference tool for weed identification in subsequent seasons. Building a comprehensive local weed collection that documents species composition across different land use histories and soil types provides agronomic intelligence that enriches farm management decisions for years. Students who develop the discipline of systematic labelling and record-keeping in herbarium work transfer these documentation habits to farm record-keeping, pest scouting, and experimental data collection throughout their careers.
3. Basic response: Pest categories: chewing (caterpillars, beetles, grasshoppers), sucking (aphids, whiteflies, thrips), boring (stem borers, pod borers), nematodes, rodents, birds. Key symptoms: stem borer dead heart and frass, aphid yellowing and honeydew, mealybug white waxy deposits on cassava. Disease categories: fungal (leaf spots, rusts, blights), bacterial

(water-soaked lesions with haloes), viral (mosaic, streaking). Specimen preservation: insects in 70% ethanol (soft-bodied) or dry-mounted on pins (large insects); disease specimens pressed and dried like herbarium sheets or preserved in ethanol.

4. Value-added response: The linkage between pest identification and control method selection is the core skill being developed in this Series. A student who can correctly identify stem borer damage versus drought stress in maize, or distinguish maize streak virus from nutrient deficiency chlorosis, will not waste money applying an insecticide to an abiotic disorder or a fungicide to a viral disease. This diagnostic competence — knowing what is causing the problem before deciding how to respond — is the intellectual foundation on which sound, evidence-based agricultural practice is built.
5. Basic response: IPM principles: manage pests below economic thresholds, use multiple methods, minimise environmental harm, use chemicals as last resort. Four steps: monitoring, identification, threshold assessment, control selection. Cultural methods: crop rotation, resistant varieties, field sanitation, timely planting. Biological methods: Trichogramma parasitoids, ladybird predators, Bt biopesticide. Chemical methods: targeted, correctly dosed, selective products. Farm implementation: weekly scouting of ten plants at five points, scouting record sheets, farm diary of all actions.
6. Value-added response: IPM is most effective when it is approached as a farm system design challenge rather than a reactive pest response. The most powerful IPM tools (resistant varieties, crop rotation, timely planting) operate before the pest arrives and require no additional cost beyond good planning. Chemical pesticides, the most expensive and environmentally disruptive option, are most effective when reserved for genuine emergencies when economic thresholds have been exceeded and faster action is needed than biological or cultural methods can provide. Students who internalise this hierarchy of preference will become agricultural professionals who add lasting value to their communities.

Answers to Pilot Questions [Series 3]

Part 3.1: Weed Collection, Identification, and Preservation

1. Accurate weed identification determines the most effective control strategy: annual grasses respond to regular hoe weeding before seeding; perennial sedges with underground tubers (nutgrass) require repeated tillage or specific systemic herbicides; broadleaved weeds respond

to broadleaf-selective herbicides; and parasitic weeds such as Striga require pre-emergence herbicides or resistant crop varieties. Applying the wrong method wastes resources and may not reduce weed populations.

2. The presence of Striga indicates a history of continuous cereal (maize, sorghum, or millet) cultivation because Striga seeds require stimulants released by cereal roots to germinate; it also indicates declining soil fertility, as Striga is most problematic in nitrogen-depleted soils, and a large accumulated seed bank in the soil from previous infestations, which can persist for up to 20 years.
3. Use a hand trowel or digging fork to lift the complete plant including the root system; avoid breaking roots or flower parts; place immediately in a polythene bag with a small piece of moist paper to prevent wilting; label the bag with collection location, date, habitat, and a unique field number before moving to the next plant.
4. Moisture within the freshly collected plant material promotes the growth of mould fungi that discolour and destroy the specimen; frequent paper changes remove the moisture released by the plant as it dries, preventing fungal colonisation and ensuring the specimen retains its natural colour and morphological features.
5. Scientific name and plant family; common name in English and local language; collection location (village, LGA, state); date of collection; habitat description; name of collector; unique accession number.

Part 3.2: Identification of Common Crop Pests

1. Any five: insect pests (stem borer); nematodes (root knot nematode); rodents (rat); birds (quelea bird); larger vertebrates (cattle or monkey).
2. Chewing insects (caterpillars, beetles, grasshoppers) use mandibles to cut and consume plant tissue, producing holes, notched leaf margins, skeletonised leaves, or complete defoliation. Piercing-sucking insects (aphids, whiteflies) use needle-like stylets to penetrate plant cells and extract sap, causing yellowing, wilting, leaf curling, and stunting; they do not produce visible holes but may cause honeydew deposits and sooty mould.
3. Any three: dead heart (central shoot death while outer leaves remain green) in young vegetative plants; stem tunnelling with frass (insect excrement) visible inside cut stems at later growth stages; windows or transparent patches on young leaves where larvae fed from

inside the whorl; presence of caterpillars (early instars) inside the whorl of young maize plants.

4. Small soft-bodied insects such as aphids and thrips are collected by brushing them with a fine paintbrush into a vial containing 70 per cent ethanol, which kills and preserves them while maintaining their morphological shape; they are not dry-mounted because drying causes them to shrivel and lose the features needed for identification.
5. A relaxing box is a sealed humid chamber used to restore flexibility to dried or stiff insect specimens before mounting; insects that have dried and hardened after killing would break at the joints if pinned without relaxing; placing them in a relaxing box for 24 to 48 hours softens their tissues so they can be pinned through the thorax and their wings spread without breaking.

Part 3.3: Identification of Crop Diseases

1. Fungal: groundnut leaf spot (Cercospora); bacterial: cowpea bacterial blight (Xanthomonas vignicola); viral: maize streak virus (transmitted by leafhopper); nematode: root knot nematode on tomato or cowpea (Meloidogyne species).
2. Infectious disorders are caused by pathogens and can spread from plant to plant; in the field they show a disease gradient (most severe near the infection source), progressive spread over time, and characteristic pathogen structures (sporulation, water-soaked lesions, mosaic patterns). Non-infectious (abiotic) disorders cannot spread; they affect plants uniformly across a zone (e.g. all plants near a waterlogged depression show the same yellowing), do not progress from a point source, and may follow soil type, drainage, or spray pattern boundaries.
3. Maize streak virus produces bright yellow streaks running parallel to the leaf veins on infected maize leaves; younger leaves show more pronounced streaking than older leaves; severely infected plants are stunted and produce poor cobs or none at all; it is transmitted by the leafhopper Cicadulina mbila, which feeds on infected plants and carries the virus to healthy plants during subsequent feeding.
4. Damping-off causes a brown, water-soaked constriction at the base of the seedling stem at or just below the soil surface; the seedling collapses and falls over, remaining attached to the soil at the constricted point; surrounding seedlings may show similar symptoms if the pathogen (Pythium or Rhizoctonia) spreads through the seedbed; the disease is most severe in wet, poorly drained, or overwatered seedbeds.

5. Crop species and variety; disease name and causal agent (if known); symptom description; collection date and location; percentage of plants showing symptoms; weather conditions at collection; collector name; field number or accession number.

Part 3.4: Integrated Pest and Disease Management

1. IPM is a science-based approach that combines multiple control methods in a coordinated programme to keep pest and disease populations below the economic injury level while minimising harm to human health, beneficial organisms, and the environment; its main objective is not the complete elimination of pests but their management at economically and ecologically acceptable levels.
2. Monitoring and scouting; accurate pest identification; economic threshold assessment; selection and application of the most appropriate control methods.
3. Any two with explanation: crop rotation disrupts host-specific pest and disease cycles by removing the host crop for one or more seasons, preventing build-up of pest populations adapted to the local crop sequence; use of resistant varieties incorporates genetic resistance that prevents or limits pest or pathogen attack without any chemical input, reducing crop losses while maintaining natural enemy populations and avoiding pesticide costs.
4. Biological control is the use of living organisms to suppress pest populations; Nigerian example: Trichogramma species (tiny parasitoid wasps) that parasitise the eggs of stem borers and other lepidopteran pests, reducing the next generation of the pest; or ladybirds (Coccinellidae) that are natural predators of aphid colonies in cowpea and vegetable fields.
5. The economic threshold is the pest population density or disease incidence at which management action must be taken to prevent losses that exceed the cost of intervention; it is important in IPM because it prevents unnecessary pesticide applications when pest populations are low enough for natural enemies and crop tolerance to maintain damage below economically significant levels, saving costs and preserving natural enemy populations.

References and Attributions [Series 3]

Textual References (Books and External Sources)

- IITA (International Institute of Tropical Agriculture). (2004). Pest management in cowpea. IITA.
- Thresh, J. M., Otim-Nape, G. W., & Fargette, D. (1998). The components and causes of the African cassava mosaic disease. African Crop Science Journal, 6(1), 1-13.
- Pedigo, L. P., & Rice, M. E. (2014). Entomology and pest management (6th ed.). Pearson Education.
- Jeffries, P. (1995). Crop disease management. CAB International.
- FAO (Food and Agriculture Organization of the United Nations). (2007). Integrated pest management. FAO.
- FAO (Food and Agriculture Organization of the United Nations). (2025). Guidelines for sustainable agriculture. FAO.

Figures, Plates, Tables, and Boxes

- Plate 3.1: Common Nigerian farm weeds for identification Attribution: AI generated using prompt "Generate an image showing common Nigerian farm weeds including spear grass, nutgrass, Tridax, and Striga laid out for student identification." Suggested OER search string: "common Nigerian farm weeds identification spear grass nutgrass Striga OER image".
- Plate 3.2: Students pressing weed specimens Attribution: AI generated using prompt "Generate an image of agricultural students arranging fresh weed specimens between sheets of newspaper inside a wooden plant press." Suggested OER search string: "students pressing weed specimens plant press herbarium practical OER image".
- Plate 3.3: Completed herbarium sheet with mounted specimen Attribution: AI generated using prompt "Generate an image of a completed herbarium sheet with a mounted dried weed specimen, herbarium label, and seed packet." Suggested OER search string: "herbarium sheet mounted weed specimen label seed packet OER image".
- Table 3.1: Crop pest categories and damage table Attribution: AI generated using prompt "Generate a table listing crop pest categories including chewing, sucking, boring insects, nematodes, rodents, and birds with examples and damage types." Suggested OER search string: "crop pest categories characteristics damage examples table OER".

- Plate 3.4: Crop pest damage composite image Attribution: AI generated using prompt "Generate a composite image showing stem borer dead heart damage on maize, aphid colony on cowpea, and mealybug infestation on cassava." Suggested OER search string: "crop pest damage stem borer dead heart aphid mealybug identification OER image".
- Plate 3.5: Students mounting insect specimens Attribution: AI generated using prompt "Generate an image of agricultural students pinning collected insect specimens onto insect boards in collection boxes during a practical session." Suggested OER search string: "students mounting insect specimens insect pins collection box practical OER image".
- Table 3.2: Crop disease categories table Attribution: AI generated using prompt "Generate a table listing crop disease categories including fungal, bacterial, viral, nematode, and abiotic disorders with agents, transmission, and examples." Suggested OER search string: "crop disease categories causal agents transmission Nigerian crops table OER".
- Plate 3.6: Crop disease symptoms composite image Attribution: AI generated using prompt "Generate a composite image showing maize streak virus yellow streaking, cassava mosaic disease chlorosis, and cowpea bacterial blight lesions." Suggested OER search string: "crop disease symptoms maize streak cassava mosaic cowpea blight identification OER image".
- Plate 3.7: Disease specimen herbarium sheet Attribution: AI generated using prompt "Generate an image of a mounted disease specimen sheet showing dried groundnut leaves with leaf spot lesions and herbarium label." Suggested OER search string: "disease specimen herbarium sheet groundnut leaf spot mounted label OER image".
- Figure 3.1: IPM decision-making flowchart Attribution: AI generated using prompt "Generate a flowchart showing the four IPM decision-making steps: field monitoring, pest identification, economic threshold assessment, and control method selection." Suggested OER search string: "IPM decision-making steps monitoring identification threshold control OER diagram".
- Table 3.3: IPM control methods comparison table Attribution: AI generated using prompt "Generate a table comparing cultural, biological, and chemical pest control methods by cost, environmental impact, effectiveness, and suitability for smallholder Nigerian farmers." Suggested OER search string: "IPM control methods cultural biological chemical comparison table OER".
- Plate 3.8: Student IPM scouting practical Attribution: AI generated using prompt "Generate an image of an agricultural student inspecting maize plants and recording pest observations on a scouting record sheet." Suggested OER search string: "student IPM scouting maize pest record sheet practical OER image".

Course code: AGE 102

Course title: Practical Farm Work 1

Course credit load: 2 Units

Series 4: Practical Animal Rearing: Poultry, Goats, Snails, and Fish

- **Part 4.1: Poultry Production and Management**
  - Sub Part 4.1.1: Types of poultry and systems of management
  - Sub Part 4.1.2: Housing, feeding, and health management of poultry
  - Sub Part 4.1.3: Record keeping and performance assessment in poultry
- **Part 4.2: Goat Production and Management**
  - Sub Part 4.2.1: Breeds of goats and their characteristics
  - Sub Part 4.2.2: Housing, feeding, and health management of goats
  - Sub Part 4.2.3: Breeding management and productivity assessment
- **Part 4.3: Snail Farming (Heliculture)**
  - Sub Part 4.3.1: Introduction to snail farming and species kept
  - Sub Part 4.3.2: Housing, feeding, and environmental management of snails
  - Sub Part 4.3.3: Harvesting, processing, and marketing of snails
- **Part 4.4: Fish Production and Management**
  - Sub Part 4.4.1: Fish production systems used in Nigeria
  - Sub Part 4.4.2: Pond management and feeding of fish
  - Sub Part 4.4.3: Harvesting, processing, and record keeping in fish production

Introduction

Animal rearing is an integral part of mixed farming systems across Nigeria, contributing to household nutrition, income, and the recycling of farm wastes into manure that improves crop production. Poultry, goats, snails, and fish are among the most widely reared livestock species by smallholder farmers and are accessible for practical management at the scale of a university farm. Developing competent skills in the rearing of these species is a core objective of this course and prepares students for roles in animal production, extension, and agribusiness.

The aim of this Series is to equip you with practical knowledge of the management systems, housing, feeding, health care, and productivity assessment of poultry, goats, snails, and fish, and to develop your skills in operating and maintaining small-scale animal production units on the university farm.

We shall commence this Series by examining poultry production and management. Next, we will study goat production including breeds, housing, and breeding management. Following that, we will cover snail farming systems and management. Finally, we will wrap up with fish production systems, pond management, and post-harvest operations.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** identify the types of poultry and describe the systems of poultry management (Linked to Part 4.1),
- **SLO 4.2** describe the housing, feeding, and health management requirements of poultry (Linked to Part 4.1),
- **SLO 4.3** maintain poultry records and assess flock performance (Linked to Part 4.1),
- **SLO 4.4** identify goat breeds kept in Nigeria and describe their characteristics (Linked to Part 4.2),
- **SLO 4.5** describe the housing, feeding, and health management requirements of goats (Linked to Part 4.2),

- **SLO 4.6** explain the principles of goat breeding management and productivity assessment (Linked to Part 4.2),
- **SLO 4.7** describe snail species kept in Nigeria and explain the management of a snail farm (Linked to Part 4.3),
- **SLO 4.8** describe the production systems, pond management, and feeding practices used in Nigerian fish farming (Linked to Part 4.4), and
- **SLO 4.9** explain harvesting, processing, and record keeping for fish production (Linked to Part 4.4).

4.1 Poultry Production and Management

4.1.1 Types of poultry and systems of management

Poultry refers to domestic birds kept for the production of meat, eggs, or both. The main types of poultry kept in Nigeria are **chickens** (the most common, including layers for egg production and broilers for meat), **turkeys** (raised primarily for festive meat production), **ducks** (adapted to waterside environments and highly efficient feed converters), **guinea fowl** (very hardy birds common in northern Nigeria), and **pigeons** (kept for meat, particularly squab production). The choice of poultry type depends on market demand, available feed, and management capacity.

Three main systems of management are used. The intensive system (deep litter or cage system) confines birds in a house with controlled feeding and watering; it supports high productivity and disease monitoring but requires high capital investment and management skill. The semi-intensive system combines a house for overnight shelter with a fenced run for daytime grazing; it reduces feed costs and improves bird welfare. The extensive (free-range) system allows birds to forage freely with minimal housing; it is lowest in cost but birds are exposed to predators, disease, and unpredictable productivity. Most smallholder poultry production in Nigeria uses the extensive or semi-intensive system.

Fill in the blank: The ________ system confines birds in a house with controlled feeding and watering and supports the highest productivity but requires the greatest capital investment.

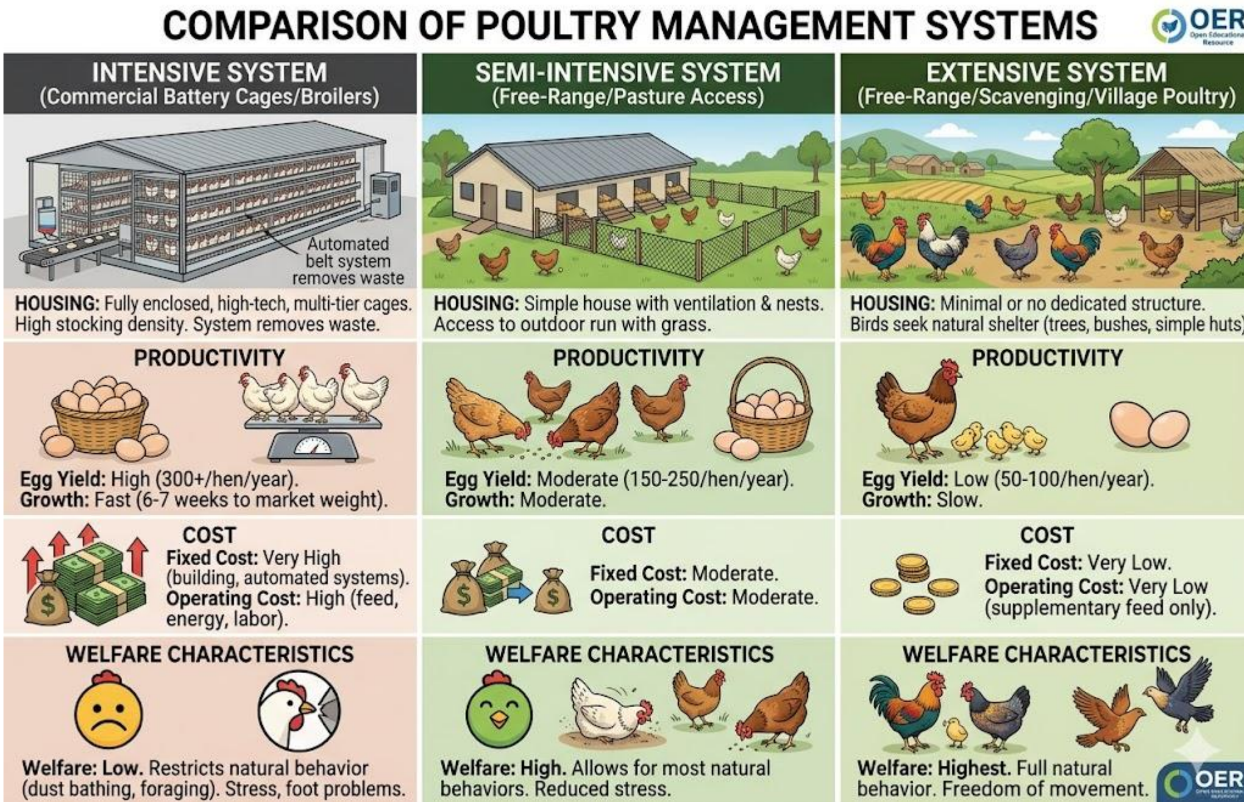


Figure 4.1: Diagram comparing intensive, semi-intensive, and extensive poultry management systems in terms of housing, productivity, cost, and welfare

4.1.2 Housing, feeding, and health management of poultry

Poultry housing must provide protection from weather and predators, adequate ventilation (open-sided houses with wire mesh walls are ideal in the Nigerian climate), sufficient floor space (at least 0.1 m² per layer, 0.07 m² per broiler in deep litter), clean litter material (sawdust, rice husks) at 5 to 10 cm depth, and access to clean water at all times. The house should be oriented east to west to minimise direct sunlight on the birds during the hottest part of the day, and positioned to allow wind to blow through the open sides.

Poultry feeding must supply protein (18 to 20 per cent for layers, 22 to 23 per cent for broiler chicks), energy, calcium (for eggshell formation in layers), vitamins, and minerals. Commercial compounded feeds (chick mash, grower mash, layer mash, broiler starter and finisher) meet these requirements when fed ad libitum. Health management includes a vaccination programme against Newcastle disease, Infectious Bursal Disease (Gumboro), and Marek's disease according to the recommended schedule; routine deworming; clean water and litter; and daily observation for sick or dead birds which must be removed immediately and the cause investigated.

Fill in the blank: The most critical health management practice in poultry is a scheduled ________ programme against Newcastle disease, Gumboro, and Marek's disease.

Disease / Vaccine	Age of Birds	Route of Administration	Remarks
Marek's disease	Day-old chicks (at hatchery)	Subcutaneous (under skin at neck)	Given once; protects against paralysis and tumors
Newcastle disease (Lasota / Hitchner B1)	7–10 days (first dose), 4–6 weeks (booster), then every 3 months	Eye drop, drinking water, or spray	Prevents severe respiratory and nervous symptoms
Gumboro disease (Infectious Bursal Disease)	14–21 days (first dose), booster at 28 days	Drinking water or oral	Protects against immune suppression and high chick mortality
Fowl pox	6–8 weeks	Wing web (needle prick)	Prevents skin lesions and reduced egg production
Avian influenza (optional in endemic areas)	8–10 weeks	Intramuscular	Used in high-risk zones under veterinary supervision

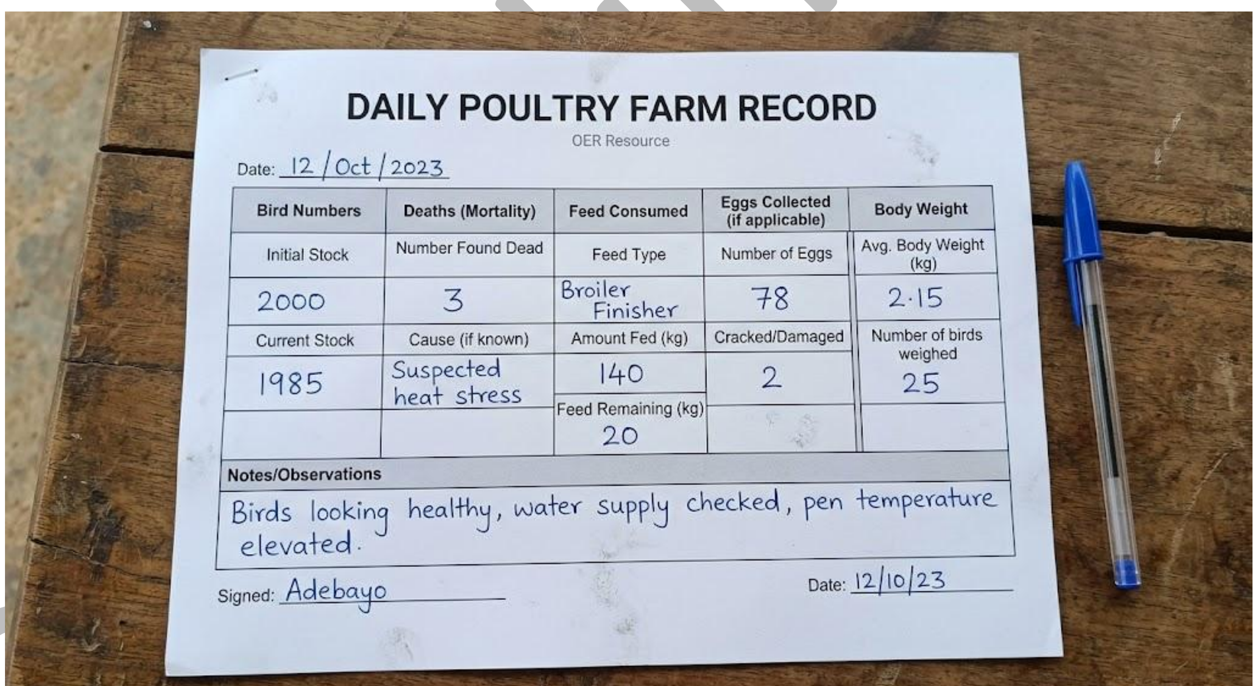
Table 4.1: Recommended vaccination schedule for chickens in Nigeria against Newcastle disease, Gumboro, and Marek's disease

4.1.3 Record keeping and performance assessment in poultry

Accurate records are the foundation of profitable poultry management. Daily records should capture: number of birds alive, number of deaths and causes, feed consumed (kg), water consumed, number of eggs collected (for layers), body weights of sample birds, and any treatments or vaccinations administered. Weekly summaries allow calculation of key performance indicators: mortality rate (percentage of birds dying per week), feed conversion ratio (FCR: kg of feed per kg of body weight gain or per dozen eggs), egg production rate (percentage of hens laying per day, also called hen-day production), and average daily gain in body weight.

Performance assessment compares actual results against breed standards and management targets. For commercial layers, a hen-day production rate above 80 per cent is considered good; broilers should reach 2 to 2.5 kg live weight in 6 to 8 weeks on an FCR of 1.8 to 2.0. When performance falls below target, records provide the data to diagnose whether the problem lies in nutrition (inadequate feed quality or quantity), health (disease-induced drop in production), management (poor ventilation, inadequate water), or genetics (poor-quality stock). Students managing the university farm poultry unit must maintain a complete farm diary and produce weekly performance summaries.

Fill in the blank: Hen-day production, expressed as the percentage of hens laying per day, is the primary ________ indicator for monitoring laying flock performance.



DAILY POULTRY FARM RECORD

OER Resource

Date: 12/Oct/2023

Bird Numbers	Deaths (Mortality)	Feed Consumed	Eggs Collected (if applicable)	Body Weight
Initial Stock	Number Found Dead	Feed Type	Number of Eggs	Avg. Body Weight (kg)
2000	3	Broiler Finisher	78	2.15
Current Stock	Cause (if known)	Amount Fed (kg)	Cracked/Damaged	Number of birds weighed
1985	Suspected heat stress	140	2	25
		Feed Remaining (kg) 20		

Notes/Observations

Birds looking healthy, water supply checked, pen temperature elevated.

Signed: Adebayo

Date: 12/10/23

Figure 4.2: Example of a completed daily poultry farm record sheet showing mortality, feed consumption, egg collection, and body weight data

Pilot questions 4.1

1. Name five types of poultry kept in Nigeria and state the primary product of each.
2. Compare the intensive and extensive poultry management systems in terms of cost, productivity, and management requirements.
3. State the minimum floor space required per layer bird in a deep litter system.
4. Name three diseases against which Nigerian chickens should be vaccinated and state the recommended vaccination schedule.
5. Explain what hen-day production means and state the acceptable target for commercial layers.

4.2 Goat Production and Management

4.2.1 Breeds of goats and their characteristics

Goats are the most widely distributed ruminant livestock in Nigeria, valued for meat (chevon), milk, skin, and manure. The main breeds kept in Nigeria are: the **West African Dwarf (WAD) goat** — a small, hardy, trypanotolerant breed found throughout the forest and derived savanna zones, well-adapted to humid conditions but with modest productivity; the **Red Sokoto (Maradi) goat** — a medium-sized breed from the semi-arid north valued for high-quality leather (Sokoto leather) and meat; and the **Sahel goat** — a large, long-legged breed from the arid north kept primarily for meat.

The West African Dwarf goat is the most common breed at university farms in southern Nigeria because of its disease tolerance, adaptability, and ease of management by students. The Boer goat, imported from South Africa, and its crosses are increasingly popular for commercial meat production because of their rapid growth rate and muscular body conformation. Breed selection should match the production objective (meat, milk, or leather), the agroclimatic zone, available feed resources, and the disease challenge of the location. Crossbreeding local breeds with exotic breeds can improve productivity while retaining some adaptation to local conditions.

Fill in the blank: The West African ________ goat is small, trypanotolerant, and well-adapted to the humid southern Nigerian climate, making it the most common breed found at university farms in the south.

Goat Breed	Size	Distribution Zone	Primary Use	Key Characteristics
West African Dwarf (WAD)	Small (20–30 kg)	Humid forest zones (Southern Nigeria)	Meat, smallholder farming	Hardy, disease-resistant, thrives in humid climates, prolific breeder
Red Sokoto (Maradi)	Medium (25–35 kg)	Semi-arid zones (Northern Nigeria)	Skin (leather), meat	Distinct red coat, produces high-quality leather ("Morocco leather"), adapted to dry climates
Sahel goat	Large (30–50 kg)	Arid and semi-arid Sahelian belt (Northern Nigeria)	Meat, milk	Tall, long-legged, tolerant of heat, good for extensive grazing systems
Boer goat	Large (60–90 kg)	Introduced breed (farms across Nigeria)	Meat (fast growth, high yield)	White body with brown head, rapid growth rate, high fertility, requires good management

Table 4.2: Characteristics of the main goat breeds kept in Nigeria

4.2.2 Housing, feeding, and health management of goats

Goat housing in smallholder and educational farm settings typically consists of a raised wooden or concrete slatted floor pen that keeps goats off the damp ground, reducing exposure to foot rot and internal parasites. Pens should provide at least 1.0 to 1.5 m² per adult goat, with a separate kidding area (maternity pen) for pregnant does close to parturition. Roofing should be adequate to keep animals dry during rain while allowing good ventilation; goats are highly susceptible to respiratory disease in damp, poorly ventilated conditions.

Goats are browsers that prefer a varied diet of leaves, shrubs, coarse grasses, and crop residues over fresh pasture. On a university farm, goats may be fed maize stover, cowpea hay, groundnut tops, kitchen vegetable waste, and concentrate supplements (200 to 400 g/day of a protein-rich feed such as groundnut cake mixed with maize offal). Fresh, clean water must be available at all times. Health management includes routine deworming every three to four months with anthelmintics (levamisole, albendazole) to control internal parasites, which are the primary health constraint in WAD goats; hoofcare (trimming overgrown hooves); and vaccination against Peste des Petits Ruminants (PPR) and contagious pleuropneumonia (CCPP).

Fill in the blank: Internal ________ are the primary health constraint in West African Dwarf goats and require routine deworming every three to four months with appropriate anthelmintic drugs.

4.2.3 Breeding management and productivity assessment

Goat breeding management at the farm level involves maintaining an appropriate buck-to-doe ratio (one buck can serve 20 to 30 does), monitoring oestrus cycles (does come into heat every 18 to 21 days, with oestrus lasting 24 to 48 hours; signs include restlessness, frequent urination, tail wagging, and mounting attempts), and recording all matings, pregnancies, and births. Pregnancy in goats lasts approximately 150 days (five months); does typically deliver one to three kids per parturition.

Productivity assessment in goat production includes kid crop (percentage of does that produce kids per year), average litter size, pre-weaning kid mortality rate (target below 10 per cent), weaning weight at 90 days, and average daily gain from weaning to marketing weight. Growth rate is influenced by breed, feeding level, parasite burden, and management quality. Kids are weaned at 90 days of age and bucks separated from does at three months to prevent inbreeding. Record keeping includes individual animal identification (ear tags), birth records, weight records, health and treatment records, and marketing records. These records enable performance assessment and selection of superior animals for the next breeding season.

Fill in the blank: Goat pregnancy lasts approximately ________ days (five months), and does typically produce one to three kids per parturition.

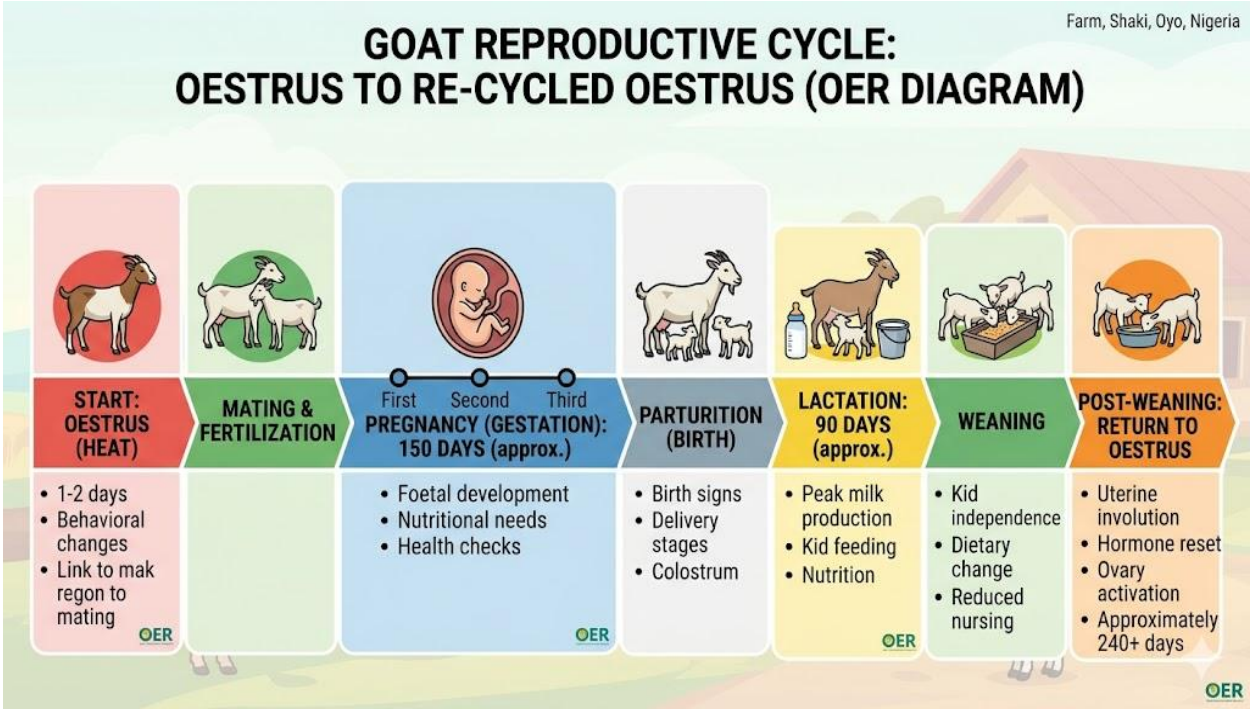


Figure 4.3: Diagram showing the goat reproductive cycle from mating through pregnancy, parturition, and lactation with key timings

Pilot questions 4.2

1. Name three breeds of goats kept in Nigeria and state the primary product and distribution zone of each.
2. Why is a raised slatted floor preferred for goat housing over a concrete floor in contact with the ground?
3. Describe the feeding programme for goats on a university teaching farm.
4. State the primary health constraint in WAD goats and describe the management practice used to control it.
5. Name three productivity indicators used to assess goat production performance.

4.3 Snail Farming (Heliculture)

4.3.1 Introduction to snail farming and species kept

Snail farming (heliculture) is the rearing of snails under controlled conditions for the production of snail meat (escargot), which is a rich source of protein, low in fat, and highly valued in Nigerian cuisine and export markets. Snails are among the easiest livestock to start rearing because they require minimal capital investment, limited space, no specialised infrastructure, and no veterinary drugs. Three species of land snails are commercially important in Nigeria: **Archachatina marginata** (the giant West African snail, the most widely farmed), **Achatina achatina** (the giant Ghana tiger snail, also large and commercially attractive), and **Achatina fulica** (the common giant African snail, prolific but smaller).

Archachatina marginata is preferred by Nigerian farmers because it is native to the region, grows to a large size (up to 500 g live weight), lays 6 to 12 large eggs per clutch (compared with up to 400 tiny eggs per clutch for Achatina fulica), and produces flavourful meat with a firm texture preferred by consumers. Snail farming is particularly appropriate for women and youth entrepreneurs in peri-urban areas because it requires neither heavy labour nor large land areas. The market for snails in Nigeria is strong and seasonal (demand peaks during festive periods), and prices are high relative to production costs.

Fill in the blank: ________ marginata is the most widely farmed snail species in Nigeria, preferred for its large size, high meat quality, and smaller clutch size that makes hatchling management easier.

4.3.2 Housing, feeding, and environmental management of snails

Snail housing (the snailery) must maintain the cool, moist, shaded conditions that snails require; they are active at night and in humid weather and aestivate (become dormant) when conditions become hot and dry. Housing options include hutch boxes (wooden boxes with wire mesh lids for small-scale operations), trench pens (shallow trenches in the ground covered with a mesh frame, which maintain natural soil moisture), and free-range pens (enclosed garden areas with shade trees and vegetable plants). All enclosures must have a secure lid or fence to prevent escape, which is a major problem with snails.

Snails are herbivores and consume a wide variety of plant materials. Preferred feeds include paw-paw leaves and fruit (one of the best feeds because snails consume both the leaves and the soft flesh), cocoyam leaves, sweet potato leaves, banana leaves and peels, water leaf (Talinum), and cabbage. Calcium supplementation is critical for shell development: crushed eggshells, snail shells, or powdered limestone are mixed with feed or provided separately. Soil in the snailery must be kept moist (not waterlogged) because snails absorb water through their skin; misting with water twice daily in the dry season prevents desiccation. Soil pH of 6.0 to 7.5 and a sandy-loam texture are optimal for egg laying and juvenile development.

Fill in the blank: ________ supplementation is critical for snail shell formation and is provided by mixing crushed eggshells, snail shells, or powdered limestone with feed.

Plate 4.3: A hutch box snailery with wire mesh lid showing snails feeding on paw-paw leaves and calcium supplement

4.3.3 Harvesting, processing, and marketing of snails

Snails are harvested by hand-picking from the enclosure when they reach market size: Archachatina marginata is marketed at 100 to 500 g live weight depending on the market segment (live snails, fresh meat, or dried). Snails intended for live sale are collected carefully without damaging the shell and packaged in ventilated crates or baskets lined with moist leaves. Snails should not be harvested during the egg-laying period (when eggs are visible in the soil or when the snail is producing mucus at the shell opening) to avoid reducing breeding stock.

Processing involves killing the snail by immersion in boiling water for three to five minutes, then removing the meat from the shell with a fork or skewer. The snail meat is washed with alum or lime to remove sliminess, de-viscerated (the digestive gland is removed to improve flavour), and can then be cooked fresh, sun-dried, smoked, or processed into canned products. Smoked and dried snail has a much longer shelf life than fresh meat and commands higher prices in markets outside the immediate producing area. Marketing of snails is most profitable when producers sell directly to hotels, restaurants, and supermarkets rather than through intermediaries; value addition through smoking or packaging increases income per kilogram significantly.

Fill in the blank: Snail meat is washed with ________ or lime after processing to remove the natural sliminess and improve the texture and appearance of the product.

Pilot questions 4.3

6. Name the three commercially important snail species in Nigeria and state which is most widely farmed and why.
7. Describe three types of housing used in snail farming.
8. Name four plant materials suitable for feeding snails.
9. Explain why calcium supplementation is important in snail farming.
10. Describe the steps in processing harvested snails from killing to the finished product.

4.4 Fish Production and Management

4.4.1 Fish production systems used in Nigeria

Fish farming in Nigeria is dominated by the production of catfish (Clarias gariepinus) and tilapia (Oreochromis niloticus), which together account for the majority of domestic aquaculture output. Three main production systems are used. **Earthen ponds** are the traditional and most widely used system; they are dug into the ground, filled with water, and fertilised to support plankton growth that provides natural food for fish. They are low in construction cost but have less precise water quality control. **Concrete ponds** allow better water management, easier harvesting, and longer service life; they are common at teaching and commercial farms.

Flow-through systems supply a continuous input of fresh water from a stream or borehole, allowing high fish density but requiring reliable water flow. Recirculating Aquaculture Systems (RAS) re-use treated water in a closed loop and allow year-round production at maximum density, but require higher capital and energy inputs. For university practical purposes, concrete ponds of 20 to 50 m^2 area stocked with catfish or tilapia are most suitable: they are manageable in scale, allow students to practise all management operations, and produce enough fish for assessment. Artisanal cage culture in rivers and reservoirs is also practised in some parts of Nigeria.

Fill in the blank: ________ ponds allow better water management and easier harvesting than earthen ponds and are the most common type at Nigerian university teaching farms.

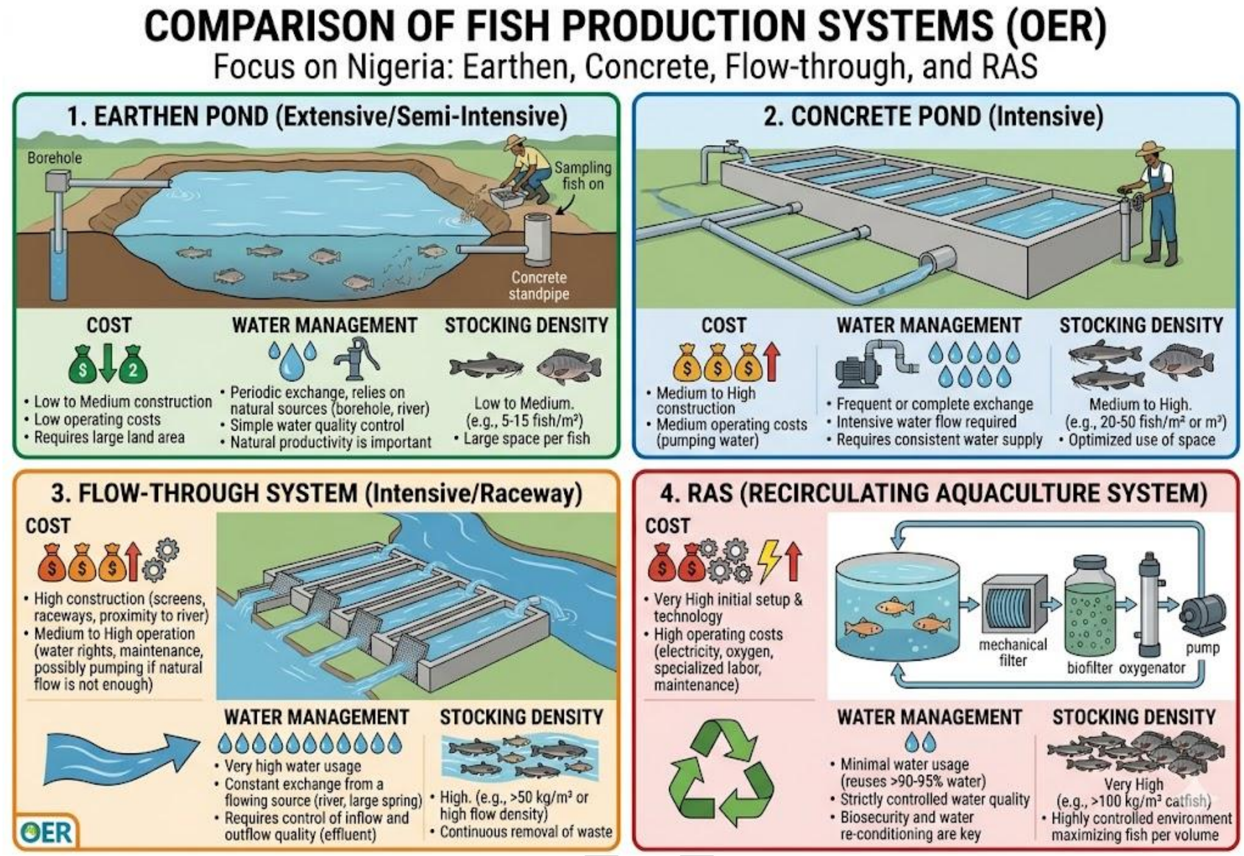


Figure 4.4: Diagram comparing earthen pond, concrete pond, flow-through, and RAS fish production systems in terms of cost, water management, and stocking density

4.4.2 Pond management and feeding of fish

New pond preparation for catfish or tilapia involves filling with water, checking pH (target 6.5 to 8.5), treating with fertiliser or lime if needed, and allowing three to five days for the water to condition before stocking fingerlings. Stocking density for catfish in concrete ponds is typically 20 to 50 fingerlings per m² depending on the intensity of management and aeration; tilapia is stocked at 3 to 5 fish per m² in earthen ponds. Water quality must be monitored daily for dissolved oxygen (target above 5 mg/L), temperature, pH, and ammonia. Aeration using paddle wheels or air blowers is essential in intensive systems.

Feeding catfish requires formulated pellets containing 35 to 45 per cent crude protein for optimal growth. Feed is offered twice daily, morning and evening, at a rate of 3 to 5 per cent of the estimated total biomass per day, adjusted as the fish grow and as water temperature and dissolved oxygen influence appetite. Overfeeding must be avoided because uneaten feed decomposes and depletes dissolved oxygen, promoting disease. Feed conversion ratio (FCR) is the primary economic performance indicator: a good FCR for catfish is 1.5 to 2.0 (1.5 to 2.0 kg feed per 1 kg fish produced). Tilapia in fertilised earthen ponds relies primarily on natural plankton food, requiring lower amounts of supplemental feed.

Fill in the blank: Feed conversion ratio (FCR) for catfish should be between 1.5 and ________ kg of feed per kg of fish produced; higher values indicate poor feed efficiency or water quality problems.

Plate 4.5: University farm concrete catfish ponds showing aeration equipment, feeding and water quality monitoring during a practical session

4.4.3 Harvesting, processing, and record keeping in fish production

Fish are harvested when they reach market size: catfish are typically harvested at 500 g to 1 kg live weight after four to six months of growth, depending on the stocking density, feeding rate, and management intensity. Harvesting is done by draining the pond partially or fully and collecting fish by hand net or seine net. Fish should be harvested in the early morning when water temperatures are lowest to minimise stress and mortality. Immediately after harvesting, fish are transferred to oxygenated water or iced containers to preserve quality.

Fish processing for the Nigerian market includes smoking (the dominant preservation method for catfish, producing a product with a shelf life of several weeks), frying (common for table-size tilapia), and fresh sale in ice. Processing waste (heads, viscera) can be used to produce low-grade fish meal for poultry and pig feed. Record keeping for a fish production unit must include pond identity and area, date of stocking, fingerling source and number stocked, average initial weight, weekly or fortnightly sample weights, daily feed quantity and type, water quality readings, mortality records, harvest date and total weight harvested, total feed consumed, and income from fish sales. These records enable FCR calculation, profitability analysis, and management improvement across production cycles.

Fill in the blank: Catfish are typically harvested at ________ g to 1 kg live weight after four to six months of growth in a well-managed intensive pond system.

Pilot questions 4.4

1. Name four fish production systems used in Nigeria and state one advantage of each.
2. State the recommended stocking density for catfish in concrete ponds and explain the factors that influence this.
3. Explain why overfeeding must be avoided in intensive fish pond management.
4. Describe the steps in harvesting catfish from a concrete pond.
5. List five items that must be recorded in a fish production farm diary.

Series Summary

This Series has covered the practical management of four important livestock species reared on Nigerian farms. We began with poultry production, describing the types of poultry and management systems used in Nigeria, the housing, feeding, and health management requirements including vaccination programmes, and the record keeping and performance assessment practices needed to manage a productive flock. We then examined goat production, identifying the main breeds and their characteristics, describing housing, feeding, and health management including parasite control, and explaining breeding management and productivity assessment.

Following that, we studied snail farming, introducing the three commercially important species with a focus on Archachatina marginata, describing housing systems and the environmental requirements for snail health and productivity, and explaining the harvesting, processing, and marketing of snail products. Finally, we covered fish production, describing the four main production systems used in Nigeria, explaining pond management and feeding practices for catfish and tilapia, and detailing the harvesting, processing, and record-keeping requirements. By completing this Series, you should now be able to achieve all nine Series Learning Outcomes (SLO 4.1 to SLO 4.9).

Glossary of Terms

- **Anthelmintic:** a drug used to expel or kill internal parasites (worms) from the digestive tract of animals; examples used in goats include levamisole and albendazole.
- **Aestivation:** a state of dormancy entered by snails during hot, dry conditions; snails seal their shell opening with a mucus membrane (epiphragm) and reduce metabolic activity to survive drought.
- **Broiler:** a chicken specifically bred and managed for rapid meat production, typically reaching 2 to 2.5 kg live weight within 6 to 8 weeks.
- **Browse:** shrubs, woody plants, leaves, and coarse vegetation consumed by goats; goats are browsers rather than grazers and prefer a varied diet of elevated vegetation over flat pasture.

- **Cage system:** an intensive poultry management system in which individual birds or small groups are housed in wire mesh cages with automatic feeding and watering; commonly used for commercial layers.
- **Chevon:** goat meat; one of the most widely consumed meats in Nigeria, valued for its lean texture and distinctive flavour.
- **Deep litter system:** an intensive poultry management system in which birds are housed on the floor of a building on a litter material (sawdust, rice husks) that is not cleaned out during the production cycle.
- **FCR (feed conversion ratio):** the mass of feed required to produce one unit of body weight gain in livestock; a primary economic performance indicator in poultry and fish production; lower values indicate greater efficiency.
- **Fingerling:** a juvenile fish that has grown to 3 to 5 cm in length and is ready for transfer from the nursery to a grow-out pond or tank.
- **Heliculture:** the farming of land snails for the production of snail meat; also called snail farming or escargot production.
- **Hen-day production:** the percentage of laying hens that produce an egg on any given day; calculated as (eggs collected / number of hens) x 100; a measure of laying flock performance.
- **Kid crop:** the percentage of does in a herd that produce surviving kids during a given breeding season; a measure of reproductive efficiency in goat production.
- **Layer:** a hen specifically bred and managed for high egg production, capable of laying 250 to 300 or more eggs per year under optimal management.
- **Newcastle disease:** a highly contagious and often fatal viral disease of poultry; vaccination is the primary control method and is mandatory for all commercial and smallholder flocks in Nigeria.
- **Oestrus:** the period of sexual receptivity (heat) in female animals; in goats it occurs every 18 to 21 days and lasts 24 to 48 hours.
- **PPR (Peste des Petits Ruminants):** a highly contagious viral disease of goats and sheep that causes fever, mouth lesions, diarrhoea, and respiratory distress; controlled by vaccination.

- **RAS (Recirculating Aquaculture System):** a closed fish production system in which water is continuously treated and recirculated, allowing high stocking densities with minimal water use.
- **Trypanotolerance:** the ability of some livestock breeds (including the West African Dwarf goat) to survive and remain productive in environments where tsetse flies transmit trypanosomiasis.
- **WAD goat (West African Dwarf):** a small, hardy, trypanotolerant goat breed native to the humid forest and derived savanna zones of West Africa; the most common goat breed at university teaching farms in southern Nigeria.

Concept Check Questions [Series 4]

Objective Questions

1. The percentage of hens producing an egg on a given day is called ________ production. (Linked to SLO 4.3)
2. The primary health constraint in West African Dwarf goats is ________ parasites. (Linked to SLO 4.5)
3. The most widely farmed snail species in Nigeria is Archachatina ________. (Linked to SLO 4.7)
4. A good FCR for catfish in an intensive pond is between 1.5 and ________ kg of feed per kg of fish. (Linked to SLO 4.8)
5. Catfish are typically harvested at ________ g to 1 kg live weight after four to six months. (Linked to SLO 4.9)

Short-Answer Questions

1. Compare the intensive and extensive poultry management systems in terms of capital requirement, productivity, and bird welfare. (Linked to SLO 4.1)
2. Describe the feeding requirements of commercial layers and state how these differ from broiler feeding requirements. (Linked to SLO 4.2)
3. Explain why the West African Dwarf goat is preferred at university teaching farms in southern Nigeria. (Linked to SLO 4.4)

4. Describe the housing and feeding requirements of snails and explain the importance of calcium supplementation. (Linked to SLO 4.7)
5. Explain why overfeeding must be avoided in intensive catfish pond management. (Linked to SLO 4.8)

Long-Answer Questions

1. Analyse the management requirements of a small-scale poultry unit, describing the system of management, housing design, feeding programme, health management including vaccinations, and the record keeping and performance assessment practices needed. (Linked to SLOs 4.1, 4.2, 4.3)
2. Discuss the production and management of goats on a university teaching farm, covering breeds and their characteristics, housing and feeding, health management especially parasite control, and breeding management and productivity assessment. (Linked to SLOs 4.4, 4.5, 4.6)
3. Evaluate snail farming and fish production as agricultural enterprises, comparing their resource requirements, management practices, harvesting and processing methods, and economic potential for smallholder farmers in Nigeria. (Linked to SLOs 4.7, 4.8, 4.9)

Answers to Concept Check Questions [Series 4]

Objective Questions

1. Hen-day.
2. Internal (worms/helminths).
3. Marginata.
4. 2.0.
5. 500.

Short-Answer Questions

1. Intensive system: high capital requirement for housing, feeders, waterers, and ventilation; highest productivity because feeding, disease control, and environment are controlled; lower bird welfare from confinement but better disease monitoring. Extensive system: very low capital required, minimal housing; lowest productivity because birds forage on uncertain natural food and are exposed to predators and disease; better welfare through freedom of movement and natural behaviour expression.
2. Layers require 18 to 20 per cent dietary protein with high calcium (3 to 4 per cent) for eggshell formation, balanced vitamins and minerals, and ad libitum access to layer mash. Broilers require higher protein (22 to 23 per cent) in the starter phase for rapid muscle growth, reducing to 18 to 20 per cent in the finisher phase; calcium requirement is lower than for layers; energy density is higher to support rapid growth rate; no calcium supplement is needed.
3. The WAD goat is preferred in southern Nigeria because it is trypanotolerant (able to survive in tsetse-fly infested humid zones that would debilitate larger exotic breeds), well-adapted to the local humid climate, easy to handle at a size manageable by students, widely available locally at low purchase cost, and productive under the relatively modest feeding and management conditions of a university farm.
4. Snail housing (the snailery) must be cool, moist, and shaded because snails aestivate in hot dry conditions; options include hutch boxes, trench pens, and free-range enclosed garden pens, all with secure lids to prevent escape. Snails are fed paw-paw, sweet potato leaves, cocoyam, banana peels, and other vegetation; calcium supplementation (crushed eggshells, limestone) is critical because snails require large amounts of calcium to build and maintain their shells, and deficiency causes thin, deformed shells and poor growth.

5. Uneaten feed decomposes rapidly in warm pond water, consuming dissolved oxygen through microbial respiration; dissolved oxygen levels can drop below the minimum required for fish survival (below 2 mg/L) within hours during the night when photosynthetic oxygen production stops; low dissolved oxygen causes fish stress, reduced feed intake, increased disease susceptibility, and mass mortality; decomposing feed also raises ammonia concentrations to toxic levels.

Long-Answer Questions

1. Basic response: Management system: semi-intensive (house plus run) for the university scale. Housing: east-west oriented open-sided house with wire mesh walls, sawdust litter at 5 to 10 cm depth, 0.1 m² per layer. Feeding: layer mash ad libitum (18 to 20% CP, high calcium). Health: vaccination schedule for Newcastle, Gumboro, Marek's; daily observation; remove sick and dead birds. Records: daily mortality, feed, eggs, body weight; weekly FCR and hen-day production; compare against breed standards.
2. Value-added response: The most common failure in student-managed poultry units is the breakdown of the vaccination programme, either through missing a scheduled vaccine, using improperly stored vaccine (Newcastle vaccine requires cold chain), or failing to administer by the correct route. The consequences (Newcastle disease outbreak destroying the entire flock) are severe and demoralising. Establishing a written vaccination schedule displayed in the poultry house and assigning a specific student to manage the vaccine cold chain and administration calendar transforms vaccination compliance from an individual memory task to a systems management responsibility.
3. Basic response: Breeds: WAD (small, trypanotolerant, south), Red Sokoto (leather and meat, semi-arid north), Sahel (meat, arid north), Boer crosses (fast-growing, meat). Housing: raised slatted floor, 1.0 to 1.5 m² per adult, separate kidding pen. Feeding: maize stover, cowpea hay, browse, 200 to 400 g/day concentrate; water always available. Health: deworming every 3 to 4 months (levamisole/albendazole); PPR and CCPP vaccination; hoof trimming. Breeding: one buck per 20 to 30 does; 150-day pregnancy; wean at 90 days; record all births and weights.
4. Value-added response: Internal parasites (strongyles, tapeworms, liver fluke) are the single most important constraint to WAD goat productivity, causing anaemia, weight loss, diarrhoea, and mortality that can reduce herd productivity by 30 to 50 per cent in untreated animals. The FAO FAMACHA system, which estimates anaemia by examining conjunctival colour against a reference card, allows targeted treatment of only the most heavily parasitised animals, reducing drug costs, preventing anthelmintic resistance development, and maintaining parasite refugia in

the population. Teaching students this targeted selective treatment approach represents best current practice in small ruminant parasite management.

5. Basic response: Snail farming: low capital, small space, Archachatina marginata preferred; hutch boxes or trench pens; feed paw-paw and other vegetation plus calcium; harvest at 100 to 500 g; process by boiling, demucilagination with alum, de-viscerating, then smoke or cook. Fish farming: catfish dominant; concrete ponds most practical at university; stock 20 to 50 fingerlings/m²; feed 35 to 45% CP pellets at 3 to 5% body weight daily; FCR target 1.5 to 2.0; harvest at 500 g to 1 kg at 4 to 6 months; smoke or sell fresh.
6. Value-added response: Snail farming and fish farming occupy complementary economic niches for smallholder entrepreneurs. Snail farming requires almost no capital to start, can be operated in a backyard, and produces a high-value product with strong demand; its limitation is slow growth rate (Archachatina marginata takes 18 to 24 months to reach market size). Catfish farming produces revenue within four to six months but requires a pond, fingerlings, and significant feed investment. A farm enterprise combining both enterprises — using fish pond effluent water to irrigate vegetable plots that produce snail feed — represents an integrated system that maximises resource use efficiency and income stability throughout the year.

Answers to Pilot Questions [Series 4]

Part 4.1: Poultry Production and Management

1. Chicken (eggs and meat); turkey (festive meat); duck (meat, eggs); guinea fowl (meat, eggs); pigeon (squab meat).
2. Intensive: high capital for housing and equipment; highest productivity through controlled feeding and disease management; lower welfare from confinement. Extensive: very low capital, minimal housing; lowest and least predictable productivity; birds exposed to predators and weather; better welfare through freedom of movement.
3. At least 0.1 m² per layer in a deep litter system.
4. Newcastle disease (Day 1 intranasally or eye drop, Day 21 intramuscularly); Infectious Bursal Disease/Gumboro (Day 14 to 18 in drinking water); Marek's disease (Day 1 subcutaneously at hatchery). Schedules should follow veterinary authority recommendations for the local strain situation.

5. Hen-day production is the percentage of hens in the flock that lay an egg on a given day, calculated as (number of eggs / number of hens) x 100; for commercial layers the acceptable target is above 80 per cent hen-day production.

Part 4.2: Goat Production and Management

1. WAD goat: meat and skin, humid forest and derived savanna (south). Red Sokoto: high-quality leather and meat, semi-arid north. Sahel goat: meat, arid north. (Boer: meat, introduced breed used for upgrading across Nigeria.)
2. A raised slatted floor keeps goats off damp soil, reducing contact with faeces and the infective larvae of gastrointestinal parasites that develop in moist faecal matter on the ground; it also reduces exposure to mud that promotes foot rot; the raised floor improves air circulation under the animal, reducing skin and hoof disease; and it makes cleaning easier, reducing ammonia build-up in the pen.
3. Goats are fed a combination of roughages (maize stover, cowpea hay, guinea grass, browse leaves, crop residues such as groundnut tops and cassava peels) available on the farm, supplemented with 200 to 400 g per day of a protein-rich concentrate (groundnut cake mixed with maize offal or commercial goat concentrate) to support growth and milk production; fresh, clean water is provided at all times.
4. The primary health constraint is internal parasites (gastrointestinal worms and liver fluke); control involves routine anthelmintic deworming every three to four months using drugs such as levamisole or albendazole, rotational grazing or zero-grazing to reduce pasture contamination, maintaining raised slatted housing, and targeted treatment of the most parasitised animals identified by FAMACHA scoring.
5. Any three: kid crop (percentage of does producing kids per year); average litter size (kids per doe per parturition); pre-weaning kid mortality rate (target below 10 per cent); weaning weight at 90 days; average daily gain from weaning to marketing weight.

Part 4.3: Snail Farming (Heliculture)

1. Archachatina marginata, Achatina achatina, Achatina fulica; Archachatina marginata is most widely farmed because it is native to Nigeria, grows to a large size (up to 500 g), produces 6 to 12 large easily managed eggs per clutch (compared with up to 400 tiny eggs for Achatina fulica), and its meat is preferred by consumers for flavour and texture.

2. Hutch boxes: wooden boxes with wire mesh lids, suitable for small-scale operations, portable and easy to clean. Trench pens: shallow trenches dug in the ground covered with a mesh frame, maintain natural soil moisture and temperature. Free-range garden pens: enclosed garden areas with shade trees and food plants, closest to natural conditions but require more land and careful fencing.
3. Any four: paw-paw leaves and fruit; sweet potato leaves; cocoyam leaves; banana leaves and peels; water leaf (Talinum); cabbage; lettuce; plantain peels; garden egg leaves.
4. Calcium is the primary mineral in snail shells; insufficient dietary calcium leads to thin, fragile, deformed shells that crack easily during harvesting and handling, reducing product quality and market value; calcium is also required for egg shell formation and is lost through mucus secretion; supplementation with crushed eggshells, snail shells, or powdered limestone ensures adequate supply for shell maintenance and growth.
5. Kill by immersion in boiling water for three to five minutes; remove meat from shell using a fork or skewer; wash with alum or lime and water to remove sliminess; rinse thoroughly; remove the digestive gland (de-viscerate) to improve flavour; the meat can then be cooked fresh, sun-dried, smoked over wood fire to extend shelf life, or processed into canned products for extended market reach.

Part 4.4: Fish Production and Management

1. Earthen ponds (advantage: low construction cost, supports natural food production); concrete ponds (advantage: better water management and easier harvesting); flow-through systems (advantage: high fish density supported by constant fresh water supply); RAS (advantage: year-round production at maximum density with minimal water use).
2. Recommended stocking density for catfish in concrete ponds is 20 to 50 fingerlings per m²; factors influencing this include: availability and quality of aeration (higher aeration supports higher density); feed management capacity (high density requires precise feeding to avoid overfeeding); water exchange rate; management skill level; and the target harvest size (higher density produces smaller individual fish at harvest).
3. Overfeeding deposits uneaten feed on the pond bottom where it decomposes through microbial activity, consuming dissolved oxygen and producing ammonia and hydrogen sulphide; dissolved oxygen drops, especially at night, to levels that cause mass fish mortality; ammonia rises to toxic levels that damage fish gills; disease outbreaks follow because stress from low oxygen and high ammonia compromises fish immune function.

4. Begin harvesting in the early morning when water temperature is lowest; partially or fully drain the pond by opening the drain outlet; as water level drops, collect fish at the drain outlet using a hand net or seine net drawn across the pond; transfer harvested fish immediately to oxygenated holding tanks or iced containers; complete the harvest quickly to minimise stress and mortality; record total weight harvested.
5. Any five: pond identity and area; date of stocking and fingerling source; number of fingerlings stocked and average initial weight; daily feed quantity and type; weekly or fortnightly sample weights; daily water quality readings (dissolved oxygen, temperature, pH); mortality records (numbers, dates, cause if known); harvest date and total weight harvested; total feed consumed during the cycle; income from fish sales.

References and Attributions [Series 4]

Textual References (Books and External Sources)

- Sonaiya, E. B., & Swan, S. E. J. (2004). Small-scale poultry production: Technical guide. FAO Animal Production and Health Manual No. 1. FAO.
- Devendra, C., & Burns, M. (1983). Goat production in the tropics. Commonwealth Agricultural Bureaux.
- Cobbinah, J. R., Vink, A., & Onwuka, B. (2008). Snail farming: Production, processing and marketing. Agromisa Foundation and CTA.
- Pillay, T. V. R., & Kutty, M. N. (2005). Aquaculture: Principles and practices (2nd ed.). Blackwell Publishing.
- FAO (Food and Agriculture Organization of the United Nations). (2014). Poultry development review. FAO.
- FAO (Food and Agriculture Organization of the United Nations). (2025). Guidelines for sustainable agriculture. FAO.

Figures, Plates, Tables, and Boxes

- Figure 4.1: Poultry management systems comparison Attribution: AI generated using prompt "Generate a three-panel diagram comparing intensive, semi-intensive, and extensive poultry management systems." Suggested OER search string: "poultry management systems intensive semi-intensive extensive comparison OER diagram".
- Table 4.1: Chicken vaccination schedule for Nigeria Attribution: AI generated using prompt "Generate a table showing the recommended vaccination schedule for Nigerian chickens including Newcastle disease, Gumboro, and Marek's disease." Suggested OER search string: "chicken vaccination schedule Nigeria Newcastle Gumboro Marek OER table".
- Figure 4.2: Daily poultry farm record sheet Attribution: AI generated using prompt "Generate an image of a completed daily poultry farm record sheet with fields for mortality, feed, eggs, and body weight." Suggested OER search string: "daily poultry farm record sheet mortality feed eggs body weight OER".
- Table 4.2: Nigerian goat breeds characteristics Attribution: AI generated using prompt "Generate a table listing Nigerian goat breeds including WAD, Red Sokoto, Sahel, and Boer with size, zone,

use, and characteristics." Suggested OER search string: "Nigerian goat breeds WAD Red Sokoto Sahel Boer characteristics table OER".

- Plate 4.1: WAD goats in raised slatted pen Attribution: AI generated using prompt "Generate an image of West African Dwarf goats in a raised slatted-floor pen at a university teaching farm." Suggested OER search string: "West African Dwarf goats raised slatted pen university farm OER image".
- Figure 4.3: Goat reproductive cycle timeline Attribution: AI generated using prompt "Generate a timeline diagram showing the goat reproductive cycle from oestrus through mating, pregnancy, parturition, lactation, and weaning." Suggested OER search string: "goat reproductive cycle timeline oestrus pregnancy parturition weaning OER diagram".
- Plate 4.2: Archachatina marginata snails on farm Attribution: AI generated using prompt "Generate an image showing Archachatina marginata snails of different sizes in a snail farm enclosure." Suggested OER search string: "Archachatina marginata snail farm juvenile adult Nigeria OER image".
- Plate 4.3: Hutch box snailery with feeding Attribution: AI generated using prompt "Generate an image of a wooden hutch box snailery with snails feeding on paw-paw leaves and crushed eggshells." Suggested OER search string: "hutch box snailery wire mesh lid snails paw-paw calcium OER image".
- Plate 4.4: Smoked snail meat at market Attribution: AI generated using prompt "Generate an image showing live Archachatina marginata snails alongside processed smoked snail meat at a Nigerian market stall." Suggested OER search string: "smoked snail meat live snails market Nigeria value added OER image".
- Figure 4.4: Fish production systems comparison Attribution: AI generated using prompt "Generate a four-panel diagram comparing earthen pond, concrete pond, flow-through, and RAS fish production systems." Suggested OER search string: "fish production systems earthen concrete flow-through RAS comparison Nigeria OER".
- Plate 4.5: University farm catfish ponds Attribution: AI generated using prompt "Generate an image of concrete catfish ponds at a university teaching farm with aeration and water quality monitoring." Suggested OER search string: "concrete catfish ponds university farm aeration feeding water quality OER image".
- Plate 4.6: Students harvesting catfish Attribution: AI generated using prompt "Generate an image of students harvesting catfish from a drained concrete pond using hand nets." Suggested OER search string: "students harvesting catfish drained concrete pond hand nets OER image".

Course code: AGE 102

Course title: Practical Farm Work 1

Course credit load: 2 Units

Series 5: Processing of Crop Products and Farm Output Evaluation

- **Part 5.1: Processing of Palm Products**
  - Sub Part 5.1.1: Palm oil extraction: traditional and improved methods
  - Sub Part 5.1.2: Palm kernel processing and uses
  - Sub Part 5.1.3: Quality assessment of palm products
- **Part 5.2: Processing of Cassava Products**
  - Sub Part 5.2.1: Garri production: steps and quality control
  - Sub Part 5.2.2: Fufu, starch, and cassava flour production
  - Sub Part 5.2.3: Food safety and quality standards for cassava products
- **Part 5.3: Processing of Other Crop Products**
  - Sub Part 5.3.1: Maize milling and corn flour production
  - Sub Part 5.3.2: Groundnut oil extraction and groundnut cake production
  - Sub Part 5.3.3: Vegetable preservation and other crop processing
- **Part 5.4: Farm Output Evaluation and Course Assessment**
  - Sub Part 5.4.1: Principles of farm output evaluation
  - Sub Part 5.4.2: Process and product evaluation methods
  - Sub Part 5.4.3: Farm diary, reporting, and entrepreneurship

Introduction

Agricultural production does not end at harvest. The transformation of raw farm produce into processed products ready for consumption, storage, or sale is an essential part of the agricultural value chain and a major source of rural income and employment. Processing adds value, extends shelf life, reduces post-harvest losses, and expands the range of markets accessible to producers. For agriculture students, competence in crop processing techniques — from palm oil extraction to garri production — is as important as field production skills.

The aim of this Series is to equip you with practical knowledge and skills in the processing of major Nigerian crop products including palm, cassava, maize, and groundnut, and to provide the tools for evaluating farm output and reflecting on what has been learnt through the practical farm work of this course.

We shall commence this Series by examining palm product processing. Next, we will study cassava processing into garri, fufu, and flour. Following that, we will cover maize milling, groundnut oil extraction, and vegetable preservation. Finally, we will wrap up with farm output evaluation methods, process and product assessment, and the farm diary and entrepreneurship skills that consolidate the learning of the whole course.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** describe the traditional and improved methods of palm oil extraction and assess the quality of palm oil produced (Linked to Part 5.1),
- **SLO 5.2** explain palm kernel processing and describe the uses of palm kernel oil and cake (Linked to Part 5.1),
- **SLO 5.3** describe the steps in garri production and explain the quality control measures applied at each stage (Linked to Part 5.2),
- **SLO 5.4** describe the production of fufu, cassava starch, and cassava flour (Linked to Part 5.2),

- **SLO 5.5** explain the food safety and quality standards relevant to cassava products (Linked to Part 5.2),
- **SLO 5.6** describe maize milling, groundnut oil extraction, and vegetable preservation techniques (Linked to Part 5.3),
- **SLO 5.7** explain the principles of farm output evaluation and describe how farm performance is assessed (Linked to Part 5.4),
- **SLO 5.8** apply process and product evaluation methods to assess the outcomes of practical farm work (Linked to Part 5.4), and
- **SLO 5.9** maintain a farm diary, produce a farm output report, and identify entrepreneurial opportunities in crop processing (Linked to Part 5.4).

5.1 Processing of Palm Products

5.1.1 Palm oil extraction: traditional and improved methods

Palm oil is extracted from the mesocarp (fleshy outer layer) of the oil palm fruit (Elaeis guineensis). It is the most widely consumed edible oil in Nigeria and a major agricultural export commodity. The traditional extraction process follows these steps: (1) bunch harvesting and fruit detachment, (2) sterilisation of fresh fruit bunches by boiling or steaming to deactivate lipases that cause free fatty acid development, (3) stripping of individual fruits from the bunch, (4) pounding or mashing in a mortar to loosen the mesocarp from the nut, (5) mixing the mash with hot water and kneading to separate oil from fibre, and (6) decanting and clarifying the oil by boiling and skimming.

Improved small-scale methods use mechanical digesters and hand-operated or motorised presses to replace manual pounding and squeezing, significantly increasing oil extraction efficiency (from 50 to 60 per cent in traditional methods to 80 to 90 per cent in mechanical methods) and reducing labour. Mechanical processing also produces cleaner oil with lower free fatty acid content and longer shelf life. Large-scale industrial mills use continuous sterilisers, mechanical digesters, and centrifuges to produce crude palm oil (CPO) at high efficiency. For practical farm work purposes, students practise the traditional boiling and kneading extraction method on small quantities of freshly harvested palm fruit.

Fill in the blank: Mechanical palm oil extraction achieves an oil extraction efficiency of ________ to 90 per cent, compared with 50 to 60 per cent using traditional manual methods.

5.1.2 Palm kernel processing and uses

Palm kernels are the hard inner seeds of the oil palm fruit remaining after mesocarp oil extraction. They contain 48 to 50 per cent oil (palm kernel oil, PKO) with a different fatty acid composition from palm oil (PKO is more saturated and solid at room temperature). The steps in palm kernel processing at the small scale are: (1) separation of the palm kernel nut from the fibre after mesocarp oil extraction, (2) drying the nuts to reduce moisture, (3) cracking the hard shell manually with a stone or mechanically with a nut cracker to release the white kernel, (4) separating kernels from shell fragments by winnowing or flotation, and (5) expressing oil from the kernels by pressing.

Palm kernel oil is used in the food industry for the production of margarine, shortening, cooking fats, and confectionery coatings; in the soap and detergent industry; and as an industrial lubricant. The solid residue remaining after oil extraction from the kernels is palm kernel cake (PKC), which contains 16 to 18 per cent crude protein and is a valuable livestock feed ingredient used in poultry, pig, and fish diets. At the household level in southern Nigeria, cracked kernels are also used directly in soups and as a snack. Efficient palm kernel cracking and kernel-shell separation are key processing skills that reduce labour costs and improve product quality.

Fill in the blank: The solid residue remaining after oil extraction from palm kernels is called palm kernel ________ (PKC) and is used as a livestock feed ingredient.

5.1.3 Quality assessment of palm products

Quality of crude palm oil is assessed by three principal parameters. **Free fatty acid (FFA) content** is the most important quality indicator; it rises when fresh fruit bunches are delayed before processing (allowing lipase enzymes to break down neutral oil into free fatty acids), when fruit is damaged, or when processing is poorly done. Good quality palm oil has an FFA content below 5 per cent; oil with FFA above 5 per cent is downgraded and commands a lower market price. **Colour** should be a clear, bright red-orange; cloudy, brown, or dark oil indicates poor processing, contamination, or rancidity.

Moisture and impurity content must also be low: palm oil is heated and allowed to settle so that water and solid impurities sink to the bottom, then the clarified oil is decanted and stored in clean, sealed containers away from light and heat. Rancid oil, detectable by a sour, musty smell, results from oxidation and hydrolysis during storage and is unfit for consumption. Palm kernel quality is assessed by moisture content (below 7 per cent for safe storage), kernel-to-shell ratio (a measure of cracking efficiency), and the absence of mould or insect damage. Students should apply these quality criteria when assessing the products of their practical palm processing exercises.

Fill in the blank: Good quality crude palm oil has a free fatty ________ (FFA) content below 5 per cent; higher FFA indicates delayed processing or poor handling of fresh fruit bunches.

Parameter	Acceptable Standards	Assessment Method
Moisture content	≤ 0.2% for crude palm oil; ≤ 7% for palm kernels	Oven-drying method or moisture meter
Free fatty acid (FFA)	≤ 5% for crude palm oil; ≤ 2.5% for palm kernels	Titration with alkali solution
Impurities	≤ 0.1% for crude palm oil; ≤ 3% for palm kernels	Filtration and gravimetric analysis
Colour	Bright orange-red for palm oil; brownish for kernels	Visual inspection or Lovibond tintometer
Odour and taste	Free from rancid or off-flavours	Sensory evaluation (smell and taste panel)
Oil content	≥ 45% in palm kernels	Soxhlet extraction or mechanical pressing
Peroxide value	≤ 10 meq/kg	Iodometric titration

Table 5.1: Quality assessment parameters for crude palm oil and palm kernels with acceptable standards and methods of assessment

Pilot questions 5.1

1. List the steps in traditional palm oil extraction in the correct order.
2. Explain why sterilisation of fresh fruit bunches is the first processing step in palm oil extraction.
3. Describe the steps in palm kernel processing from nut to palm kernel oil.
4. State two uses of palm kernel oil and two uses of palm kernel cake.
5. Define free fatty acid content and explain why it is the most important quality parameter for crude palm oil.

5.2 Processing of Cassava Products

5.2.1 Garri production: steps and quality control

Garri is the most widely consumed cassava product in Nigeria, produced by fermenting grated cassava mash and then frying the dewatered mash to produce a dry, granular, shelf-stable product. The production steps are: (1) root washing (removing soil and debris), (2) peeling (removing the brown outer skin), (3) grating (reducing peeled roots to a wet mash using a hand grater or mechanical grater), (4) bagging and pressing (placing mash in jute or polythene bags under heavy weights for 24 to 72 hours to remove water and allow fermentation by naturally occurring lactic acid bacteria and yeasts, which reduce the hydrogen cyanide content of bitter varieties), and (5) sieving (breaking up the pressed mash into granules through a wire mesh sieve).

Step 6 is frying (garification): the sieved mash is spread in a heated iron pan (tawa) or frying drum and stirred continuously with a wooden paddle until dry and evenly toasted. White garri is fried without palm oil; yellow garri has palm oil added during frying, giving it a yellow colour and higher energy content. Quality garri has a uniform colour, dry texture, good expansion on addition of water, and low cyanide content (below 10 mg HCN equivalent per kg for safe consumption). The duration of fermentation is the key quality control variable: shorter fermentation (24 hours) leaves more HCN in bitter varieties and is only safe for sweet (low-HCN) cassava varieties.

Fill in the blank: The ________ step in garri production reduces the hydrogen cyanide content of bitter cassava varieties through the action of naturally occurring lactic acid bacteria and yeasts.

5.2.2 Fufu, starch, and cassava flour production

Fufu is a traditional fermented cassava food produced by soaking peeled whole cassava roots in water for two to five days until softened by fermentation, then removing the fibrous core, hand-mashing or machine-mashing the fermented flesh to a smooth paste, and boiling or fermenting further for consumption. The extended fermentation gives fufu its characteristic sour taste and smell. Sun-dried fufu powder is a commercial product that reconstitutes quickly on addition of hot water.

Cassava starch is produced by grating fresh cassava, washing the grated mash in large volumes of water to separate the starch granules from the fibre and cell material, allowing the starch to settle in the washing vessel, decanting the water, and sun-drying or oven-drying the wet starch to less than 14 per cent moisture. **Cassava flour** (high-quality cassava flour, HQCF) is produced from fresh cassava by peeling, grating, pressing to remove excess water, drying at controlled temperature, and milling to a fine flour that can substitute wheat flour at up to 20 per cent inclusion in bread and confectionery. HQCF production maintains a low HCN content because no prolonged fermentation is used.

Fill in the blank: High-quality cassava ________ (HQCF) can substitute wheat flour at up to 20 per cent inclusion in bread and confectionery without significantly affecting product quality.

5.2.3 Food safety and quality standards for cassava products

Hydrogen cyanide (HCN) is the primary food safety concern in cassava processing because cassava roots contain cyanogenic glucosides (linamarin and lotaustrasin) that release HCN when cells are ruptured. The WHO safe limit for HCN in cassava products is 10 mg HCN equivalent per kg of product. Effective processing — particularly fermentation, pressing, and frying in garri production, and soaking in fufu production — reduces HCN to safe levels if done correctly. Using sweet (low-HCN) varieties, fermenting for the full recommended period, and ensuring thorough drying all contribute to HCN reduction.

Microbial safety is the second major food safety concern; garri and cassava flour must be dried to below 12 per cent moisture content to prevent mould growth and aflatoxin contamination during storage. Packaging in clean, sealed containers protects dried products from re-absorption of moisture and from insect or rodent contamination. Cassava products sold for export or institutional supply must comply with Nigerian Industrial Standards (NIS) specified by the Standards Organisation of Nigeria (SON), which set maximum limits for moisture, HCN, total plate count, and physical impurities. Students should apply these standards when evaluating the quality of cassava products produced during practical farm processing sessions.

Fill in the blank: The World Health Organization safe limit for hydrogen cyanide in cassava products is ________ mg HCN equivalent per kilogram of product.

Control Point	Acceptable Standard	Assessment Method
Variety selection	Use low-cyanide cassava varieties	Variety certification, extension guidelines
Fermentation	24–72 hours to reduce cyanide	Observation of pH drop, sensory check
Pressing	Adequate removal of water and toxins	Mechanical press efficiency, weight loss
Drying	Hygienic sun or mechanical drying	Visual inspection, absence of mold
Moisture content	$\leq$ 12% for flour, $\leq$ 10% for garri	Moisture meter or oven-drying test
Packaging standards	Clean, food-grade, airtight packaging	Inspection of packaging materials

Box 5.1: Food safety checklist for garri and cassava flour production

Pilot questions 5.2

1. List the steps in garri production in the correct order.

2. Explain the role of fermentation in garri production and state the consequence of insufficient fermentation of bitter cassava.
3. Describe the production of cassava starch from fresh roots.
4. Explain what high-quality cassava flour (HQCF) is and how it differs from garri production.
5. State the WHO safe limit for HCN in cassava products and name two processing steps that reduce HCN.

5.3 Processing of Other Crop Products

5.3.1 Maize milling and corn flour production

Maize (corn) is the most widely consumed cereal in Nigeria and is processed into a variety of products. Dry milling of maize grain produces **corn flour** (a fine powder used for porridge, tuwo, and composite bread), **grits** (coarse broken endosperm used for brewing and breakfast cereals), and **maize bran** (the outer layer rich in fibre used as animal feed). Wet milling separates the grain into its components (starch, gluten, germ oil, and fibre) for industrial processing.

At the small and medium scale relevant to practical farm work, maize grain is cleaned to remove foreign material and damaged grain, dried to below 13 per cent moisture, and then milled in a hammer mill or plate mill to produce flour of the desired fineness. Fermented maize products include ogi (akamu or pap) — a thin fermented porridge produced by soaking and wet-grinding maize, allowing the slurry to ferment for 24 to 72 hours, then sieving and cooking — and kunu, a fermented beverage. Popcorn is produced by rapid heating of whole maize grain; the rapid steam build-up inside the hard pericarp causes the kernel to explode and the starch to expand. Proper drying of maize before milling is critical because high moisture flour stores poorly and is prone to mould and aflatoxin contamination.

Fill in the blank: Maize grain must be dried to below ________ per cent moisture before milling to prevent mould growth and aflatoxin contamination of the flour during storage.

5.3.2 Groundnut oil extraction and groundnut cake production

Groundnut (Arachis hypogaea) is one of the most important oilseed crops in Nigeria, providing edible oil, protein-rich cake, and direct food products. The oil extraction process begins with shelling (removing the pod), cleaning and grading of the kernels, and roasting at 120 to 140 degrees Celsius to reduce moisture, develop flavour, and improve oil extraction efficiency. Traditional small-scale extraction uses a mechanical screw press (expeller press) to express oil from the roasted kernels; solvent extraction is used at the industrial scale for more complete oil recovery.

The expelled oil is allowed to settle and is decanted from sediment, then filtered through a clean cloth for clarity. Good quality groundnut oil is a clear, golden-yellow colour with a characteristic nutty aroma; cloudy or dark oil indicates poor quality roasting or contamination. The solid residue from pressing is groundnut cake (also called groundnut meal or Kano cake), which contains 45 to 48 per cent crude protein and is one of the most important livestock protein supplements used in poultry, pig, and fish feed compounding. Groundnut paste (groundnut butter or suya paste) is produced by grinding roasted kernels without pressing; it is widely consumed in Nigerian cuisine and is a high-value product for direct marketing.

Fill in the blank: Groundnut cake contains 45 to 48 per cent crude ________ and is one of the most important protein supplements used in compounding livestock feeds in Nigeria.

5.3.3 Vegetable preservation and other crop processing

Fresh vegetables are highly perishable due to their high moisture content (85 to 95 per cent), active respiration, and susceptibility to fungal and bacterial decay. Key preservation methods for vegetables used in practical farm processing include: **sun drying** (slicing vegetables thinly and spreading on clean raised racks in full sunlight; effective for tomato, pepper, onion, leafy vegetables; reduces moisture to below 10 per cent and extends shelf life from days to months), **blanching and drying** (briefly immersing vegetables in boiling water for one to three minutes to inactivate enzymes before drying, preserving colour and nutritional value better than sun drying alone), and **salting and fermentation** (traditional preservation of African locust beans, melon seed, and fermented pepper condiments).

Other crop processing skills taught in practical farm work include: production of palm wine (tapping the inflorescence of oil palm or raffia palm to collect the sap, which ferments naturally to produce the alcoholic beverage); production of coconut oil from dried coconut flesh (copra); cassava-based starch adhesives for bookbinding and paper craft; and composting of processing waste (cassava peels, groundnut shells, palm fruit fibre) to produce organic fertiliser for return to the farm. Processing of crop wastes into compost closes the nutrient cycle and demonstrates the integrated nature of a sustainable farm system, a principle that students should carry into professional agricultural practice.

Fill in the blank: ________ involves briefly immersing vegetables in boiling water before drying to inactivate enzymes, preserving colour and nutritional value better than sun drying alone.

Pilot questions 5.3

1. Name four products obtained from the processing of maize and state the end use of each.
2. Describe the steps in small-scale groundnut oil extraction.
3. State the crude protein content of groundnut cake and explain its importance in livestock production.
4. Explain why blanching before drying preserves vegetable quality better than sun drying alone.
5. Give two examples of how processing waste from crop products can be utilised productively.

5.4 Farm Output Evaluation and Course Assessment

5.4.1 Principles of farm output evaluation

Farm output evaluation is the systematic assessment of what has been produced, how it was produced, and what was learnt during the production process. It serves three functions: accountability (demonstrating to instructors and institutions that the practical objectives of the course were met), improvement (identifying what worked well and what should be done differently in future), and learning consolidation (reflecting on practical experience to extract the maximum educational value from it). In AGE 102, assessment is explicitly through process and product evaluation rather than written examination alone.

The principles of farm output evaluation include completeness (all aspects of the farm operation should be documented, not only successes), accuracy (records and measurements should be precise and verifiable), honesty (failures and losses should be reported as candidly as successes, since understanding failure is as important to professional development as understanding success), and relevance (evaluation should focus on the outcomes most important to the course learning objectives). Applying these principles produces a farm output report that is credible, informative, and useful both to the student and to the instructor evaluating it.

Fill in the blank: The principle of ________ in farm output evaluation requires that failures and losses be reported as candidly as successes, because understanding what went wrong is essential to professional development.

5.4.2 Process and product evaluation methods

Process evaluation assesses how farm operations were conducted: whether correct procedures were followed, tools were used appropriately and safely, operations were performed at the right time, and students demonstrated competence, initiative, and ethical behaviour during practical sessions. Process evaluation is conducted by instructors observing student performance in real time during farm practicals and by reviewing the farm diary entries that students maintain throughout the course. A process evaluation rubric specifies the criteria and scoring for each practical activity.

Product evaluation assesses the quality and quantity of what was produced: the area of land prepared and planted, the yield of crops harvested, the quality of processed products, the condition of the student herbarium and insect collection, and the performance of the animal production units managed. Product quality is assessed against the standards described in the preceding parts of this Series: garri is assessed for colour, texture, expansion, and HCN safety; palm oil for colour, clarity, and FFA; groundnut oil for colour and aroma; dried vegetables for moisture content and freedom from mould. Both process and product evidence are required for a complete assessment of practical farm work competence.

Fill in the blank: ________ evaluation assesses how farm operations were conducted, including correct procedure, tool use, timing, student competence, and ethical behaviour during practical sessions.

Criteria	Excellent (4)	Good (3)	Fair (2)	Poor (1)
Land preparation	Land well-cleared, ploughed, leveled; no weeds	Land cleared with minor weeds; fairly leveled	Land partially cleared; uneven surface	Land poorly cleared; unsuitable for planting
Crop management	Timely planting, weeding, fertilization, pest control	Most operations timely; minor lapses	Some operations late or incomplete	Poor management; crops neglected
Animal care	Animals well-fed, housed, healthy; records kept	Animals fed and housed; minor health lapses	Feeding irregular; housing inadequate	Poor care; animals unhealthy or neglected
Processing	Produce processed hygienically with proper methods	Processing fairly hygienic; minor errors	Processing incomplete or inconsistent	Poor processing; contamination risk
Record keeping	Accurate, complete, up-to-date records	Records kept with minor gaps	Records incomplete or irregular	No records or inaccurate entries

Table 5.2: Farm output evaluation rubric showing criteria, performance levels, and scores for practical farm work assessment

5.4.3 Farm diary, reporting, and entrepreneurship

The farm diary is a daily record of all practical farm activities carried out by the student throughout the course. It must include: the date and time of each activity, a description of the work done, the area or number of animals involved, the inputs used (quantities, types, costs where known), observations made (crop growth, animal health, weather), problems encountered, and actions taken. The farm diary is both a learning tool (writing up daily observations consolidates understanding and reveals patterns) and an assessment document reviewed by instructors at the end of the course.

The farm output report is a structured end-of-course document that summarises the student's practical farm work experience across all five Series, analyses the results against targets and standards, reflects on what was learnt and what would be done differently, and identifies entrepreneurial opportunities in the farming and processing activities experienced. Identifying an enterprise opportunity means specifying a product or service with a clear market, estimating the costs and revenues, and explaining why it is viable. Students who can move from practical farm experience to a written business case demonstrate the entrepreneurial readiness that is a central learning outcome of the course and a preparation for professional practice in the agricultural sector.

Fill in the blank: The farm ________ is a daily record of all practical farm activities that serves both as a learning tool and as an assessment document reviewed by instructors.

Pilot questions 5.4

1. State three principles of farm output evaluation and explain the importance of each.
2. Distinguish between process evaluation and product evaluation in practical farm work assessment.
3. List five items that must be recorded in a farm diary entry.
4. Describe the structure and content of a farm output report.
5. Explain what it means to identify an entrepreneurial opportunity from practical farm experience and give one example.

Series Summary

This final Series has completed the course by covering the processing of major Nigerian crop products and the evaluation of farm output. We began with palm product processing, describing the traditional and improved methods of palm oil extraction, the steps in palm kernel processing to produce PKO and PKC, and the quality assessment parameters for palm products. We then studied cassava processing, explaining garri production step by step with its quality control implications, describing the production of fufu, starch, and HQCF, and establishing the food safety standards relevant to cassava products including the WHO HCN limit.

Following that, we covered the processing of maize, groundnut, and vegetables, describing corn milling and fermented maize products, groundnut oil extraction by screw press and the production of groundnut cake and paste, and vegetable preservation by sun drying and blanching. Finally, we established the principles and methods of farm output evaluation, described process and product evaluation methods and rubrics, and explained the farm diary and output report as assessment and learning documents, and the entrepreneurial skills of identifying business opportunities from practical farm experience. By completing this Series and the course as a whole, you should now be able to achieve all nine Series Learning Outcomes (SLO 5.1 to SLO 5.9) and all four course learning outcomes.

Glossary of Terms

- **Aflatoxin:** a toxic compound produced by Aspergillus moulds on improperly dried grain and groundnuts; a serious food safety hazard managed by thorough drying to safe moisture levels before storage.
- **Blanching:** the brief immersion of vegetables in boiling water (one to three minutes) followed by cooling, used to inactivate enzymes before drying; preserves colour, texture, and nutritional value better than sun drying alone.
- **Cyanogenic glucoside:** a naturally occurring compound in cassava (linamarin, lotaustrasin) that releases hydrogen cyanide when cassava cells are ruptured; removed to safe levels by fermentation, pressing, and drying during processing.
- **Expeller press (screw press):** a mechanical device that applies continuous pressure to oilseeds or palm kernels to express oil from the solid matrix; used for small and medium scale groundnut and palm kernel oil extraction.

- **Fermentation (in cassava processing):** the natural breakdown of cassava cell contents by lactic acid bacteria and yeasts during pressing and soaking, reducing hydrogen cyanide content and developing the characteristic flavour of garri and fufu.
- **Free fatty acid (FFA) content:** a measure of the degree of oil breakdown in crude palm oil; rises when fruit is delayed before processing; good quality palm oil has FFA below 5 per cent.
- **Fufu:** a traditional Nigerian cassava food produced by soaking whole peeled roots in water for two to five days, mashing the fermented flesh into a smooth paste, and cooking for consumption as a staple accompaniment to soups.
- **Garification:** the frying step in garri production in which sieved fermented cassava mash is continuously stirred on a heated iron pan or drum until dry, granular, and toasted to the desired colour and texture.
- **Garri:** a dry, granular, shelf-stable cassava product produced by grating, fermenting, pressing, sieving, and frying (garification) fresh cassava; the most widely consumed cassava product in Nigeria.
- **Groundnut cake:** the solid protein-rich residue (45 to 48 per cent crude protein) remaining after oil has been extracted from groundnut kernels by pressing; a major livestock feed ingredient.
- **HQCF (high-quality cassava flour):** a fine flour produced from fresh cassava by peeling, grating, pressing, controlled drying, and milling; can substitute wheat flour at up to 20 per cent inclusion in bread and confectionery.
- **Hydrogen cyanide (HCN):** the toxic gas released from cyanogenic glucosides when cassava cells are ruptured; the WHO safe limit in cassava products is 10 mg HCN equivalent per kg.
- **Ogi (akamu/pap):** a thin fermented maize porridge produced by soaking, wet-grinding, fermenting, sieving, and cooking maize; widely consumed as a breakfast food and weaning food in Nigeria.
- **Palm kernel cake (PKC):** the solid residue remaining after oil extraction from palm kernels; contains 16 to 18 per cent crude protein and is used as a livestock feed ingredient.
- **Palm kernel oil (PKO):** the oil extracted from the inner seed (kernel) of the oil palm fruit; high in saturated fats, solid at room temperature, used in food, soap, and industrial applications.

- **Process evaluation:** assessment of how farm operations are conducted, including correct procedure, appropriate tool use, timing, student competence, and ethical behaviour during practical farm work sessions.
- **Product evaluation:** assessment of the quality and quantity of what is produced during practical farm work, including crop yields, processed product quality, herbarium and insect collection quality, and animal production outcomes.
- **Sterilisation (palm oil processing):** the first major processing step after harvest, in which fresh fruit bunches are boiled or steamed to deactivate lipase enzymes that would otherwise raise the free fatty acid content of the oil.
- **Sweet cassava:** a cassava variety with inherently low cyanogenic glucoside content; can be processed with shorter fermentation times than bitter cassava varieties without exceeding safe HCN limits.

Concept Check Questions [Series 5]

Objective Questions

1. Good quality crude palm oil has a free fatty acid (FFA) content below ________ per cent. (Linked to SLO 5.1)
2. The solid residue after palm kernel oil extraction is called palm kernel ________. (Linked to SLO 5.2)
3. The fermentation step in garri production reduces the content of ________ cyanide in the cassava mash. (Linked to SLO 5.3)
4. Maize grain must be dried to below ________ per cent moisture before milling to prevent aflatoxin contamination. (Linked to SLO 5.6)
5. The farm ________ is a daily record of all practical activities that serves as both a learning and assessment document. (Linked to SLO 5.9)

Short-Answer Questions

1. Explain why sterilisation is the first step in palm oil extraction and what happens if it is omitted. (Linked to SLO 5.1)
2. Describe the role of fermentation in garri production and explain the consequence of insufficient fermentation of bitter cassava varieties. (Linked to SLO 5.3)
3. Distinguish between high-quality cassava flour (HQCF) and garri in terms of production process and end use. (Linked to SLO 5.4)
4. Explain the difference between process evaluation and product evaluation in practical farm work assessment. (Linked to SLO 5.8)
5. Explain what identifying an entrepreneurial opportunity from farm practical experience means and give one example. (Linked to SLO 5.9)

Long-Answer Questions

1. Analyse the processing of palm products, explaining the steps in traditional palm oil extraction, the production of palm kernel oil and cake, and the quality parameters used to assess crude palm oil and palm kernels. (Linked to SLOs 5.1, 5.2)
2. Discuss the processing of cassava into garri and other products, explaining the garri production steps with their quality control implications, the production of fufu, cassava

starch, and HQCF, and the food safety standards applicable to cassava products. (Linked to SLOs 5.3, 5.4, 5.5)

3. Evaluate the farm output evaluation framework for this course, explaining the principles of evaluation, the methods of process and product assessment, the role of the farm diary and output report, and how entrepreneurial thinking can be developed from practical farm work experience. (Linked to SLOs 5.7, 5.8, 5.9)

Answers to Concept Check Questions [Series 5]

Objective Questions

1. 5.
2. Cake (PKC).
3. Hydrogen.
4. 13.
5. Diary.

Short-Answer Questions

1. Sterilisation deactivates lipase enzymes naturally present in the oil palm fruit mesocarp; if omitted, these enzymes rapidly break down the neutral oil into free fatty acids as soon as the fruit cells are ruptured during processing, producing high-FFA oil that is downgraded in quality and market price; sterilisation also loosens the fruit from the bunch and softens the mesocarp, making subsequent mashing and oil release more efficient.
2. Fermentation during the pressing and bagging stage of garri production allows naturally occurring lactic acid bacteria and yeasts to break down cyanogenic glucosides in the cassava mash, releasing HCN as a gas that escapes the bag while water is pressed out; insufficient fermentation of bitter cassava varieties (typically less than 24 hours) leaves residual HCN above the WHO safe limit of 10 mg/kg, which can cause chronic cyanide poisoning in consumers who eat the garri regularly.
3. HQCF is produced by peeling, grating, pressing to remove water, controlled low-temperature drying, and dry milling to a fine flour; it retains low HCN because no prolonged fermentation is used; end use is as a wheat flour substitute (up to 20 per cent) in bread, biscuits, and

confectionery. Garri is produced by grating, fermenting (24 to 72 hours), pressing, sieving, and frying on a hot iron pan; it is a dry granular product consumed by adding hot or cold water and eaten as a meal with soup, soaked in cold water, or used as a snack.

4. Process evaluation assesses how operations are conducted by observing student performance during practical sessions and reviewing farm diary entries; it covers correct procedure, tool use, timing, safety, and ethical behaviour. Product evaluation assesses what was produced by examining the quality and quantity of harvested crops, processed products (garri colour and texture, palm oil FFA, groundnut oil clarity), and collections (herbarium, insect collection); both forms of evidence are required for a complete competency assessment.
5. Identifying an entrepreneurial opportunity means using the knowledge gained from practical farm experience to define a specific product or service with a real market, estimate the production costs and revenues, and explain why the enterprise is economically viable. Example: a student who has practised garri production identifies that yellow garri in 1 kg sealed bags commands a premium price of twice the farm-gate bulk price in urban supermarkets; the business opportunity is small-scale commercial garri production with hygienic packaging and labelling targeted at urban consumers.

Long-Answer Questions

1. Basic response: Palm oil extraction steps: harvest and fruit detachment, sterilisation (boiling), mashing, kneading with hot water, decanting and clarifying; improved methods use mechanical digesters and presses achieving 80 to 90 per cent efficiency versus 50 to 60 per cent traditional. Palm kernel processing: nut separation, drying, cracking, kernel-shell separation, pressing yielding PKO (48 to 50 per cent oil) and PKC (16 to 18 per cent CP). Quality parameters: FFA below 5 per cent, clear red-orange colour, low moisture and impurities for CPO; moisture below 7 per cent, high kernel purity for palm kernels.
2. Value-added response: The quality of palm oil produced at village level in Nigeria is systematically lower than it could be because of delays in processing fresh fruit bunches, which raise FFA, and inadequate clarification, which increases moisture and impurities. Teaching students to diagnose FFA problems from colour and odour and to trace them back to the length of the delay between harvest and sterilisation builds the diagnostic habits that transform them from processors who follow recipes into food scientists who understand the chemistry behind the process. This understanding is the foundation for quality improvement and premium market access.

3. Basic response: Garri steps: washing, peeling, grating, bagging and pressing (24 to 72 hours fermentation), sieving, frying; yellow garri adds palm oil during frying. Quality control: fermentation duration (key HCN reduction variable), FFA below 5 per cent, moisture below 12 per cent, uniform toasting colour. Fufu: soaking whole peeled roots 2 to 5 days, mashing, cooking. Starch: grating, water washing, settling, drying. HQCF: peeling, grating, pressing, low-temperature drying, milling; substitutes wheat at 20 per cent. Food safety: HCN WHO limit 10 mg/kg, moisture below 12 per cent, NIS compliance.
4. Value-added response: The diversity of cassava products reflects cassava's extraordinary versatility as a raw material: the same root can be fermented to produce sour fufu, fried to produce savoury garri, or carefully dried and milled to produce a neutral HQCF that is almost indistinguishable from wheat flour in baked goods. For agriculture students, understanding these diverse processing pathways and their food safety implications enables them to advise farmers and processors on product diversification strategies that spread market risk and extract maximum value from the cassava harvest.
5. Basic response: Evaluation principles: completeness, accuracy, honesty, relevance. Process evaluation: instructor observation during practicals, farm diary review, rubric-based scoring of procedure, tool use, safety, ethics. Product evaluation: quality assessment of crops, processed products, collections, and animal outputs against specified standards. Farm diary: daily activity records (date, work, inputs, observations, problems, actions). Output report: course summary, results analysis, reflection on learning, entrepreneurial opportunity identification with business case.
6. Value-added response: The most powerful learning from practical farm work occurs not during the activity itself but during the reflection that follows: writing up the farm diary entry that same evening forces the student to recall what was done, why it was done, and what the outcome was. This deliberate reflective practice, when sustained throughout the course, builds the metacognitive habit of learning from experience that distinguishes an adaptable agricultural professional from a technician who can only perform procedures that have been explicitly taught. The farm diary and output report are therefore not administrative compliance tasks but the primary mechanism through which the practical experience of AGE 102 is converted into lasting professional competence.

Answers to Pilot Questions [Series 5]

Part 5.1: Processing of Palm Products

1. Harvest and fruit detachment; sterilisation (boiling or steaming fresh fruit bunches); stripping individual fruits from bunch; pounding or mashing to loosen mesocarp; kneading with hot water to separate oil from fibre; decanting and clarifying by boiling and skimming.
2. Sterilisation deactivates the lipase enzymes present in the fruit mesocarp that rapidly hydrolyse neutral oil to free fatty acids when fruit cells are ruptured; without sterilisation, the oil produced has very high FFA content and is of poor quality; sterilisation also softens the mesocarp and loosens the fruit from the bunch, improving mashing efficiency and oil yield.
3. Separate the palm kernel nut from the fibre after mesocarp oil extraction; dry the nuts; crack the hard shell manually (with a stone) or mechanically (with a nut cracker) to release the white kernel; separate kernels from shell fragments by winnowing or water flotation; press the cleaned kernels in a screw press or hand press to express palm kernel oil; collect the expelled oil and allow to settle; the solid residue is palm kernel cake.
4. Palm kernel oil (PKO) uses: cooking fat, margarine and shortening, confectionery coatings, soap and detergent manufacture. Palm kernel cake (PKC) uses: livestock feed ingredient (poultry, pig, fish diets), compounded animal feed component.
5. Free fatty acid content is the measure of the proportion of oil that has been broken down from neutral triglycerides to free fatty acids by lipase enzymes or oxidation; it is the most important quality parameter because high FFA indicates rancid, degraded oil with shorter shelf life, lower nutritional value, and inferior cooking properties; oil with FFA above 5 per cent is downgraded and commands a significantly lower market price.

Part 5.2: Processing of Cassava Products

1. Washing (removing soil and debris); peeling (removing outer brown skin); grating (reducing peeled roots to wet mash); bagging and pressing (loading mash into bags under heavy weights to express water and initiate fermentation, 24 to 72 hours); sieving (breaking up pressed mash into granules); frying/garification (stirring sieved mash on heated iron pan until dry and toasted); packaging and storage.
2. Fermentation by naturally occurring lactic acid bacteria and yeasts during pressing reduces hydrogen cyanide content by breaking down cyanogenic glucosides and allowing HCN gas to escape; insufficient fermentation of bitter cassava varieties (below 24 hours) leaves HCN above the WHO safe limit of 10 mg/kg, which can cause acute or chronic cyanide poisoning in regular consumers; sweet (low-HCN) varieties can be processed with shorter fermentation without exceeding safe limits.

3. Peel fresh cassava roots; grate to a wet mash; place mash in a cloth or bag and wash in successive changes of water, rubbing the mash to release starch granules into the wash water; allow the starch-rich wash water to settle in a settling tank or bucket for several hours; decant the clear water from the top; remove the settled wet starch from the bottom; sun-dry or oven-dry the wet starch to below 14 per cent moisture content; package in sealed containers.
4. HQCF is a fine flour produced from fresh cassava by peeling, grating, pressing to remove excess water, controlled low-temperature drying, and milling; it retains low HCN because no prolonged fermentation is used and can substitute wheat flour in baked products at up to 20 per cent. Garri production uses prolonged fermentation (24 to 72 hours) and high-temperature frying (garification) that are absent from HQCF production; garri is a granular product consumed as a cooked starchy meal, while HQCF is a fine flour for baking.
5. WHO safe limit for HCN in cassava products: 10 mg HCN equivalent per kilogram of product. Two processing steps that reduce HCN: fermentation (allows microbial breakdown of cyanogenic glucosides and escape of HCN gas during pressing); frying/garification (heat drives off residual HCN as gas during the frying step of garri production).

Part 5.3: Processing of Other Crop Products

1. Corn flour (porridge, tuwo, composite bread); maize grits (brewing, breakfast cereal); maize bran (animal feed); maize germ oil (cooking oil from wet milling); ogi/akamu (fermented porridge weaning food); popcorn (snack).
2. Shell the groundnut pods; clean and grade kernels; roast at 120 to 140 degrees Celsius to reduce moisture and improve oil release; feed roasted kernels into a mechanical screw press (expeller press); collect the expressed oil; allow to settle and decant from sediment; filter through a clean cloth for clarity; store in sealed containers away from light and heat; the solid residue is groundnut cake.
3. Groundnut cake contains 45 to 48 per cent crude protein; it is one of the most important and widely used protein supplements in compounding livestock feeds in Nigeria for poultry (layers and broilers), pigs, and fish, because it supplies high-quality protein at a cost lower than most alternative plant protein sources and is widely available as a co-product of edible oil production.
4. Raw vegetables contain active enzymes (peroxidase, polyphenol oxidase) that continue to break down pigments, vitamins, and cell walls during drying, causing discolouration, loss of flavour, and nutritional degradation; blanching in boiling water for one to three minutes denatures these enzymes before drying, stopping degradative reactions; the result is a dried

vegetable that retains its natural colour, better flavour, and higher vitamin content compared with unblanched sun-dried product.

5. Any two: cassava peels and fibre composted with other organic waste to produce organic fertiliser for crop production; groundnut shells composted or used as mulch; palm fruit fibre used as boiler fuel for steam generation in processing mills or composted; processing waste water from cassava starch production used to irrigate vegetable crops; palm kernel shells used as biomass fuel or mixed with concrete for construction.

Part 5.4: Farm Output Evaluation and Course Assessment

1. Any three: completeness — all aspects of the farm operation including failures and losses must be documented, not only successes, because a partial record is misleading and prevents accurate performance assessment; accuracy — records and measurements must be precise and verifiable so that performance indicators (yield, FCR, hen-day production) are calculated correctly; honesty — failures and losses must be reported candidly because understanding and learning from failure is as important to professional development as recording success; relevance — evaluation must focus on outcomes most important to the course learning objectives rather than peripheral details.
2. Process evaluation assesses how farm operations were conducted (correct procedure, appropriate tool use, safety, timing, ethical behaviour) by instructor observation during practical sessions and review of farm diary entries. Product evaluation assesses what was produced (crop yields, processed product quality against specified standards, herbarium and insect collection completeness, animal production outcomes) against measurable benchmarks; both are required for a complete and fair competency assessment.
3. Any five: date and time of the activity; description of the work done; area of land or number of animals involved; inputs used (quantities and types, costs where known); observations made (crop growth stage, animal health, weather conditions, water quality); problems encountered during the activity; actions taken to address problems; results or outcomes observed.
4. The farm output report is a structured document summarising the student's practical farm work experience across all five Series of the course; it includes: an introduction identifying the farm location and period of work; a summary table of all activities carried out (land prepared, crops planted, areas, dates, yields); analysis of results against targets and standards for each activity; honest reflection on what was learnt and what would be done differently in

future; and identification of an entrepreneurial opportunity based on the processing or production skills experienced during the course, with a basic feasibility argument.

5. Identifying an entrepreneurial opportunity means using practical experience to define a specific product or service, assess its market, and estimate its financial viability. Example: a student who has practised small-scale garri production identifies that hygienically processed and correctly labelled yellow garri in 1 kg sealed polythene bags commands a price of two to three times the bulk market price in urban supermarkets and online food platforms; the opportunity is to organise a cooperative of female processors, standardise the recipe and packaging, and supply directly to urban retailers, eliminating the middleman margin and capturing the quality premium.

References and Attributions [Series 5]

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