La-Net

# AGE 208

## FARM TOOLS AND EQUIPMENT

**Course code: AGE 208**

**Course title: Farm Tools and Equipment**

**Course credit load: 2 Units**

# Series 1: Identification and Classification of Farm Tools

- ## Part 1.1: Introduction to Farm Tools
  - Sub Part 1.1.1: Definition and importance of farm tools
  - Sub Part 1.1.2: Differences between tools and equipment
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## Introduction

Farm tools are the basic implements that enable agricultural operations to be carried out efficiently and safely. Without appropriate tools, even fertile land and good crop varieties cannot be exploited to their full potential. For students of agriculture, identifying tools correctly and knowing their specific uses and care requirements are foundational practical competencies that underpin all subsequent work on the school farm and in the wider agricultural sector.

This Series introduces the definition and classification of farm tools, the materials from which they are made, the major categories of hand tools used in garden preparation, planting, cultivation, harvesting, and animal production, and the safety, storage, and maintenance practices that keep tools in serviceable condition. We begin with the definition and distinction between tools and equipment, cover the main tool categories, and conclude with safety and maintenance.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define farm tools and explain their importance to agricultural production (Linked to Part 1.1),
- **SLO 1.2** distinguish between farm tools and farm equipment (Linked to Part 1.1),
- **SLO 1.3** identify the materials used in making farm tools and state the properties each material contributes (Linked to Part 1.1),
- **SLO 1.4** identify and describe the hand tools used in soil preparation and state the correct use of each (Linked to Part 1.2),
- **SLO 1.5** identify and describe the hand tools used in planting and cultivation (Linked to Part 1.2),
- **SLO 1.6** describe the routine care and maintenance of garden tools (Linked to Part 1.2),
- **SLO 1.7** identify and describe the hand tools used in crop harvesting and post-harvest handling (Linked to Part 1.3),
- **SLO 1.8** identify the tools used in animal production (Linked to Part 1.3), and
- **SLO 1.9** apply safety rules for tool use and describe how farm tools are stored and maintained (Linked to Part 1.4).

## 1.1 Introduction to Farm Tools

### 1.1.1 Definition and importance of farm tools

A farm tool is a simple, hand-held implement used directly by the farmer to carry out a specific agricultural operation. Tools are operated by hand or human muscle power and do not require an external power source such as an engine or motor. Examples include the hoe, cutlass, rake, shovel, and hand trowel. Farm tools are important because they reduce the time and effort required for agricultural operations, enable precision in tasks such as planting and weeding, extend the productive capacity of the individual farmer, and are affordable for smallholder farmers in Nigeria who cannot access mechanised equipment.

The majority of Nigerian smallholder farmers depend entirely on hand tools for crop production, land preparation, weeding, harvesting, and post-harvest handling. Understanding the correct tool for each operation, how to use it efficiently, and how to maintain it in working condition are therefore among the most practically important competencies for any agriculture student. Tools that are used incorrectly are inefficient, cause injury, and are damaged more rapidly than tools used for their intended purpose.

Fill in the blank: A farm ________ is a simple hand-held implement operated by human muscle power, used to carry out a specific agricultural operation without the need for an external power source.

### 1.1.2 Differences between tools and equipment

Farm equipment refers to more complex implements and machines that may be animal-drawn or engine-powered and that typically perform multiple functions or cover larger areas than hand tools. A plough drawn by an ox or tractor is equipment; a hoe is a tool. Equipment generally has more moving parts, requires more technical knowledge to operate and maintain, and costs more than a hand tool. The distinction matters because tools and equipment have different maintenance requirements, safety considerations, and appropriate scales of use.

In practice, the boundary between tool and equipment is not always sharp. A knapsack sprayer is sometimes classified as equipment because it has mechanical parts (the pump, nozzle, and lance) even though it is carried and operated by hand. For this course, the term tool refers to simple, non-powered hand implements (hoes, cutlasses, rakes, shovels) and the term equipment refers to more complex, often powered or animal-drawn implements (sprayers, threshers, cultivators, irrigation pumps) covered in later Series.

Fill in the blank: Farm **________** refers to more complex implements that may be animal-drawn or engine-powered, perform multiple functions, and require more technical knowledge to operate and maintain than simple hand tools.

| Category | Farm Tools | Farm Equipment |
|---|---|---|
| **Power Source** | Manual, human effort | Mechanical, powered by engines, electricity, or animals |
| **Complexity** | Simple design, easy to use | Complex machinery with multiple parts and systems |
| **Cost** | Low cost, affordable for small-scale farmers | High cost, significant investment required |
| **Maintenance** | Minimal, occasional sharpening or cleaning | Regular servicing, repairs, and spare parts needed |
| **Examples** | Hoe, cutlass, rake, sickle | Tractor, plough, harvester, irrigation pump |

Table 1.1: Comparison of farm tools and farm equipment

### 1.1.3 Materials used in making farm tools

Farm tools are made from a combination of materials chosen for their strength, durability, and suitability for the intended function. The working parts of most tools (blades, tines, and cutting edges) are made from steel or iron because these metals are strong, can be sharpened to a cutting edge, and resist deformation under load. Stainless steel is used for tools in wet environments (aquaculture, irrigation) because it resists rust. Cast iron is harder and more brittle than wrought iron and is used for heavier components such as plough shares.

Handles are made from hardwood (iroko, mahogany, or bamboo in Nigeria) for strength, lightness, and a comfortable grip, or from fibre-reinforced polymers (plastic) in modern tools. Rubber or plastic grips are added for comfort and to reduce vibration. Aluminium is used for lightweight tools such as small hand forks and seedling trays. Understanding the material composition of a tool helps the farmer choose the right tool for the job, identify when a component has failed due to material fatigue, and select an appropriate replacement or repair method.

Fill in the blank: The working parts of most farm tools such as blades and cutting edges are made from ________ because it is strong, can be sharpened, and resists deformation under load.

*Pilot questions 1.1*

1. Define a farm tool and state three reasons why farm tools are important in Nigerian smallholder agriculture.
2. Explain the difference between a farm tool and farm equipment and give one example of each.
3. State three materials used in making farm tools and explain why each material is used.
4. Explain why using a tool for a purpose other than its intended use is problematic.
5. Give two examples of implements that are difficult to classify strictly as either tool or equipment and explain why.

## 1.2 Garden and Soil Working Tools

### 1.2.1 Hand tools for soil preparation

Soil preparation tools loosen, break up, and shape the soil for planting. The hoe is the most widely used soil preparation tool in Nigeria; it has a flat steel blade attached at an angle to a wooden handle and is used for digging, breaking clods, mounding, and ridging. The spade has a flat rectangular blade used for digging, cutting, and lifting soil, while the fork (garden fork or digging fork) has four or five steel tines used to break up and aerate compacted soil. The shovel has a concave blade suitable for scooping and moving loose soil or compost.

The mattock has a heavy head with an adze blade on one side for chopping roots and compacted soil and a pick on the other for breaking hard ground; it is particularly useful for rocky or hard-clay soils. The cutlass (machete) is used for clearing vegetation, cutting stems, and slashing weeds before soil preparation. The crowbar (iron bar) is used to make planting holes in hard soil and to lever out stumps and large stones. Each of these tools should be selected based on the soil condition, the scale of operation, and the specific task to be performed.

Fill in the blank: The ________ is the most widely used soil preparation tool in Nigeria and is used for digging, breaking clods, mounding, and ridging.


Figure 1.1: Diagram showing common soil preparation hand tools

### 1.2.2 Hand tools for planting and cultivation

Planting and cultivation tools are used to open the soil for seed or seedling placement, to apply fertiliser or compost, and to control weeds. The hand trowel is a small scoop-shaped tool used for transplanting seedlings, digging small planting holes, and applying compost around individual plants. The dibber (dibble) is a pointed stick or metal tool used to make holes at precise depths and spacings for seed placement or seedling transplanting. The seed drill line (spacing cord) is used to mark straight planting rows at the correct inter-row spacing.

The hand weeder (weeding hoe or cultivator) has a small blade or set of tines designed to cut weeds at or just below soil level without deeply disturbing the soil around crop plants. The hand fork (three-tined fork) is used for loosening soil around established plants and for lifting root vegetables at harvest. The watering can and hand-pump sprayer are used in the garden and nursery for irrigation and pesticide application. Each tool must be cleaned after use and stored in a dry place to prevent rust and handle rot.

Fill in the blank: The ________ is a pointed stick or metal tool used to make holes at precise depths and spacings for seed placement or seedling transplanting.

### 1.2.3 Care and maintenance of garden tools

Proper care of garden tools after each use extends their working life and maintains their effectiveness. After use, all soil and plant material should be cleaned from tool surfaces; metal parts are wiped dry to prevent rust. Cutting edges (hoe blades, spades, cutlasses) should be sharpened regularly using a file or whetstone; a sharp edge requires less effort, reduces operator fatigue, and produces cleaner cuts that heal faster in plants. Wooden handles should be inspected for cracks and splinters; a cracked handle should be replaced before it fails during use and causes injury.

Metal parts showing early rust should be rubbed with steel wool and lightly oiled with waste engine oil or vegetable oil to protect the surface. Loose tool heads should be re-fixed before use; a loose hoe or mattock head that flies off during use is a serious safety hazard. Tools should be stored in a dry, covered tool shed or store, hung on wall hooks or placed in a rack rather than leaned against walls where they can fall and injure passers-by. A simple tool inventory and check-out register maintained in the school farm tool store prevents loss and ensures accountability.

Fill in the blank: Cutting edges of hoe blades and cutlasses should be sharpened using a file or ________ to maintain efficiency and reduce operator fatigue during farm operations.

*Pilot questions 1.2*

1. Name and describe the function of four tools used for soil preparation.
2. Explain what a mattock is and when it is most appropriate to use it.
3. Describe the correct use of a dibber in seedling transplanting.
4. State four routine maintenance actions that should be performed on garden tools after use.
5. Explain why a loose tool head is a safety hazard and how it should be corrected.

## 1.3 Harvesting and Processing Tools

### 1.3.1 Tools used in crop harvesting

Harvesting tools are used to cut, pull, or dig crops at maturity. The sickle is a short-handled tool with a curved serrated blade used for cutting cereal crops (rice, sorghum, wheat) at the stem; it allows the operator to harvest while stooped or kneeling close to the ground. The reaping hook is similar to the sickle but with a smoother blade, used for cutting grass and small-diameter stems. The cutlass is used for harvesting maize, cassava stems, plantain bunches, and clearing harvested plots. Pruning shears (secateurs) are spring-loaded cutting tools used for harvesting vegetables, fruits, and small branches at precise points.

The yam hook (vine cutter) is used to cut the yam vine from the tuber at harvest without damaging the tuber itself. The harvesting knife is a short, stiff knife used for cutting pineapples, cabbages, tomato clusters, and other produce. The pick (or digging bar) is used to break hard soil around root tubers (yam, cassava) before lifting. Baskets, plastic crates, and harvesting bags are not tools in the strict sense but are essential harvesting accessories for collecting and transporting produce from the field to the processing or storage area.

Fill in the blank: The ________ is a short-handled tool with a curved serrated blade used for cutting cereal crops such as rice and sorghum at the stem during harvesting.


Figure 1.2: Diagram of harvesting tools used for different crops

### 1.3.2 Tools used in post-harvest handling

Post-harvest handling tools are used to prepare produce for storage, processing, or market after harvesting. The threshing mat or threshing board is used to thresh cereal crops (rice, sorghum, millet) by beating the harvested plants against the board to separate grain from straw. The winnowing basket is a flat or concave woven basket used to winnow grain by tossing it in the air so that the wind separates the chaff from the heavier grain. Sieves and screens of different mesh sizes are used to grade grain and remove large foreign material.

The root crop peeling knife and cassava grater (hand-operated metal scraper) are used in cassava processing for garri production; the mortar and pestle are used for pounding yam, spices, and dried products. Measuring tools (weighing scales, measuring cups, grain moisture meters) are used in post-harvest assessment of produce quantity and quality. Proper care of post-harvest tools (washing, drying, and correct storage) prevents contamination of food products and extends tool life.

Fill in the blank: The ________ basket is a flat or concave woven basket used to separate chaff from grain by tossing the mixture in the air so that wind carries the lighter chaff away.

### 1.3.3 Animal production tools

Tools used in animal production include: the drenching gun (a syringe-like device for administering liquid medicine or dewormer orally to livestock), the dosing syringe (for injecting vaccines or drugs subcutaneously or intramuscularly), the hypodermic needle and syringe set, the trocar and cannula (for relieving bloat in cattle and small ruminants by puncturing the rumen), and the castration knife and burdizzo clamp (for surgical or bloodless castration of male livestock). Ear-tagging pliers and ear tags are used for permanent individual animal identification.

Poultry tools include the debeaking blade (for beak trimming in layer hens to reduce cannibalism), the poultry catcher hook (for catching and restraining individual birds), and egg candling lamps (for checking embryo development in fertilised eggs during incubation). Milking equipment includes the milking bucket and teat dip cup (used with teat dip solution to disinfect teats before and after milking). All animal production tools that contact animal tissue must be sterilised before and after use to prevent transmission of disease between animals.

Fill in the blank: The ________ and cannula is used in cattle and small ruminant management to relieve life-threatening bloat by puncturing the rumen and releasing trapped gas.

| Tool | Species | Function |
|---|---|---|
| **Milking machine** | Dairy cattle, goats | Extracts milk efficiently and hygienically |
| **Shearing clippers** | Sheep | Removes wool for textile production |
| **Hoof trimmer** | Cattle, goats, horses | Maintains hoof health, prevents lameness |
| **Artificial insemination kit** | Cattle, pigs | Facilitates controlled breeding and genetic improvement |
| **Incubator** | Poultry | Provides controlled environment for hatching eggs |

| | | |
|---|---|---|
| **Water trough** | All livestock | Supplies clean drinking water |
| **Feed mixer** | Cattle, poultry, pigs | Blends feed ingredients for balanced nutrition |
| **Ear tag applicator** | Cattle, sheep, goats | Identifies animals for record-keeping and management |
| **Castration tool (elastrator, scalpel)** | Cattle, goats, pigs | Used for reproductive control and management |
| **Vaccination syringe** | All livestock | Administers vaccines and medications |

Table 1.2: Common animal production tools with their uses

*Pilot questions 1.3*

1. Distinguish between a sickle and a reaping hook and state the crops each is best suited for.
2. Name three post-harvest tools and state the specific operation each performs.
3. Explain the function of the trocar and cannula in cattle production.
4. State two reasons why animal production tools that contact animal tissue must be sterilised.
5. Name two poultry-specific tools and explain the purpose of each.

## 1.4 Safety, Storage, and Maintenance of Farm Tools

### 1.4.1 Safety rules for using farm tools

Farm tools cause serious injuries when used incorrectly. The most important safety rules are: always carry cutting tools (cutlass, sickle, harvesting knife) with the blade pointing downward or in a sheath; never swing a cutting tool when another person is within striking distance; always wear protective footwear when using spades, forks, and heavy hoes to protect against dropped tools; use gloves when handling sharp tools or rough handles to prevent cuts and blisters; and inspect every tool for loose heads, cracked handles, or bent tines before use and remove defective tools from service immediately.

During group farm work (as on the school farm), students must maintain a safe working distance of at least two arm-lengths from each other when using long-handled tools to prevent accidental strikes. When a farm session ends, all tools must be accounted for, cleaned, and returned to the tool store; no tool should be left in the field where it can be stepped on or picked up by an unsupervised person. The teacher or farm captain should conduct a tool count at the end of every session and record any missing, broken, or damaged tools.

Fill in the blank: Students must maintain a safe working distance of at least two ________ lengths from each other when using long-handled tools during group farm work.

| Safety Rule | Guideline |
|---|---|
| **Wear protective gear** | Always use gloves, boots, and goggles to prevent injuries. |
| **Inspect tools before use** | Check for cracks, rust, or loose parts to avoid accidents. |
| **Use tools correctly** | Follow proper handling techniques; never misuse tools. |
| **Keep tools clean** | Wash and dry after use to prevent rust and contamination. |
| **Store tools safely** | Place tools in designated storage areas, away from children. |
| **Work under supervision** | Students should only use tools when supervised by a teacher. |
| **Avoid horseplay** | Never run or play with tools to prevent harm. |
| **Report damaged tools** | Inform the teacher immediately if a tool is broken. |

Box 1.1: Key safety rules for farm tool use on the school farm

### 1.4.2 Storage of farm tools

Proper storage preserves tools and prevents accidents. Tools should be stored in a dedicated, locked tool store or shed with adequate space to hang or rack each tool individually. Long-handled tools (hoes, forks, rakes, spades) should be hung vertically on wall hooks with the working end upward, or placed in a floor rack with the handles upward; this prevents handles from rotting on damp floors and keeps blades safely elevated. Cutting tools should never be left loose in a box where the hand must reach in blindly and risk contacting a blade.

Before storage, all tools must be cleaned of soil and plant material, metal surfaces lightly oiled, and wooden handles inspected. A tool inventory card listing each tool's name, condition, and assigned location should be posted in the tool store and updated each time tools are issued or returned. The school farm tool register records which student or group received which tools on a given date, ensuring accountability and allowing damaged or lost tools to be traced. Padlocking the tool store prevents theft and unauthorised access outside supervised hours.

Fill in the blank: Long-handled tools should be hung vertically on wall ________ or placed in a floor rack to prevent handle rot on damp floors and keep blades safely elevated.

### 1.4.3 Routine maintenance of farm tools

Routine maintenance extends tool life and maintains performance. A simple maintenance schedule should specify: daily (clean soil from all tools, wipe metal dry, hang or rack tools); weekly (sharpen cutting edges, check and tighten all tool heads, inspect handles for cracks, oil metal surfaces); and termly (replace cracked handles, repaint tool handles with identifying school colours, inventory all tools against the register and reconcile discrepancies). The schedule should be posted in the tool store and adhered to consistently.

Sharpening is the most frequently neglected maintenance task. A hoe blade sharpened to a thin edge cuts soil with far less effort than a blunt one; a blunt cutlass bruises rather than cuts plant tissue, leaving ragged wounds that are slow to heal and vulnerable to disease. The file is moved across the blade at a consistent angle (approximately 30 degrees) to restore the bevel; the opposite face is then de-burred with a whetstone. Students should practise sharpening tools under supervision as part of the manipulative skills programme. Correct sharpening is a demonstrable competency.

Fill in the blank: A hoe blade sharpened to a thin edge cuts soil with far less effort than a ________ one; the file is moved across the blade at approximately 30 degrees to restore the cutting bevel.

*Pilot questions 1.4*

1. State five safety rules for using farm tools on the school farm.
2. Explain why long-handled tools should not be stored lying flat on the floor of the tool store.
3. Describe a daily, weekly, and termly tool maintenance schedule.
4. Explain the correct procedure for sharpening a hoe blade.
5. Explain why a tool inventory register is important in the school farm tool store.

## Series Summary

This Series introduced the identification and classification of farm tools. We defined farm tools, distinguished them from farm equipment, and described the materials (steel, iron, hardwood, aluminium) from which tools are made. We covered the major categories of soil preparation tools (hoe, spade, fork, shovel, mattock, cutlass, crowbar), planting and cultivation tools (hand trowel, dibber, hand weeder, watering can), harvesting tools (sickle, reaping hook, cutlass, pruning shears, harvesting knife), and post-harvest tools (threshing mat, winnowing basket, sieves). We also identified the key animal production tools used in livestock and poultry management.

We concluded with safety rules (safe working distances, protective footwear, pre-use inspection, tool count at session end), storage practices (hanging or racking tools vertically, locking the tool store, maintaining a tool inventory and register), and routine maintenance schedules (daily cleaning, weekly sharpening, termly handle replacement and inventory). By completing this Series, you should be able to achieve all nine Series Learning Outcomes (SLO 1.1 to SLO 1.9).

## Glossary of Terms

- **Burdizzo clamp:** a bloodless castration instrument that crushes the spermatic cord of male livestock without breaking the skin, rendering them infertile.
- **Crowbar:** a heavy iron bar used to lever out stumps, large stones, and hard soil; also used to make planting holes in very hard ground.
- **Cutlass (machete):** a large single-edged blade on a short handle used for vegetation clearing, harvesting maize and plantain, and slashing weeds.
- **Dibber (dibble):** a pointed stick or metal tool used to make holes of consistent depth and spacing for seed placement or seedling transplanting.

- **Drenching gun:** a syringe-like device for administering measured doses of liquid medicine or dewormer orally to livestock.
- **Farm equipment:** more complex implements that may be animal-drawn or engine-powered, with multiple moving parts, used for larger-scale or multi-function agricultural operations.
- **Farm tool:** a simple hand-held implement operated by human muscle power used to carry out a specific agricultural operation.
- **Garden fork (digging fork):** a tool with four or five steel tines used to break up and aerate compacted soil and lift root crops at harvest.
- **Hand trowel:** a small scoop-shaped hand tool used for transplanting seedlings and digging small planting holes.
- **Hoe:** the most widely used farm hand tool in Nigeria; has a flat steel blade at an angle to a wooden handle; used for digging, ridging, mounding, and weeding.
- **Mattock:** a heavy tool with an adze blade on one side and a pick on the other; used for chopping roots and breaking hard or rocky soil.
- **Pruning shears (secateurs):** spring-loaded cutting tools used for harvesting fruits and vegetables and pruning small branches at precise points.
- **Sickle:** a short-handled tool with a curved serrated blade used for harvesting cereal crops by cutting at the stem.
- **Tool inventory register:** a record in the school farm tool store listing each tool's name, condition, location, and to whom it was issued on each date.
- **Trocar and cannula:** a surgical instrument used to puncture the rumen of bloated cattle or small ruminants to release trapped gas.
- **Winnowing basket:** a flat or concave woven basket used to separate grain from chaff by tossing in the air so wind carries the lighter chaff away.

## Concept Check Questions [Series 1]

Objective Questions

1. A farm ________ is a simple hand-held implement operated by human muscle power used for a specific agricultural operation. (Linked to SLO 1.1)
2. The working parts of most farm tools are made from ________ because it is strong, can be sharpened, and resists deformation. (Linked to SLO 1.3)
3. The ________ is the most widely used soil preparation hand tool in Nigeria and is used for digging, ridging, and mounding. (Linked to SLO 1.4)
4. The sickle has a curved ________ blade used for cutting cereal crops at the stem during harvesting. (Linked to SLO 1.7)
5. Students must maintain a safe working distance of at least two ________ lengths from each other when using long-handled tools. (Linked to SLO 1.9)

Short-Answer Questions

6. Distinguish between a farm tool and farm equipment and give two examples of each. (Linked to SLO 1.2)
7. Name and describe four tools used in soil preparation. (Linked to SLO 1.4)
8. State the function of the dibber and explain when it is used in crop production. (Linked to SLO 1.5)
9. Name three animal production tools and state the function of each. (Linked to SLO 1.8)
10. Describe five safety rules for using farm tools on the school farm. (Linked to SLO 1.9)

Long-Answer Questions

11. Describe the classification of farm hand tools, covering the tools used in soil preparation, planting and cultivation, and harvesting, and stating the correct use and appropriate crop or operation for each named tool. (Linked to SLOs 1.4, 1.5, 1.7)

12. Explain the safety rules for farm tool use, the correct storage of tools in a school farm tool store, and the routine maintenance schedule needed to keep tools in serviceable condition. (Linked to SLO 1.9)

## Answers to Concept Check Questions [Series 1]

Objective Questions

1. Tool.
2. Steel.
3. Hoe.
4. Serrated.
5. Arm.

Short-Answer Questions

6. Farm tools are simple, hand-held implements operated by human muscle power (hoe, cutlass). Farm equipment is more complex, often animal-drawn or engine-powered, with multiple moving parts (ox-drawn plough, knapsack sprayer).
7. Hoe: flat steel blade at angle to handle; used for digging, ridging, mounding, weeding. Spade: flat rectangular blade; used for digging and cutting soil. Garden fork: four or five steel tines; used for breaking and aerating compacted soil. Mattock: adze and pick head; used for chopping roots and breaking hard soil.
8. The dibber is a pointed stick or metal tool used to make holes of consistent depth and spacing in the soil. It is used when transplanting seedlings from a nursery to the field, or when placing large seeds (yam, melon) at a precise depth to ensure uniform germination and spacing.
9. Drenching gun: administers measured doses of liquid medicine or dewormer orally to livestock. Trocar and cannula: punctures the rumen of a bloated ruminant to release trapped gas and relieve life-threatening bloat. Burdizzo clamp: crushes the spermatic cord of male livestock for bloodless castration.

10. Carry cutting tools blade-down or in a sheath. Maintain at least two arm-lengths from other workers when using long-handled tools. Wear protective footwear when using spades and heavy hoes. Inspect every tool for loose heads and cracked handles before use. Return all tools to the store and conduct a tool count at the end of every session.

Long-Answer Questions

11. Soil preparation tools: hoe (digging, ridging, mounding, weeding; used for most crops), spade (digging and cutting; soil turning), garden fork (aerating compacted soil; also used to lift root crops at harvest), shovel (scooping and moving loose soil and compost), mattock (chopping roots and breaking hard or rocky soil), cutlass (clearing vegetation before land preparation), crowbar (making holes in hard soil and levering stumps). Planting and cultivation tools: hand trowel (transplanting seedlings; digging small holes), dibber (making precise planting holes for seeds or seedlings), hand weeder (cutting weeds at soil level without disturbing crop roots), watering can (nursery and garden irrigation). Harvesting tools: sickle (cutting cereals at stem; rice, sorghum, millet), reaping hook (cutting grasses and small stems), cutlass (harvesting maize, cassava stems, plantain), pruning shears (harvesting fruits and vegetables at precise points), harvesting knife (cabbages, pineapples, tomato clusters), yam hook (cutting yam vine at harvest without damaging tuber).
12. Safety rules: carry cutting tools blade-down or sheathed; maintain two arm-lengths from other workers; wear protective footwear; wear gloves with sharp tools; inspect tools before use and remove defective tools; conduct a tool count at session end. Storage: store in dedicated, locked shed; hang long-handled tools on wall hooks or in floor rack, working end upward; never leave tools loose in a box; clean and oil tools before storage; maintain tool inventory card and issue register. Maintenance schedule: daily (clean soil from tools, wipe metal dry, hang or rack); weekly (sharpen cutting edges, check and tighten tool heads, inspect and replace cracked handles, oil metal surfaces); termly (replace cracked handles, repaint handles, inventory all tools against register). Sharpening: move file across blade at approximately 30 degrees to restore the bevel; de-burr with whetstone on the opposite face.

## Answers to Pilot Questions [Series 1]

## Part 1.1: Introduction to Farm Tools

1. A farm tool is a simple hand-held implement operated by human muscle power used for a specific agricultural operation. Three reasons: tools reduce the time and effort required for farm operations; they enable precision in tasks such as planting and weeding that cannot be done accurately by hand alone; they are affordable for smallholder farmers who cannot access engine-powered equipment.
2. A farm tool is a simple, non-powered, hand-held implement (hoe, cutlass, sickle). Farm equipment is a more complex implement that may be animal-drawn or engine-powered, with multiple moving parts and a higher cost (ox-drawn plough, knapsack sprayer). Farm equipment generally covers larger areas and performs multiple functions; tools are used for small-scale, precise operations.
3. Any three: steel (used for cutting edges and blades because it is strong, can be sharpened to a fine edge, and resists deformation under load); hardwood (used for handles because it is strong, relatively light, and provides a comfortable grip); aluminium (used for lightweight tools and seedling trays because it is light, does not rust, and is easy to work).
4. Using a tool for a purpose other than its intended use causes inefficiency (the tool is not designed for that task, requiring more effort for less result), damage to the tool (misuse causes bending, breakage, or dulling of the cutting edge faster than normal use), and increased risk of injury (an improvised use of a tool often places the operator in an unsafe position or subjects the tool to unusual forces that cause it to break suddenly).
5. Any two: a knapsack sprayer (hand-carried but has a pump, nozzle, and lance, giving it equipment-level complexity); a hand-pushed wheel hoe (pushed by hand but has a wheel and mechanical tines, making it more complex than a simple hand hoe).

## Part 1.2: Garden and Soil Working Tools

1. Any four: hoe (flat steel blade at angle to wooden handle; used for digging, ridging, mounding, breaking clods, and weeding); spade (flat rectangular blade; used for digging, cutting, and lifting soil); garden fork (four or five steel tines; used for breaking up and aerating compacted soil); shovel (concave blade; used for scooping and moving loose soil or compost); mattock (adze and pick head; used for chopping roots and breaking very hard or rocky soil).

2. A mattock is a heavy tool with an adze blade on one side and a pick on the other. It is most appropriate when working in rocky or very hard clay soils where a standard hoe cannot penetrate effectively; the pick end breaks up the hardpan and the adze blade chops through roots and compacted soil.
3. The dibber is inserted into the soil at the desired depth (marked on the tool or calculated beforehand) at the correct spacing (measured with a garden line or tape), withdrawn, and the seedling is placed root-first into the hole and firmed in. This ensures consistent planting depth and spacing, which are critical for uniform germination and ease of later cultivation.
4. Any four: clean all soil and plant material from tool surfaces after use; wipe metal parts dry to prevent rust; sharpen cutting edges with a file or whetstone; check and tighten all loose tool heads; inspect wooden handles for cracks and replace cracked ones; oil metal surfaces with waste engine oil or vegetable oil.
5. A loose tool head is dangerous because it can fly off the handle during the swing, striking the operator or nearby persons with high-energy impact, causing serious injury. To correct it: drive a wooden or steel wedge further into the kerf of the handle to expand it inside the tool head socket; if the handle is too worn, replace it entirely.

Part 1.3: Harvesting and Processing Tools

1. A sickle has a curved, serrated blade used for cutting cereal crop stems close to the ground; it is best suited for rice, sorghum, wheat, and millet. A reaping hook is similar but has a smoother blade and is used for cutting grass, hay, and small-diameter stems rather than the coarser stems of cereals.
2. Any three: threshing mat or board (used to thresh cereal crops by beating harvested plants against the surface to separate grain from straw); winnowing basket (used to separate grain from chaff by tossing in the air so wind carries the lighter chaff away); sieve or screen (used to grade grain by size and remove large foreign material from harvested grain).
3. When a ruminant animal (cattle or small ruminant) suffers from bloat, gas accumulates rapidly in the rumen and cannot escape; without intervention the animal can die within hours from respiratory failure and circulatory collapse. The trocar is inserted through the abdominal wall into the rumen (in the left paralumbar fossa) and the cannula is left in place to allow the trapped gas to escape continuously until normal eructation resumes.

4. Any two: to prevent transmission of infectious diseases (bacteria, viruses, fungi) from one animal to another through contaminated needles, syringes, or surgical instruments; to prevent post-procedure infection at the injection or incision site that could cause abscess formation, septicaemia, or death of the animal.
5. Any two: debeaking blade (used to trim the sharp tip of the beak of layer hens to reduce feather pecking and cannibalism in the flock); poultry catcher hook (a long wire hook used to catch and restrain individual birds by the leg without chasing them through the pen, reducing stress and injury).

Part 1.4: Safety, Storage, and Maintenance

1. Any five: carry cutting tools (cutlass, sickle, harvesting knife) blade-down or in a sheath; maintain at least two arm-lengths from other workers when using long-handled tools; wear protective footwear when using spades, forks, and heavy hoes; wear gloves when handling sharp tools or rough handles; inspect every tool for loose heads, cracked handles, or bent tines before use and remove defective tools; never leave tools in the field at the end of a session; conduct a tool count at the end of every session.
2. If tools are stored lying flat on a damp floor, the wooden handles absorb moisture, swell, and eventually rot, weakening the handle-head joint and causing the head to become loose; loose heads are a safety hazard during use. In addition, cutting blades in contact with a damp floor rust more rapidly, reducing the service life of the tool.
3. Daily: clean all soil from tools; wipe metal surfaces dry; hang or rack in the tool store. Weekly: sharpen cutting edges with file or whetstone; check and tighten all tool heads; inspect handles for cracks; oil all metal surfaces lightly. Termly: replace all cracked or weakened handles; repaint handles with the school's identifying colour; take a full inventory of all tools against the register and investigate and record any discrepancies.
4. Secure the hoe blade in a vice or on a firm surface. Select a flat metal file appropriate for the blade steel. Hold the file at approximately 30 degrees to the face of the blade bevel. Push the file forward along the blade edge from heel to tip in smooth, consistent strokes, maintaining the 30-degree angle throughout. After several strokes, check the edge with the thumb for sharpness. Turn the blade over and use a whetstone to de-burr the back face (remove the wire edge). Test the sharpness by pressing the blade lightly against the thumbnail; a sharp edge grips rather than slides.

5. The tool inventory register lists every tool by name, quantity, condition, and assigned storage location, and records each time a tool is issued to a student or group and returned. It is important because it ensures accountability (any tool not returned can be identified and traced to the person who had it), allows the condition of each tool to be tracked over time so maintenance needs can be anticipated, supports stock management (knowing when tools need to be replaced), and deters theft or careless handling of school farm property.

## References and Attributions [Series 1]

Textual References (Books and External Sources)


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- Hunt, D. (2001). Farm power and machinery management (10th ed.). Iowa State University Press.
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Figures, Plates, Tables, and Boxes

- Table 1.1: Farm tools vs farm equipment comparison Attribution: AI generated. Suggested OER search string: "farm tools vs equipment comparison table power cost maintenance OER".
- Figure 1.1: Common soil preparation hand tools Attribution: AI generated. Suggested OER search string: "farm soil preparation hand tools hoe spade fork shovel OER diagram".
- Figure 1.2: Harvesting tools diagram Attribution: AI generated. Suggested OER search string: "farm harvesting tools sickle reaping hook cutlass pruning shears OER diagram".
- Table 1.2: Animal production tools and uses Attribution: AI generated. Suggested OER search string: "animal production tools drenching gun trocar burdizzo castration OER table".
- Box 1.1: Safety rules for farm tool use Attribution: AI generated. Suggested OER search string: "farm tool safety rules school farm protective footwear OER box".

**Course code: AGE 208**

**Course title: Farm Tools and Equipment**

# Series 2: Types and Uses of School Farm Equipment

- **Part 2.1: Introduction to Farm Equipment**
  - Sub Part 2.1.1: Definition and classification of farm equipment
  - Sub Part 2.1.2: Importance of farm equipment in school agriculture
  - Sub Part 2.1.3: Selection criteria for school farm equipment
- **Part 2.2: Spraying Equipment**
  - Sub Part 2.2.1: Types of spraying equipment
  - Sub Part 2.2.2: Operation and calibration of the knapsack sprayer
  - Sub Part 2.2.3: Safety and maintenance of spraying equipment
- **Part 2.3: Harvesting Equipment**
  - Sub Part 2.3.1: Types of harvesting equipment
  - Sub Part 2.3.2: Operation and use of harvesting equipment
  - Sub Part 2.3.3: Maintenance of harvesting equipment
- **Part 2.4: Storage Equipment**
  - Sub Part 2.4.1: Types of storage equipment
  - Sub Part 2.4.2: Principles of correct storage
  - Sub Part 2.4.3: Maintenance of storage equipment and structures

## Introduction

Farm equipment extends the capacity of the individual farmer and student beyond what is possible with hand tools alone. On the school farm, spraying equipment, harvesting equipment, and storage equipment are the three categories most commonly encountered and are directly connected to the NERDC curriculum for agricultural science. Knowing how to select, operate, and maintain this equipment is a core practical competency for every student and agriculture teacher.

This Series covers the definition and classification of farm equipment, the importance and selection criteria for school farm equipment, and then addresses spraying, harvesting, and storage equipment in turn. Each section covers types of equipment, correct operation, and maintenance. Safety is emphasised throughout, particularly for chemical application using spraying equipment.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** define farm equipment and describe its classification (Linked to Part 2.1),
- **SLO 2.2** explain the importance of farm equipment in school agriculture and state the criteria for selecting school farm equipment (Linked to Part 2.1),
- **SLO 2.3** identify and describe the types of spraying equipment used on the school farm (Linked to Part 2.2),
- **SLO 2.4** describe the operation and calibration of a knapsack sprayer (Linked to Part 2.2),
- **SLO 2.5** state the safety precautions and maintenance procedures for spraying equipment (Linked to Part 2.2),
- **SLO 2.6** identify and describe the types of harvesting equipment used on the school farm (Linked to Part 2.3),
- **SLO 2.7** describe the operation and maintenance of harvesting equipment (Linked to Part 2.3), and

- **SLO 2.8** identify the types of storage equipment, explain the principles of correct storage, and describe storage equipment maintenance (Linked to Part 2.4).

## 2.1 Introduction to Farm Equipment

### 2.1.1 Definition and classification of farm equipment

Farm equipment comprises the more complex implements used in agricultural production that typically have mechanical parts, may be powered by human effort, animal draught, or an engine, and are designed to cover larger areas or perform multiple steps of an operation more efficiently than simple hand tools. Equipment is classified by power source: hand-operated equipment (knapsack sprayer, hand-operated thresher), animal-drawn equipment (plough, harrow, seed drill), and engine-powered or motorised equipment (tractor-mounted sprayer, combine harvester, powered thresher).

Equipment is also classified by function: tillage equipment (ploughs, ridgers, harrows), planting equipment (seed drills, transplanting machines), crop protection equipment (sprayers), harvesting equipment (reapers, threshers, shellers), and storage equipment (silos, cribs, hermetic bags, drying floors). On the school farm, the focus is on hand-operated and small-scale mechanical equipment that students can operate and maintain within their training environment. Engine-powered equipment is introduced conceptually and is covered more fully in later Series.

Fill in the blank: Farm equipment is classified by power source into hand-operated, animal-drawn, and ________ or motorised categories, and by function into tillage, planting, crop protection, harvesting, and storage equipment.

### 2.1.2 Importance of farm equipment in school agriculture

Farm equipment increases the efficiency, quality, and scale of agricultural operations on the school farm. A knapsack sprayer applies pesticide more uniformly and at a more controlled rate than hand application, reducing both chemical waste and crop damage. A hand thresher separates grain from straw more quickly and with less grain loss than manual threshing on a mat. A properly constructed storage crib reduces post-harvest loss from moisture, pests, and rodents more effectively than open storage. Equipment therefore directly improves both the educational and commercial outcomes of the school farm.

From an educational perspective, students who learn to operate and maintain farm equipment on the school farm develop transferable technical skills that are directly applicable in commercial agriculture and agribusiness employment. The school farm is often the only environment in which many rural students will have supervised, hands-on contact with agricultural equipment before entering the workforce. The agriculture teacher has a responsibility to ensure that equipment is available, functional, and used in properly structured practical sessions.

Fill in the blank: Farm equipment increases the _________, quality, and scale of agricultural operations on the school farm and develops transferable technical skills in students.

### 2.1.3 Selection criteria for school farm equipment

Selecting appropriate equipment for the school farm requires evaluating five criteria: educational value (does the equipment provide practical learning experiences aligned with the curriculum?), affordability (can the school purchase and maintain the equipment within its budget?), local availability (can spare parts, fuel, and servicing be obtained in the local area?), safety (can the equipment be operated safely by secondary school students under teacher supervision?), and appropriateness of scale (is the equipment sized appropriately for the school farm area and student group size?).

Equipment that scores well on all five criteria should be prioritised. A motorised rice combine harvester, for example, has high educational value for students in rice-growing areas but fails on affordability, local availability of spare parts, and safety for secondary school students. A hand-operated knapsack sprayer, by contrast, scores well on all five criteria and is the most commonly selected spraying equipment for school farms across Nigeria. The selection decision should be made by the agriculture teacher in consultation with the school administration and farm committee.

Fill in the blank: The five criteria for selecting school farm equipment are educational value, affordability, local ________, safety, and appropriateness of scale.

| Criteria | Knapsack Sprayer | Hand Thresher | Tractor-mounted Plough |
|---|---|---|---|
| **Cost** | Low, affordable for school budgets | Moderate, manageable for small-scale use | High, requires significant investment |
| **Ease of Use** | Simple, requires basic training | Moderate, needs some skill | Complex, requires trained operator |
| **Maintenance** | Minimal, cleaning and nozzle checks | Moderate, occasional repairs | High, regular servicing and spare parts |
| **Suitability for Scale** | Best for small plots and gardens | Suitable for small to medium plots | Ideal for large-scale school farms |
| **Efficiency** | Moderate, covers limited area | Moderate, speeds up threshing compared to manual | High, saves time and labor on large plots |

Table 2.1: Selection criteria applied to common school farm equipment

### Pilot questions 2.1

1. Define farm equipment and distinguish it from a farm tool.
2. State two ways in which farm equipment is classified.
3. Explain why farm equipment is important on the school farm from an educational perspective.
4. List the five criteria for selecting equipment for the school farm.
5. Explain why a motorised combine harvester is not appropriate for most Nigerian school farms.

## 2.2 Spraying Equipment

### 2.2.1 Types of spraying equipment

Spraying equipment applies liquid pesticides, herbicides, fungicides, and foliar fertilisers to crops in controlled droplet sizes and at regulated rates. The most common types on Nigerian school farms are: the hand compression sprayer (a small pressurised canister holding one to two litres, used for small plots and nurseries), the knapsack sprayer (a 15 to 20 litre tank carried on the back, with a hand-operated pump and an adjustable nozzle, the most widely used sprayer on Nigerian smallholder farms), and the motorised knapsack sprayer (fitted with a small petrol engine and blower, covering larger areas more quickly).

Other types include the wheel-barrow sprayer (a larger tank mounted on a wheel for movement across the field), the tractor-mounted boom sprayer (for large-scale farms), and the ultra-low volume (ULV) sprayer (producing very fine droplets from a small volume of concentrated chemical). For school farm purposes, the manual knapsack sprayer is the standard equipment because it is affordable, locally available, operable by students, and capable of treating the areas typical of school farm plots. Students should be able to assemble, fill, operate, calibrate, and clean the knapsack sprayer.

Fill in the blank: The ________ sprayer is a 15 to 20 litre tank carried on the back with a hand-operated pump and adjustable nozzle; it is the most widely used sprayer on Nigerian smallholder and school farms.

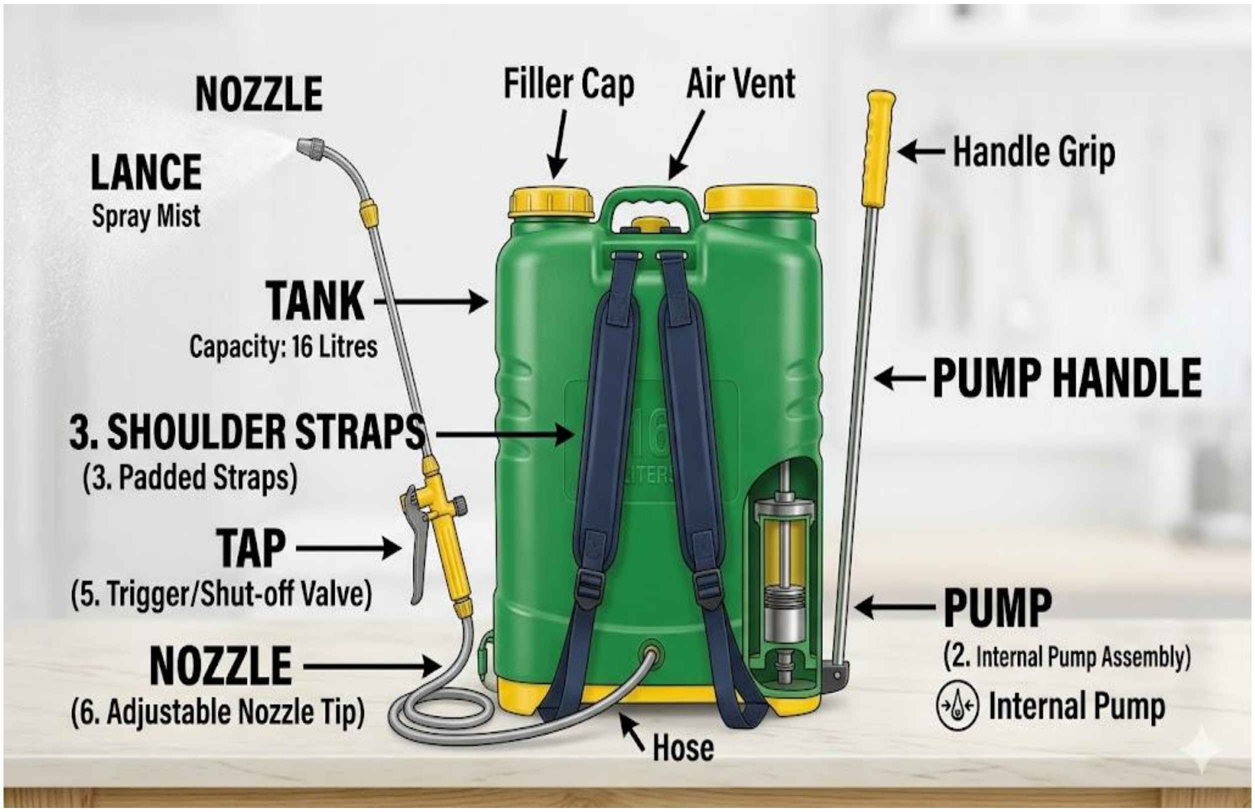


Figure 2.1: Diagram of a knapsack sprayer showing its major components

### 2.2.2 Operation and calibration of the knapsack sprayer

To operate the knapsack sprayer correctly: (1) calculate the required pesticide concentration from the label instructions (for example, 10 ml of concentrate per litre of water); (2) fill the tank with the calculated volume of clean water; (3) add the correct quantity of pesticide concentrate and mix; (4) close the tank and pump to the operating pressure (typically 10 to 15 strokes); (5) open the nozzle tap and walk at a steady pace, maintaining the nozzle at the recommended height above the crop canopy (typically 45 to 50 cm); (6) re-pump every 5 to 10 steps to maintain constant pressure.

Calibration ensures that the correct volume of spray solution is applied per unit area. A simple calibration method: fill the tank with clean water; spray a test plot of known area (for example, 100 square metres) at normal walking speed and nozzle height; measure the volume of water used; calculate the application rate in litres per hectare. If the rate is too high or too low, adjust walking speed or nozzle setting and repeat. Students should perform a calibration exercise before every chemical spraying session to prevent under- or over-dosing.

Fill in the blank: Calibration of a knapsack sprayer involves spraying a test plot of known area with clean water and measuring the volume used to calculate the ________ rate in litres per hectare.

### 2.2.3 Safety and maintenance of spraying equipment

Chemical spraying carries significant health risks. Personal protective equipment (PPE) must be worn during all spraying operations: chemical-resistant gloves, a face mask or respirator, protective goggles, a long-sleeved shirt, long trousers, and rubber boots. Spraying should be done in the early morning or late afternoon when wind speed is low and temperatures are cool, reducing spray drift and operator heat stress. Students must never spray without a supervising teacher present, and no student with a skin condition, open wound, or respiratory condition should participate in chemical spraying.

After use, the sprayer must be rinsed three times with clean water; rinse water should be disposed of away from water sources and food gardens. The nozzle should be removed, cleaned with a soft brush, and checked for blockages; blocked nozzles should never be cleared by blowing through them with the mouth. The tank, pump, and seals should be inspected for cracks and leaks. All rubber seals and gaskets should be lightly greased. The sprayer should be stored empty, disassembled, and in a secure, locked store away from food, animals, and children.

Fill in the blank: After spraying, the knapsack sprayer tank must be rinsed ________ times with clean water; rinse water must be disposed of away from water sources and food gardens.

#### Pilot questions 2.2

1. Name four types of spraying equipment and state one advantage of each.
2. Describe the steps for filling and operating a knapsack sprayer.
3. Explain how to calibrate a knapsack sprayer using the test-plot method.
4. List five items of personal protective equipment required during chemical spraying.

5. Describe the correct cleaning and storage procedure for a knapsack sprayer after use.

## 2.3 Harvesting Equipment

### 2.3.1 Types of harvesting equipment

Harvesting equipment mechanises the cutting, threshing, shelling, or picking of crops to reduce labour demand and post-harvest loss. The main types used or demonstrated on Nigerian school farms are: the hand-operated thresher (a rotating drum or beater mechanism that strips grain from the panicle or ear by mechanical action), the maize sheller (a hand-cranked or foot-pedal device that removes maize kernels from the cob without cracking them), the groundnut sheller (a hand-turned drum that shells groundnuts from their pods), and the rice thresher (a pedal-operated drum thresher for small-scale rice production).

Animal-drawn reapers (for cutting standing cereals) and motorised threshers are used on larger farms and are important for students to know conceptually even if they are not available on the school farm. The combine harvester performs reaping, threshing, and cleaning in a single pass and is used on large mechanised farms; it is covered in Series 4 (Farm Machines). For the school farm, the hand thresher and maize sheller are the most practical and affordable harvesting equipment, and both should be available for student practical sessions.

Fill in the blank: The maize ________ is a hand-cranked or foot-pedal device that removes maize kernels from the cob without cracking them, reducing the labour of manual shelling.

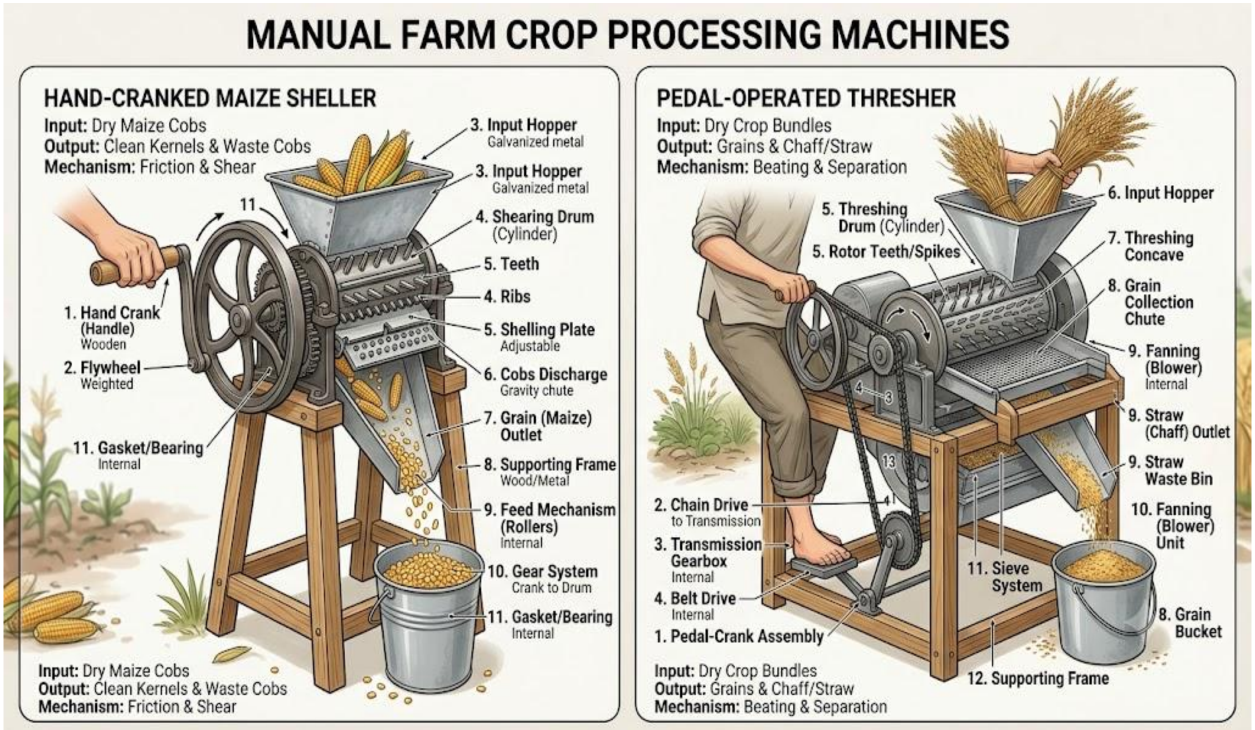


Figure 2.2: Diagram showing a hand-operated maize sheller and a pedal thresher

### 2.3.2 Operation and use of harvesting equipment

To operate the hand thresher: (1) cut and collect the crop at the correct stage of maturity; (2) feed small bundles of the harvested crop into the threshing drum opening at a steady rate, holding the stalks firmly to avoid entanglement; (3) the rotating drum or beater strips the grain from the panicle; (4) grain falls through a sieve into a collection tray while straw exits from the side; (5) grain is then winnowed to remove remaining chaff. Feeding rate must be controlled: overfeeding blocks the drum and underfeeding reduces efficiency.

To operate the maize sheller: place a dried maize cob into the shelling chamber and turn the handle or operate the pedal at a steady speed; the cob rotates against fixed pegs or a toothed plate that strips the kernels cleanly; the bare cob exits from one end and the kernels fall into a collection bag or tray. Maize must be sufficiently dry before shelling (moisture content below 13 per cent) to prevent kernel cracking and mould development in storage. Students should measure moisture content with a grain moisture meter before shelling.

Fill in the blank: Maize must have a moisture content below ________ per cent before shelling to prevent kernel cracking and mould development during storage.

### 2.3.3 Maintenance of harvesting equipment

After each use, all crop residues, grain, and dust must be cleaned from the thresher or sheller drum, sieves, and collection trays. A stiff brush and compressed air (or a blower) are used to clear blockages from sieve holes. All moving parts (bearings, rotating shafts, chains, and belts where present) should be lubricated with the type of lubricant specified in the manufacturer's manual; over-lubrication attracts dust and grain residues that can accelerate wear. Bolts and fasteners should be checked for tightness after every use.

Before storage, metal surfaces exposed to moisture should be lightly oiled. Equipment should be stored in a dry, covered store and never left outdoors where it is exposed to rain and humidity. Annually or at the start of each season, the equipment should be fully inspected: sieves checked for holes or deformation, bearings checked for wear, and any worn or damaged parts replaced before the harvesting season begins. A maintenance log recording dates, operations performed, and parts replaced helps the agriculture teacher plan servicing and budget for replacements.

Fill in the blank: A maintenance ________ recording dates, operations performed, and parts replaced helps the teacher plan servicing and budget for equipment replacement.

#### Pilot questions 2.3

1. Name four types of harvesting equipment and state the crop or operation each is used for.
2. Describe the steps for operating a pedal-operated rice thresher.
3. Explain why maize must be dried before shelling and state the required moisture content.
4. Describe three maintenance actions to be performed on harvesting equipment after use.
5. Explain the importance of a maintenance log for school farm harvesting equipment.

## 2.4 Storage Equipment

### 2.4.1 Types of storage equipment

Storage equipment preserves harvested produce from deterioration caused by moisture, pests, microorganisms, and physical damage. The main types used or demonstrated on Nigerian school and smallholder farms include: the metal silo (a sealed cylindrical metal container used for grain storage at low oxygen levels that inhibit insect pests and fungi), the cribs (raised, ventilated wooden or bamboo structures used for storing maize on the cob in the husk, allowing air circulation while keeping the grain above soil moisture and rodents), and hermetic storage bags (triple-layer plastic bags that create an oxygen-depleted environment inhibiting insect and fungal activity without chemical treatment).

Other storage equipment includes: the traditional mud or clay pot (used for small quantities of seed grain in rural households), the jute or polypropylene bag (for bulk grain but offering limited pest protection), the raised platform or pallet (for stacking bagged produce off a damp floor), and the moisture meter (for measuring grain moisture content before storage). On the school farm, hermetic bags are the most practical and cost-effective modern storage technology for students to use and demonstrate, as they require no chemical inputs and can be used at household scale.

Fill in the blank: Hermetic storage bags are triple-layer plastic bags that create an ________ environment inside, inhibiting insect pests and fungi without the use of chemical storage pesticides.

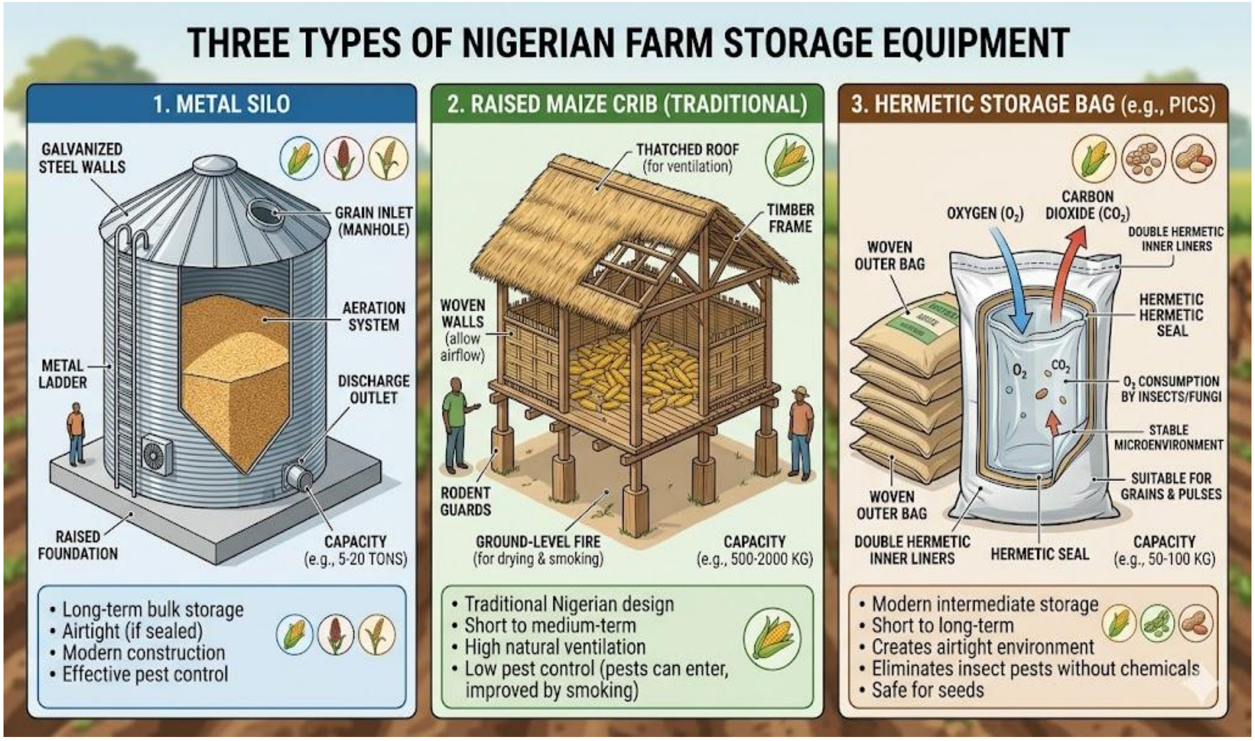


Figure 2.3: Diagram showing types of storage equipment used on Nigerian farms

## 2.4.2 Principles of correct storage

Correct storage of grain and produce requires attention to six factors: dryness (grain must be dried to the safe moisture content before storage: 12 to 13 per cent for maize, rice, and sorghum; 8 per cent for groundnuts), cleanliness (storage structures must be cleaned and disinfested before new produce is loaded), pest management (approved chemical protectants such as actellic dust or pirimiphos-methyl may be applied to grain at loading; hermetic bags eliminate this requirement), temperature (cooler storage temperatures slow insect and fungal activity), rodent exclusion (structures must be rat-proof with metal guards on supporting posts), and good stock rotation (first-in, first-out: oldest stock used before new).

Moisture is the single most important cause of storage loss in Nigeria. Grain harvested at too high a moisture content continues to respire and generates heat and humidity within the store, rapidly promoting mould growth and insect multiplication. Farmers and students must measure grain moisture content with a moisture meter before storage and continue drying if the reading exceeds the safe level. Spreading grain on a clean tarpaulin in full sunlight for one to three days is the most practical drying method on the school farm and for smallholder producers.

Fill in the blank: The safe moisture content for maize, rice, and sorghum before storage is ________ to 13 per cent; grain stored above this level generates heat and moisture that promotes mould and insect damage.

### 2.4.3 Maintenance of storage equipment and structures

Storage equipment requires inspection and maintenance before, during, and after the storage season. Before loading: clean all internal surfaces; check for holes, cracks, or gaps that could admit rodents or insects; repair or seal all openings; apply a residual insecticide to walls and floor if chemical storage is used; and ensure that raised structures (cribs, pallets) are stable and that rodent guards are intact. During storage: inspect at monthly intervals for signs of insect infestation, mould, moisture condensation, or rodent activity; take corrective action immediately.

After the storage season: remove all residual produce; sweep and clean the interior; allow the structure to air for several days; treat with an approved protectant if required; repair any structural damage (replace rotted wooden members, reseal metal seams, replace torn hermetic bags); and record the condition in the farm equipment register. Hermetic bags should be inspected for punctures before reuse; a bag with even a small hole is no longer hermetic and should be replaced. Metal silos should be inspected for rust at the seams; rust spots should be wire-brushed, primed, and repainted before the next season.

Fill in the blank: Hermetic storage bags should be inspected for ________ before reuse; even a small hole destroys the hermetic seal and allows oxygen in, defeating the purpose of the bag.

| Stage | Maintenance Actions |
|---|---|
| **Before Loading** | • Clean and disinfect equipment • Inspect for cracks, leaks, or rust • Ensure proper ventilation and dryness • Test locks, hinges, and covers |
| **During Storage** | • Monitor temperature and humidity • Check for pest or rodent activity • Rotate stored produce regularly • Keep records of stored items |

| Stage | Maintenance Actions |
| --- | --- |
| **At Season End** | • Empty and clean thoroughly • Repair or replace damaged parts • Apply protective coatings against rust • Store equipment in a dry, safe place |

Box 2.1: Storage checklist: actions before, during, and after the storage season

Pilot questions 2.4

1. Name four types of storage equipment and state one advantage of each.
2. State six factors that must be controlled for correct grain storage.
3. Explain why moisture is the most important cause of storage loss in Nigeria.
4. State the safe moisture content for maize before storage and explain how it is measured.
5. Describe three maintenance actions to be performed on storage structures before loading produce.

## Series Summary

This Series covered the types and uses of school farm equipment. We defined farm equipment, classified it by power source and function, explained its educational importance, and established five selection criteria for the school farm. We then covered spraying equipment in detail: types (hand compression, knapsack, motorised), operation and calibration of the knapsack sprayer, and safety and maintenance requirements including three-rinse cleaning, PPE use, and locked storage.

We covered harvesting equipment (hand thresher, maize sheller, groundnut sheller, rice thresher), their operation, the moisture content requirement for safe shelling, and post-use maintenance including lubrication, cleaning, and maintenance logs. Finally, we described storage equipment (metal silos, cribs, hermetic bags), the six principles of correct storage (dryness, cleanliness, pest management, temperature, rodent exclusion, stock rotation), the importance of the moisture meter, and the maintenance of storage structures before, during, and after the storage season. By completing this Series, you should be able to achieve all eight Series Learning Outcomes (SLO 2.1 to SLO 2.8).

## Glossary of Terms

- **Calibration:** the process of measuring the application rate of a sprayer by spraying a known area with clean water and calculating the volume used per unit area.
- **Crib:** a raised, ventilated storage structure made from wood or bamboo used for storing maize on the cob; elevated to keep produce above soil moisture and inaccessible to rodents.
- **Grain moisture meter:** an electronic instrument that measures the moisture content of grain as a percentage; used to determine whether grain is dry enough for safe storage or shelling.
- **Hermetic storage bag:** a triple-layer plastic bag that creates an oxygen-depleted environment inside, preventing insect and fungal activity without chemical treatment.
- **Knapsack sprayer:** a 15 to 20 litre spray tank carried on the back with a hand-operated pump, lance, and adjustable nozzle; the most common sprayer on Nigerian smallholder and school farms.
- **Maintenance log:** a record kept for farm equipment documenting dates, maintenance operations performed, and parts replaced; used for servicing planning and budget management.
- **Maize sheller:** a hand-cranked or foot-pedal device that removes maize kernels cleanly from the cob without cracking; requires grain to be dried below 13 per cent moisture before use.
- **Metal silo:** a sealed cylindrical metal storage container that maintains low oxygen levels inside, inhibiting insect pests and fungi; used for grain storage on improved smallholder farms.

- **Nozzle:** the removable tip of a sprayer lance that controls the spray pattern, droplet size, and flow rate of the spray solution; must be cleaned after each use.
- **Personal protective equipment (PPE):** clothing and devices worn to protect the operator from chemical exposure during spraying; includes gloves, face mask, goggles, long-sleeved shirt, long trousers, and rubber boots.
- **Safe moisture content:** the moisture level at or below which grain can be stored without significant mould growth or insect damage; 12 to 13 per cent for maize, rice, and sorghum; 8 per cent for groundnuts.
- **Stock rotation:** the practice of using older stored produce before newer produce (first-in, first-out) to prevent any batch from remaining in storage beyond its safe storage life.
- **Ultra-low volume (ULV) sprayer:** a sprayer that produces very fine droplets from a small volume of concentrated pesticide solution, covering large areas with minimal water use.

## Concept Check Questions [Series 2]

Objective Questions

1. Farm equipment is classified by power source into hand-operated, animal-drawn, and ________ categories. (Linked to SLO 2.1)
2. The ________ sprayer is a 15 to 20 litre back-carried tank with a hand-operated pump and adjustable nozzle; the most common sprayer on Nigerian school farms. (Linked to SLO 2.3)
3. After spraying, the knapsack sprayer tank must be rinsed ________ times with clean water. (Linked to SLO 2.5)
4. Maize must have a moisture content below ________ per cent before shelling to prevent kernel cracking and mould. (Linked to SLO 2.7)
5. Hermetic storage bags create an ________ environment that inhibits insects and fungi without chemical treatment. (Linked to SLO 2.8)

Short-Answer Questions

6. State five criteria for selecting equipment for the school farm. (Linked to SLO 2.2)
7. Describe the steps for operating a knapsack sprayer. (Linked to SLO 2.4)
8. List five items of PPE required for chemical spraying. (Linked to SLO 2.5)
9. Name four types of harvesting equipment and state the crop each is used for. (Linked to SLO 2.6)
10. State six factors that must be controlled for correct grain storage. (Linked to SLO 2.8)

Long-Answer Questions

11. Describe the types of spraying equipment used on the school farm, explain how to operate and calibrate a knapsack sprayer, and state the safety precautions and maintenance procedures required. (Linked to SLOs 2.3, 2.4, 2.5)
12. Describe the types of storage equipment available to Nigerian farmers, explain the principles of correct grain storage, and outline the maintenance actions required for storage equipment before, during, and after the storage season. (Linked to SLO 2.8)

## Answers to Concept Check Questions [Series 2]

Objective Questions

1. Engine-powered (motorised).
2. Knapsack.
3. Three.
4. 13.
5. Oxygen-depleted.

Short-Answer Questions

6. Educational value, affordability, local availability of spare parts and servicing, safety for secondary school students, and appropriateness of scale for the school farm area.
7. Calculate concentration from label; fill tank with measured water; add correct pesticide quantity and mix; close and pump to operating pressure; open nozzle tap and walk at steady pace with nozzle at correct height; re-pump every 5 to 10 steps to maintain pressure.
8. Chemical-resistant gloves, face mask or respirator, protective goggles, long-sleeved shirt, long trousers, and rubber boots.
9. Hand thresher (rice, sorghum, millet); maize sheller (maize); groundnut sheller (groundnuts); rice thresher (rice).
10. Dryness (correct moisture content); cleanliness (clean and disinfested structure); pest management (approved chemical protectant or hermetic bags); temperature (cool storage); rodent exclusion (rat-proof structure with metal guards); stock rotation (first-in, first-out).

Long-Answer Questions

11. Types of spraying equipment: hand compression sprayer (1 to 2 litres, small plots and nurseries), knapsack sprayer (15 to 20 litres, most widely used, operable by students), motorised knapsack sprayer (engine-powered blower, faster coverage), wheel-barrow sprayer (larger tank, field movement), tractor-mounted boom sprayer (large farms), ULV sprayer (fine droplets, low water volume). Operation: calculate concentration, fill tank with water, add pesticide, close and pump to pressure, open nozzle tap, walk at steady pace at correct height, re-pump regularly. Calibration: spray a known area (100 m2) with water, measure volume used, calculate litres per hectare, adjust and repeat. Safety: wear full PPE (gloves, mask, goggles, long clothing, boots); spray in early morning or late afternoon; teacher supervision mandatory; exclude students with skin or respiratory

conditions. Maintenance: triple rinse after use; clean nozzle with soft brush; inspect seals; grease rubber parts; store empty, disassembled, and locked.

12. Storage equipment: metal silo (sealed, low oxygen, inhibits insects and fungi); maize crib (raised, ventilated, maize on cob); hermetic bags (triple-layer, oxygen-depleted, no chemical needed); jute or polypropylene bag (bulk grain, limited pest protection); raised platform or pallet (keeps bags off damp floor); moisture meter (measures grain moisture before storage). Six storage principles: dryness (12 to 13 per cent for cereals, 8 per cent for groundnuts); cleanliness (cleaned and disinfested before loading); pest management (actellic dust or hermetic sealing); temperature (cooler is better); rodent exclusion (metal guards on crib posts); stock rotation (first-in, first-out). Moisture as main loss cause: wet grain respires and generates heat and humidity, rapidly promoting mould and insect multiplication. Maintenance: before loading: clean interior, seal gaps, check rodent guards, apply protectant; during storage: monthly inspection for insects, mould, condensation; after season: remove all residue, clean, air, repair structures, record in equipment register; hermetic bags: inspect for punctures before reuse; metal silos: inspect seams for rust, wire-brush and repaint.

## Answers to Pilot Questions [Series 2]

Part 2.1: Introduction to Farm Equipment

1. Farm equipment comprises more complex implements with mechanical parts, powered by hand, animal, or engine, designed for larger areas or multiple operations. A farm tool is a simple, hand-held implement operated solely by human muscle power for a single operation (hoe, cutlass). Equipment example: knapsack sprayer. Tool example: hand trowel.
2. By power source (hand-operated, animal-drawn, engine-powered/motorised); by function (tillage, planting, crop protection, harvesting, storage).
3. Equipment on the school farm develops transferable technical skills students can use in commercial agriculture and agribusiness employment. The school farm is often the only

place where rural students will have supervised hands-on contact with agricultural equipment before entering the workforce, making this training critical for their employability.

4. Educational value, affordability, local availability of spare parts and servicing, safety for secondary school students, and appropriateness of scale for the school farm.
5. It fails on affordability (very high purchase and operating cost), local availability of spare parts (not stocked in most local markets), and safety (unsuitable for secondary school students to operate without specialist training). It may have educational value in rice-growing areas but the other criteria disqualify it for most Nigerian school farms.

Part 2.2: Spraying Equipment

1. Any four: hand compression sprayer (small and lightweight, suitable for nurseries and small plots); knapsack sprayer (widely available, affordable, operable by students, suitable for school farm plots); motorised knapsack sprayer (faster coverage of larger areas); wheel-barrow sprayer (carries larger volume without back strain); ULV sprayer (very low water volume, effective in water-scarce conditions).
2. Calculate pesticide concentration from label instructions. Fill tank with the calculated volume of clean water. Add the correct quantity of pesticide concentrate and mix thoroughly. Close the tank and pump the handle to build operating pressure (about 10 to 15 strokes). Open the nozzle tap. Walk at a steady, even pace with the nozzle held at the recommended height above the crop canopy (45 to 50 cm). Re-pump every 5 to 10 steps to maintain constant operating pressure.
3. Fill the tank with a measured volume of clean water. Spray a test plot of precisely known area (for example, 100 square metres) at normal walking speed and nozzle height. Measure the volume of water remaining in the tank and subtract from the starting volume to determine the volume used. Calculate the application rate: if 2 litres were used on 100 m2, the rate = 200 litres per hectare. Compare this with the recommended application rate on the pesticide label and adjust walking speed, nozzle setting, or pressure, then repeat until the correct rate is achieved.

4. Chemical-resistant gloves, face mask or respirator, protective goggles, long-sleeved shirt, long trousers (rubber boots also required).
5. Triple-rinse the tank with clean water, disposing rinse water away from water sources and gardens. Remove the nozzle and clean it with a soft brush; check for blockages. Inspect all rubber seals and gaskets for cracks; lightly grease to preserve flexibility. Check the tank and pump for leaks or cracks. Store the sprayer empty, disassembled, and in a locked store away from food, animals, and children.

Part 2.3: Harvesting Equipment

1. Hand-operated thresher (rice, sorghum, millet: strips grain from panicle by mechanical beater action); maize sheller (maize: removes kernels from cob by rotating against pegs or a toothed plate); groundnut sheller (groundnuts: shells pods by rotating drum action); rice pedal thresher (rice: foot-pedal drum thresher for small-scale rice production).
2. Collect rice at correct maturity; cut and bundle the harvested plants. Feed small bundles into the threshing drum opening at a steady rate, holding stalks firmly. Operate the foot pedal at a steady rhythm to rotate the drum; the beaters strip grain from the panicle. Grain falls through the sieve into the collection tray; straw exits from the side. Winnow the collected grain to remove remaining chaff.
3. Maize harvested above 13 per cent moisture content contains enough free water for fungi to germinate and grow on the grain surface during storage, producing mycotoxins harmful to humans and animals. At high moisture, grain continues to respire, generating heat and further moisture that accelerate spoilage. High-moisture grain shelled through the machine also tends to have the germ area crack under pressure, reducing grain quality and marketability.
4. Any three: clean all crop residues, dust, and grain from the drum, sieves, and collection trays using a stiff brush; lubricate all moving parts (bearings, rotating shafts) with the lubricant specified in the manual; check and tighten all bolts and fasteners; inspect sieves for holes or deformation and replace damaged ones.

5. A maintenance log records the dates on which servicing was performed, the specific operations carried out, and any parts replaced. It helps the agriculture teacher plan scheduled servicing (so equipment is ready at the start of harvest season), identify recurring problems (which may indicate a design or operation issue), and budget for spare parts and repairs in advance, preventing unexpected breakdowns during the harvesting period.

Part 2.4: Storage Equipment

1. Any four: metal silo (sealed, oxygen-depleted environment inhibits insects and fungi without chemicals); hermetic bag (no chemical input required, low cost, household scale); maize crib (ventilated air circulation dries maize naturally; raised above soil moisture and rodents); raised platform or pallet (keeps bagged grain off damp floor, preventing moisture absorption through bag base).
2. Dryness (grain at correct moisture content before loading); cleanliness (storage structure cleaned and disinfested before use); pest management (chemical protectant or hermetic sealing); temperature (cool storage slows insect and fungal activity); rodent exclusion (rat-proof structure with metal guards on posts); stock rotation (first-in, first-out, oldest stock used first).
3. Moisture is the single most critical factor because grain stored above the safe moisture content continues to respire, releasing heat and water vapour into the store. This raises the temperature and relative humidity inside the store, creating ideal conditions for mould germination and rapid insect multiplication. A small initial moisture excess can lead to total loss of the stored batch within weeks, especially in Nigeria's humid conditions.
4. The safe moisture content for maize before storage is 12 to 13 per cent. It is measured using a grain moisture meter: a small sample of grain is placed in the meter's chamber; the meter passes a small electrical current through the grain and calculates moisture content from the electrical resistance, displaying the result as a percentage. If the reading exceeds 13 per cent, the grain must be further dried before storage.

5. Any three: clean all internal surfaces of the storage structure thoroughly, removing all residues from the previous season; inspect the structure for holes, cracks, or gaps in walls, floors, or roofing that could admit rodents, insects, or rainwater and seal or repair them before loading; check that raised structures (cribs, pallets) are stable and that rodent guards (metal flashing or inverted cones on support posts) are intact and undamaged.

## References and Attributions [Series 2]

Textual References (Books and External Sources)


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Figures, Plates, Tables, and Boxes

- Table 2.1: School farm equipment selection criteria Attribution: AI generated. Suggested OER search string: "school farm equipment selection criteria knapsack sprayer thresher OER table".
- Figure 2.1: Knapsack sprayer components diagram Attribution: AI generated. Suggested OER search string: "knapsack sprayer diagram labelled components tank pump nozzle OER".

- Figure 2.2: Maize sheller and pedal thresher diagram Attribution: AI generated. Suggested OER search string: "hand maize sheller pedal thresher diagram labelled harvesting equipment OER".
- Figure 2.3: Farm storage equipment types Attribution: AI generated. Suggested OER search string: "farm storage equipment metal silo maize crib hermetic bag Nigeria OER".
- Box 2.1: Storage maintenance checklist Attribution: AI generated. Suggested OER search string: "farm storage equipment maintenance checklist before during after season OER box".

**Course code: AGE 208**

**Course title: Farm Tools and Equipment**

**Course credit load: 2 Units**

# Series 3: Use and Maintenance of Farm Tools and Equipment

- **Part 3.1: Principles of Correct Use of Farm Tools and Equipment**
    - Sub Part 3.1.1: General principles of correct tool and equipment use
    - Sub Part 3.1.2: Matching tools and equipment to tasks
    - Sub Part 3.1.3: Ergonomics and operator efficiency
- **Part 3.2: Maintenance of Farm Tools**
    - Sub Part 3.2.1: Daily and weekly maintenance of hand tools
    - Sub Part 3.2.2: Sharpening and handle replacement
    - Sub Part 3.2.3: Tool maintenance records
- **Part 3.3: Maintenance of Farm Equipment**
    - Sub Part 3.3.1: Principles of equipment maintenance
    - Sub Part 3.3.2: Maintenance of spraying and harvesting equipment
    - Sub Part 3.3.3: Equipment maintenance records and scheduling
- **Part 3.4: Troubleshooting Common Faults**
    - Sub Part 3.4.1: Common faults in farm tools and their remedies
    - Sub Part 3.4.2: Common faults in spraying equipment and their remedies

- Sub Part 3.4.3: Common faults in harvesting and storage equipment

## Introduction

Correct use and systematic maintenance are the two practices that determine how long a farm tool or piece of equipment remains productive. A hoe used incorrectly wears out faster and tires the operator more quickly than one used correctly; a knapsack sprayer that is not cleaned after each use develops blocked nozzles and corroded seals within a few seasons. For students on the school farm and for future farmers, the habits of correct use, daily care, and scheduled maintenance are as important as knowing the names and functions of tools and equipment.

This Series builds on the tool and equipment knowledge from Series 1 and 2 by covering the principles of correct use, daily and weekly maintenance of hand tools, equipment maintenance procedures, maintenance records, and systematic troubleshooting of common faults. The Series equips students with the practical competencies needed to keep tools and equipment in serviceable condition throughout the farming season.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** state the general principles of correct tool and equipment use (Linked to Part 3.1),
- **SLO 3.2** explain how to match tools and equipment to specific agricultural tasks (Linked to Part 3.1),
- **SLO 3.3** describe the ergonomic principles that improve operator efficiency and reduce fatigue (Linked to Part 3.1),
- **SLO 3.4** describe the daily and weekly maintenance procedures for farm hand tools (Linked to Part 3.2),

- **SLO 3.5** demonstrate the correct procedure for sharpening a tool blade and replacing a handle (Linked to Part 3.2),
- **SLO 3.6** explain the principles of farm equipment maintenance (Linked to Part 3.3),
- **SLO 3.7** describe the maintenance procedures for spraying and harvesting equipment (Linked to Part 3.3),
- **SLO 3.8** maintain a tool and equipment maintenance record (Linked to Part 3.3), and
- **SLO 3.9** identify and remedy common faults in farm tools, spraying equipment, and harvesting and storage equipment (Linked to Part 3.4).

## 3.1 Principles of Correct Use of Farm Tools and Equipment

### 3.1.1 General principles of correct tool and equipment use

Every farm tool and piece of equipment is designed for a specific purpose; using it for that purpose at the correct intensity produces the best results with the least wear. The general principles of correct use are: use the right tool for the right job (a cutlass is for cutting, not levering); apply force in the direction the tool is designed to work (a hoe blade cuts most efficiently when drawn toward the operator, not pushed away); maintain the recommended operating pressure, speed, or flow rate for equipment (overworking a sprayer pump shortens seal life); and inspect before each use to confirm the tool or equipment is in safe working condition.

Students must also be taught not to use tools as substitutes for equipment they do not have; improvised use (for example, using a cutlass as a crowbar, or a shovel as a hammer) damages the tool and creates safety risks. When a tool breaks during correct use, it should be reported, recorded, and repaired before the next session. A culture of respecting tools and equipment as shared school resources, reporting damage promptly, and never leaving the field with broken implements is a professional habit that should be instilled from the first farm session.

Fill in the blank: The first principle of correct tool use is to use the ________ tool for the right job; improvised use of a tool damages it and creates safety risks for the operator.

### 3.1.2 Matching tools and equipment to tasks

Correct task-to-tool matching requires knowledge of both the task requirements and the tool's design capabilities. Soil type is a key variable: a garden hoe is sufficient for loose, sandy loam soils; a mattock or powered cultivator is needed for compacted clay or rocky soils. Crop type and growth stage determine whether a broad hoe, a narrow hand weeder, or a precision dibber is most appropriate. Scale of operation determines whether a hand tool or equipment should be used: a knapsack sprayer covers one to two hectares per day; plots smaller than 0.1 hectare may be more practically treated with a hand compression sprayer.

A simple task-tool matching guide can be developed by the agriculture teacher as a classroom reference: rows listing each major farm operation (soil preparation, planting, weeding, pest control, harvesting, storage), columns listing the available tools and equipment, and cells indicating the suitability (high, medium, or not suitable) for each combination. Students should practise this matching exercise as a classroom activity before each practical session, developing the habit of selecting the correct tool before starting work rather than simply using whatever is nearest to hand.

Fill in the blank: Correct task-to-tool matching requires knowledge of the ________ requirements and the design capabilities of the tool; soil type, crop type, and scale of operation are the key variables.

| **Farm Task** | **Hoe** | **Cutlass** | **Knapsack Sprayer** | **Hand Thresher** | **Tractor-mounted Plough** |
|---|---|---|---|---|---|
| **Land preparation** | Suitable for small plots | Suitable for clearing weeds | Not suitable | Not suitable | Highly suitable for large plots |
| **Weeding** | Very suitable | Suitable for cutting weeds | Not suitable | Not suitable | Moderately suitable (mechanized weeding attachments) |

| | | | | | |
|---|---|---|---|---|---|
| **Planting** | Suitable for making holes | Suitable for clearing planting spots | Not suitable | Not suitable | Suitable for large-scale row planting |
| **Pest/Disease control** | Not suitable | Not suitable | Very suitable for spraying chemicals | Not suitable | Not suitable |
| **Harvesting** | Moderately suitable for root crops | Suitable for cutting stems | Not suitable | Suitable for separating grains | Not suitable |
| **Threshing** | Not suitable | Not suitable | Not suitable | Very suitable for grain separation | Not suitable |

Table 3.1: Task-to-tool matching guide for common school farm operations

### 3.1.3 Ergonomics and operator efficiency

Ergonomics is the science of designing work to fit the worker, reducing physical strain and the risk of injury. Applied to farm tool use, ergonomic principles include: adjusting the tool handle length so the operator can work in an upright or slightly bent position rather than a deeply stooped one (a handle too short forces the back into an unnatural curve that causes fatigue and injury); gripping the handle firmly but not with excessive tension (a tight grip increases forearm fatigue); using the body's weight and momentum rather than arm strength alone for digging and hoeing actions; and taking regular rest breaks of five to ten minutes every hour during sustained tool use.

Operator efficiency is also improved by organising the work systematically: completing one row or plot before moving to the next, moving in a consistent direction so that each stroke clears new ground, and not doubling back unnecessarily. In group farm work, spacing students so they are not in each other's way, and assigning tasks that match each student's physical capacity, reduce both fatigue and the risk of accidental injury. The agriculture teacher should observe students during farm sessions and provide feedback on posture, grip, and work organisation as part of practical skills development.

Fill in the blank: ________ is the science of designing work to fit the worker; applied to farm tools, it includes adjusting handle length and using body weight rather than arm strength for hoeing and digging.

### Pilot questions 3.1

1. State three general principles of correct tool and equipment use.
2. Explain what task-to-tool matching means and give one example from crop production.
3. Explain what ergonomics means in the context of farm tool use.
4. Describe two ergonomic adjustments a student should make when using a long-handled hoe.
5. Explain why improvised use of a tool for a purpose it was not designed for is harmful.

## 3.2 Maintenance of Farm Tools

### 3.2.1 Daily and weekly maintenance of hand tools

Daily maintenance is performed at the end of every farm session and takes only a few minutes per tool. The steps are: remove all soil, plant material, and moisture from the tool surface using a cloth, brush, or scraper; wipe all metal parts dry (moisture on metal initiates rust within hours in Nigeria's humid climate); apply a thin coat of waste engine oil or vegetable oil to exposed metal surfaces using a rag; check the tool head for looseness by holding the handle and shaking; and hang or rack the tool correctly in the tool store. Students should be trained to complete these steps as a routine before leaving the farm, not as an afterthought.

Weekly maintenance is more thorough. Inspect all cutting edges for bluntness and sharpen as needed. Check all tool heads and tighten or re-wedge any that are loose. Inspect wooden handles for cracks, splinters, and rot; sand down rough spots that could cause blisters. Apply linseed oil or used engine oil to wooden handles to prevent drying and cracking. Oil all metal surfaces again. Remove any rust spots with steel wool or sandpaper before they deepen into pitting. Record the condition of each tool in the tool maintenance register, noting any tool that needs repair or replacement.

Fill in the blank: Daily maintenance of farm tools includes removing soil, wiping metal ________, applying a thin coat of oil to metal surfaces, checking for loose heads, and storing correctly.

### 3.2.2 Sharpening and handle replacement

Sharpening restores the cutting bevel of a blade that has become blunt through use. For a hoe, cutlass, or spade: secure the tool in a vice or on a firm surface; select a flat bastard file matched to the metal hardness; hold the file at the angle of the existing bevel (typically 25 to 35 degrees); push the file forward along the blade in smooth, even strokes from heel to tip, maintaining the bevel angle consistently; after every five to ten strokes, check the edge for sharpness by pressing lightly against the thumbnail (a sharp edge grips; a blunt edge slides); when the bevel is restored, use a whetstone on the back face of the blade to remove the wire burr.

Handle replacement is needed when a handle is cracked, split, or so worn that the head cannot be securely re-wedged. To replace: drive out the old handle from the tool head using a punch and hammer if necessary; obtain a new handle of the correct length and diameter (replacement handles are available at hardware stores); insert the new handle through the eye of the tool head from the bottom; drive a hardwood or metal wedge into the kerf at the top of the handle to expand it firmly inside the eye; test by striking the head on the ground to confirm it is secure. A newly fitted handle should be sanded smooth and treated with linseed oil before use.

Fill in the blank: After sharpening a hoe blade with a file, a ________ is used on the back face of the blade to remove the wire burr left by the file.

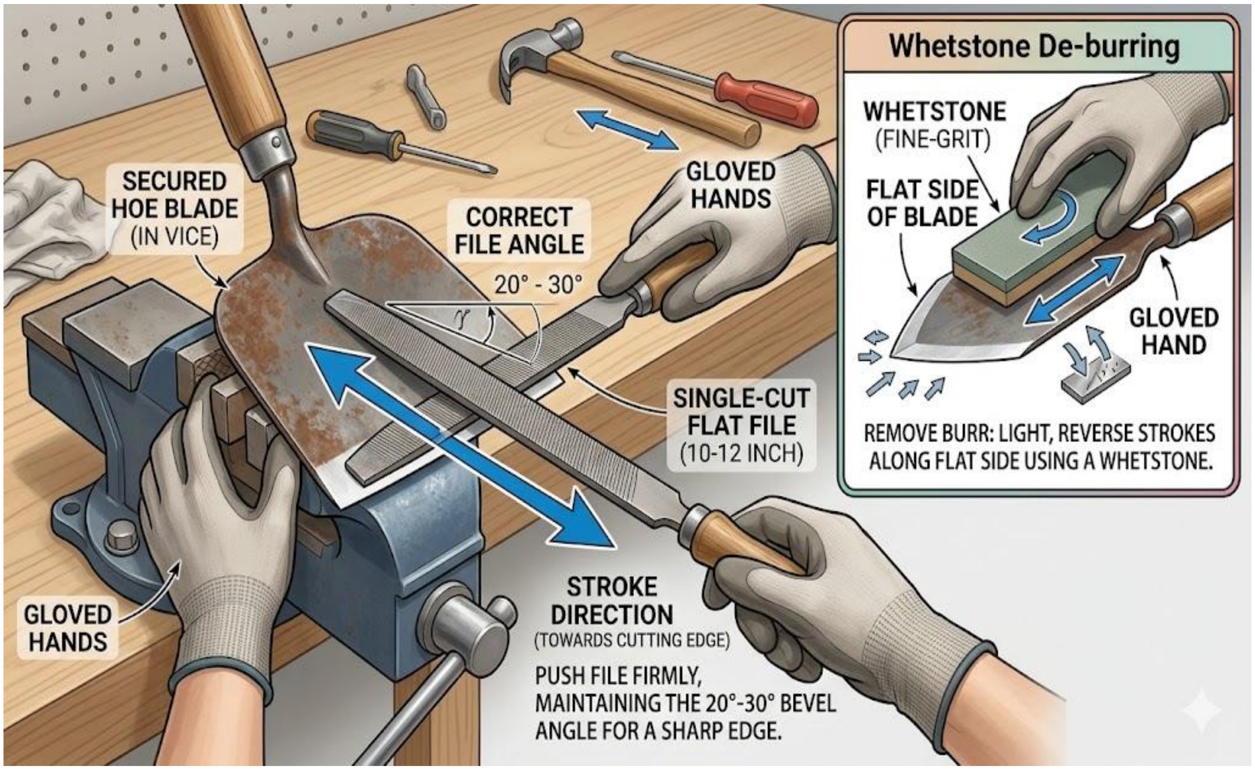


Figure 3.1: Diagram showing the correct file angle and procedure for sharpening a hoe blade

### 3.2.3 Tool maintenance records

A tool maintenance record is a simple register in the school farm tool store that documents the condition and maintenance history of every tool. For each tool, the record should show: the tool name and identification number, date of purchase or acquisition, initial condition, dates on which maintenance was performed (sharpening, oiling, handle replacement), the current condition, and whether the tool is serviceable or requires repair or replacement. The record is updated after each weekly maintenance session.

Tool maintenance records serve three purposes: accountability (the record shows which tools are in service and which are damaged, preventing tools from disappearing without documentation), planning (the record enables the agriculture teacher to anticipate which tools will need replacement at the start of the next season and budget accordingly), and quality control (patterns in the record such as a particular tool type consistently breaking can prompt investigation into whether the tool is being misused). Records should be reviewed at the start of each term and at the close of the school year.

Fill in the blank: Tool maintenance records serve three purposes: ________, planning for replacement and budgeting, and quality control by identifying patterns of breakage or misuse.

### Pilot questions 3.2

1. Describe the daily maintenance steps for a hand tool after a farm session.
2. Describe the weekly maintenance steps for garden hand tools.
3. Explain the correct procedure for sharpening a hoe blade with a file.
4. Describe the steps for replacing a loose or broken tool handle.
5. State three purposes of tool maintenance records.

## 3.3 Maintenance of Farm Equipment

### 3.3.1 Principles of equipment maintenance

Equipment maintenance is governed by four principles. Prevention is better than cure: scheduled maintenance at regular intervals prevents most equipment failures; a breakdown during harvesting season costs far more in lost time and produce than the cost of routine servicing. Follow the manufacturer's instructions: each piece of equipment has specific lubrication, cleaning, and adjustment requirements that must be followed; using the wrong lubricant or over-tightening a component can cause as much damage as neglecting it. Use only genuine spare parts or approved equivalents: substitute parts of inferior quality may fail prematurely and damage other components.

The fourth principle is to train operators properly: most equipment failures result from operator error (overloading, incorrect assembly, ignoring warning signs) rather than from genuine mechanical failure. On the school farm, students must be taught how each piece of equipment works, what normal operation sounds like, what signs indicate a developing fault (unusual noise, vibration, reduced output, leaking fluid), and what to do when a fault appears. A student who recognises the early warning signs of equipment failure and reports them promptly prevents minor faults from becoming major breakdowns.

Fill in the blank: The first principle of equipment maintenance is that ________ is better than cure; scheduled maintenance at regular intervals prevents most equipment failures before they occur.

### 3.3.2 Maintenance of spraying and harvesting equipment

Spraying equipment maintenance after each use: triple-rinse the tank and lance with clean water; remove, disassemble, and clean the nozzle with a soft brush; check all rubber seals and O-rings for cracks and replace if damaged; lightly grease all rubber seals; inspect the pump mechanism for wear; store the sprayer empty and disassembled. Before the spraying season: fill with clean water and operate to check for leaks at all joints and the tank seam; calibrate; confirm that all nozzle settings produce the correct spray pattern; replace any worn or cracked seals before chemical use begins.

Harvesting equipment maintenance after each use: brush all grain, crop residues, and dust from the threshing drum, sieves, and collection trays; lubricate all bearings and rotating shafts with the correct lubricant as specified; check and tighten all bolts and fasteners; inspect sieves for holes or deformation; oil all unpainted metal surfaces. Before the harvesting season: perform a full inspection of all moving parts; replace worn bearings, belts, or chains; check that the drum is correctly aligned and balanced; test-run with a small quantity of the crop before full-scale operation begins.

Fill in the blank: Before the harvesting season begins, equipment should be ________ by running it with a small quantity of the crop to confirm correct operation before full-scale use.

| Stage | Knapsack Sprayer | Hand Thresher |
| --- | --- | --- |
| **After Each Use** | • Rinse tank and nozzle with clean water • Check for leaks in hose and seals • Dry thoroughly before storage | • Clean grain residues from drum and sieves • Inspect moving parts for wear • Oil joints lightly to prevent rust |
| **Weekly** | • Inspect straps, harness, and spray lance • Test spray pattern for uniformity • Tighten loose nuts and bolts | • Check bearings and belts • Sharpen or adjust threshing teeth • Tighten bolts and lubricate moving parts |

| | | |
|---|---|---|
| **Before Season Start** | • Deep clean and disinfect tank • Replace worn-out gaskets, filters, or nozzles • Calibrate sprayer for correct dosage | • Overhaul machine, replace worn parts • Apply anti-rust coating • Test run to ensure smooth operation |

Table 3.2: Maintenance schedule for knapsack sprayer and hand thresher

### 3.3.3 Equipment maintenance records and scheduling

An equipment maintenance record is kept for each piece of equipment on the school farm. It records: the equipment name and identification number, date of acquisition and purchase cost, scheduled maintenance intervals (from manufacturer's manual or standard practice), dates on which maintenance was performed, description of work done, parts replaced and their cost, and current operational status. The record enables the agriculture teacher to verify that maintenance is being performed on schedule and to project the equipment's remaining useful life.

A maintenance schedule is a calendar that specifies when each maintenance task is due for each piece of equipment. For a knapsack sprayer: clean after every use, inspect seals monthly, full service at the start of each spraying season. For a hand thresher: clean after every use, lubricate weekly during the harvest season, full inspection before the start of harvest. The schedule should be posted on the tool store wall and the agriculture teacher or farm supervisor should tick off each task as it is completed. Missed maintenance should be noted and rescheduled, not simply skipped.

Fill in the blank: A maintenance ________ is a calendar specifying when each maintenance task is due for each piece of equipment; it should be posted in the tool store and ticked off as tasks are completed.

Pilot questions 3.3

1. State the four principles of equipment maintenance.
2. Describe the maintenance steps for a knapsack sprayer after each use.
3. Describe the maintenance steps for a hand thresher after each use.

4. Explain what should be recorded in an equipment maintenance record.
5. Explain what a maintenance schedule is and why it should be posted in the tool store.

## 3.4 Troubleshooting Common Faults

### 3.4.1 Common faults in farm tools and their remedies

The most common faults in hand tools and their remedies are: loose tool head (the head moves on the handle during use) caused by a dried or worn handle shrinking inside the eye; remedy: drive a new wedge into the handle kerf, or replace the handle if it is too worn to re-wedge. Blunt cutting edge (the hoe or cutlass requires excessive force to cut soil or vegetation); remedy: sharpen with a file at the correct bevel angle and de-burr with a whetstone. Rusted metal surface (orange rust on the blade or tines); remedy: rub with steel wool or fine sandpaper to remove surface rust, then apply oil; if pitting is severe, the tool should be replaced.

Cracked or splintered handle: the handle develops a crack along the grain or a splinter that could cause injury; remedy: if the crack is superficial, sand smooth and apply linseed oil; if the crack penetrates more than halfway through the handle cross-section, replace the handle immediately as it may fail without warning during use. Bent tine or blade: a fork tine or hoe blade bent out of alignment from misuse; remedy: if the metal is still ductile, a blacksmith can straighten the tine or blade using heat and hammering; if the metal has been work-hardened or cracked, the tool should be condemned and replaced.

Fill in the blank: A cracked handle that penetrates more than halfway through the cross-section must be ________ immediately, as it may fail without warning during use and cause injury.

### 3.4.2 Common faults in spraying equipment and their remedies

Common knapsack sprayer faults and remedies: blocked nozzle (no spray or uneven spray pattern) caused by dried chemical or soil particles lodging in the nozzle orifice; remedy: remove the nozzle, soak in clean water, and clean with a soft brush; never blow through the nozzle with the mouth as this causes chemical exposure. Leaking tank (spray solution drips from tank seams or lid) caused by cracked plastic or a worn lid gasket; remedy: for a cracked tank, repair with appropriate plastic adhesive or replace the tank; replace the lid gasket. Pump not building pressure (handle moves freely but pressure does not build) caused by a worn or cracked pump cup or piston seal; remedy: replace the pump cup or seal (available as a spare parts kit from the supplier).

Chemical residue corrosion (pitting or discolouration inside the tank or on metal fittings) caused by failure to rinse after use with acidic or alkaline pesticides; remedy: flush with a dilute solution of washing soda (sodium carbonate) if acidic residue is suspected, or dilute vinegar if alkaline; then triple-rinse with clean water. Spray drift (spray carried off-target by wind) caused by spraying in high wind or using an excessively fine nozzle; remedy: avoid spraying when wind speed exceeds three metres per second; switch to a coarser nozzle to produce larger, heavier droplets less susceptible to drift.

Fill in the blank: A blocked nozzle on a knapsack sprayer should be cleaned by soaking in water and using a soft _________, never by blowing through the nozzle with the mouth.

| **Fault** | **Cause** | **Remedy** |
|---|---|---|
| **No spray output** | Blocked nozzle or clogged filter | Clean nozzle and filter thoroughly |
| **Uneven spray pattern** | Worn or damaged nozzle | Replace nozzle with correct type |
| **Leakage from tank** | Cracked tank or loose seals | Tighten seals or replace damaged tank |
| **Pressure not building** | Faulty pump or worn washers | Repair pump, replace washers |
| **Straps breaking** | Worn or overloaded harness | Replace straps and avoid overloading |
| **Chemical residue after use** | Inadequate cleaning | Rinse tank and hose with clean water after each use |

Box 3.1: Troubleshooting guide for common knapsack sprayer faults

### 3.4.3 Common faults in harvesting and storage equipment

Common hand thresher and maize sheller faults: drum blockage (crop material builds up and stops the drum rotating) caused by feeding too much crop at once or feeding wet crop; remedy: stop feeding, reverse the drum manually if possible to clear the blockage, reduce feed rate, and ensure crop is adequately dry before threshing. Grain cracking (maize kernels crack during shelling) caused by shelling at moisture content above 13 per cent or by worn or misaligned shelling pegs; remedy: dry the maize further before shelling; inspect and replace worn shelling pegs. Excessive grain loss through the drum (grain exits with straw) caused by worn drum beaters or incorrect drum-to-concave clearance; remedy: adjust clearance or replace worn beaters.

Common storage equipment faults: holes in hermetic bags (bag loses hermetic seal allowing oxygen entry); remedy: inspect all bags before loading and replace any with holes; once a loaded bag develops a hole during storage, move the grain to a functional bag immediately or treat chemically. Rust at metal silo seams (moisture penetrates the seal and initiates internal rusting that contaminates grain); remedy: inspect seams at the end of each season, wire-brush rust, apply anti-rust primer, and repaint before reloading. Rodent damage to cribs (gnawed wood allowing entry); remedy: repair gnawed sections and install sheet metal rodent guards at the base of all supporting posts.

Fill in the blank: Drum blockage in a hand thresher is caused by feeding too ________ crop at once or feeding wet crop; the remedy is to stop feeding, clear the blockage, and reduce the feed rate.

| Equipment | Fault | Cause | Remedy |
|---|---|---|---|
| **Hand Thresher** | Poor grain separation | Worn or blunt threshing teeth | Sharpen or replace teeth |
| **Hand Thresher** | Excessive grain breakage | Incorrect drum speed or misalignment | Adjust drum speed and align parts |

| | | | |
|---|---|---|---|
| **Knapsack Sprayer (used in harvest prep)** | Leakage during spraying | Damaged seals or cracked tank | Replace seals or repair tank |
| **Storage Bin/Silo** | Pest infestation | Poor sealing or cracks in structure | Seal cracks, fumigate, and maintain hygiene |
| **Storage Bin/Silo** | Mold growth | High moisture content in stored produce | Dry produce properly before storage, improve ventilation |
| **Tractor-mounted Plough (harvest prep)** | Poor soil turning | Worn ploughshare or improper depth setting | Replace ploughshare, adjust depth |
| **Tractor-mounted Plough** | Excessive fuel consumption | Poor maintenance or dull blades | Service tractor, sharpen blades |

Table 3.3: Common faults in harvesting and storage equipment with causes and remedies

### Pilot questions 3.4

1. State the cause and remedy for a loose tool head on a hoe.
2. Explain the correct procedure for clearing a blocked nozzle on a knapsack sprayer.
3. Explain why a cracked handle that penetrates halfway through the cross-section must be replaced immediately.
4. Describe the cause and remedy for drum blockage in a hand thresher.
5. State two common faults in storage equipment and the remedy for each.

## Series Summary

This Series covered the correct use and systematic maintenance of farm tools and equipment. We established three general principles of correct use (right tool for right job, apply force in the correct direction, inspect before use), explained task-to-tool matching, and described ergonomic principles for reducing fatigue during sustained tool use. We then covered the daily maintenance steps for hand tools (clean, dry, oil, check head, store correctly), the weekly steps (sharpen, tighten, inspect handles, oil), and the procedures for sharpening blades at the correct bevel angle and replacing cracked handles.

We covered the four principles of equipment maintenance (prevention, manufacturer instructions, genuine parts, trained operators), the specific maintenance procedures for spraying and harvesting equipment after use and before the season, and the purpose of maintenance records and schedules. Finally, we described a systematic troubleshooting approach for common faults in hand tools (loose head, blunt edge, rust, cracked handle, bent tine), spraying equipment (blocked nozzle, leaking tank, pump failure, corrosion, drift), and harvesting and storage equipment (drum blockage, grain cracking, hermetic bag holes, silo rust, rodent damage to cribs). By completing this Series, you should be able to achieve all nine Series Learning Outcomes (SLO 3.1 to SLO 3.9).

## Glossary of Terms

- **Bevel angle:** the angle at which the cutting edge of a blade is ground; typically 25 to 35 degrees for farm tools such as hoes and cutlasses.
- **De-burring:** the process of removing the wire burr (a thin rough edge) left on the back face of a blade after filing, using a whetstone or ceramic rod.
- **Ergonomics:** the science of designing work environments and tools to fit the physical capabilities of the worker, reducing strain, fatigue, and injury risk.
- **Equipment maintenance record:** a document recording the maintenance history of a piece of equipment including dates of service, work performed, parts replaced, and current operational status.
- **Handle kerf:** the slot cut into the top of a tool handle into which a wedge is driven to expand the handle inside the tool head socket, securing the head.

- **Maintenance schedule:** a calendar specifying when each maintenance task is due for each piece of equipment or tool; posted in the tool store and ticked off as completed.
- **Nozzle orifice:** the small opening at the tip of a spray nozzle through which the spray solution is forced under pressure to form a controlled droplet pattern.
- **Operator efficiency:** the rate and quality of work output achieved by an operator per unit of time and effort; improved by correct tool selection, ergonomic working posture, and systematic work organisation.
- **Pump cup (piston seal):** a rubber cup or seal inside the knapsack sprayer pump that creates the pressure needed to force spray solution through the nozzle; worn seals are a common cause of pump failure.
- **Rust:** the reddish-brown oxide of iron formed when iron or steel is exposed to moisture and oxygen; weakens metal and reduces tool life if not removed and the surface protected.
- **Spray drift:** the movement of spray droplets off-target due to wind; reduced by spraying in low-wind conditions and using coarser nozzle settings that produce larger, heavier droplets.
- **Task-to-tool matching:** the practice of selecting the most appropriate tool or equipment for a specific agricultural task based on soil type, crop type, scale of operation, and tool design capabilities.
- **Tool maintenance register:** a record in the school farm tool store documenting the condition, maintenance history, and serviceable status of every farm tool.
- **Wedge:** a tapered piece of hardwood or metal driven into the kerf at the top of a tool handle to expand it inside the eye of the tool head, securing the head firmly.
- **Wire burr:** a thin, rough metal edge left on the non-filed face of a blade after sharpening with a file; must be removed with a whetstone to produce a clean, durable cutting edge.
- **Whetstone:** a fine-grained abrasive stone used to de-burr a blade and produce a final fine edge after primary sharpening with a file.

## Concept Check Questions [Series 3]

Objective Questions

1. The first principle of correct tool use is to use the ________ tool for the right job. (Linked to SLO 3.1)
2. ________ is the science of designing work to fit the worker, reducing strain and fatigue during farm tool use. (Linked to SLO 3.3)
3. Daily maintenance of farm tools includes cleaning, drying, oiling metal surfaces, checking for loose heads, and ________ correctly in the tool store. (Linked to SLO 3.4)
4. After sharpening with a file, a ________ is used on the back face of the blade to remove the wire burr. (Linked to SLO 3.5)
5. A blocked nozzle should be cleaned with a soft brush after soaking in water; it must never be cleared by ________ through it with the mouth. (Linked to SLO 3.9)

Short-Answer Questions

6. State three general principles of correct tool and equipment use. (Linked to SLO 3.1)
7. Describe the daily maintenance steps for a hand tool after a farm session. (Linked to SLO 3.4)
8. Describe the correct procedure for sharpening a hoe blade. (Linked to SLO 3.5)
9. State the four principles of equipment maintenance. (Linked to SLO 3.6)
10. State the cause and remedy for three common faults in a knapsack sprayer. (Linked to SLO 3.9)

Long-Answer Questions

11. Explain the principles of correct tool and equipment use, describe how to match tools to tasks, and explain the ergonomic principles that improve operator efficiency and reduce fatigue during farm work. (Linked to SLOs 3.1, 3.2, 3.3)
12. Describe the daily, weekly, and seasonal maintenance procedures for farm hand tools and farm equipment, and explain the purpose and content of maintenance records and schedules. (Linked to SLOs 3.4, 3.5, 3.6, 3.7, 3.8)
13. Identify and describe the causes and remedies for common faults in farm hand tools, knapsack sprayers, and harvesting and storage equipment. (Linked to SLO 3.9)

## Answers to Concept Check Questions [Series 3]

Objective Questions

1. Right.
2. Ergonomics.
3. Storing.
4. Whetstone.
5. Blowing.

Short-Answer Questions

6. Use the right tool for the right job; apply force in the direction the tool is designed to work; inspect the tool before each use to confirm it is in safe working condition.
7. Remove all soil and plant material from the tool surface; wipe all metal parts completely dry; apply a thin coat of oil to exposed metal surfaces; check the tool head for looseness; hang or rack the tool correctly in the tool store.
8. Secure the blade in a vice; hold a flat bastard file at the bevel angle (25 to 35 degrees); push the file forward from heel to tip in smooth even strokes; check the edge for

sharpness after every five to ten strokes; when the bevel is restored, use a whetstone on the back face to remove the wire burr.

9. Prevention is better than cure; follow manufacturer's instructions; use only genuine spare parts or approved equivalents; train operators correctly to avoid errors that cause most equipment failures.
10. Any three with cause and remedy: blocked nozzle (dried chemical or soil in orifice; remove, soak, and clean with soft brush); leaking tank (cracked tank or worn lid gasket; repair with adhesive or replace gasket); pump not building pressure (worn or cracked pump cup or piston seal; replace the seal); spray drift (high wind or excessively fine nozzle; spray in low wind and switch to coarser nozzle).

Long-Answer Questions

11. General principles: right tool for right job; apply force in correct design direction; inspect before use and report damage promptly. Improvised use damages tools and creates safety risks. Task-to-tool matching: soil type (garden hoe for sandy loam, mattock for hard clay), crop type and growth stage (broad hoe for inter-row weeding, narrow hand weeder for within-row), scale (knapsack sprayer for 1 to 2 ha/day, hand compression for plots under 0.1 ha). Ergonomics: adjust handle length so operator works without deep stooping; grip firmly but not excessively; use body weight and momentum rather than arm strength; take 5 to 10 minute rests every hour; organise work in systematic rows; assign tasks matched to physical capacity.
12. Daily tool maintenance: clean soil and plant material, wipe metal dry, apply oil, check head tightness, store correctly. Weekly: sharpen cutting edges (file at 25 to 35 degrees, de-burr with whetstone), tighten loose heads with wedge, inspect handles for cracks, apply linseed oil to wooden handles, remove rust with steel wool, record condition in register. Equipment maintenance: spraying equipment (triple-rinse, disassemble and clean nozzle, check seals, grease rubber parts, store empty and disassembled; pre-season: check for leaks, calibrate, replace worn seals); harvesting equipment (clean drum/sieves, lubricate bearings, tighten bolts, inspect sieves; pre-season: full inspection, replace worn

parts, test-run). Maintenance records: name, ID, acquisition date, scheduled intervals, dates of service, work done, parts replaced, status. Maintenance schedule: calendar specifying when tasks are due, posted in tool store, ticked off as completed, missed tasks rescheduled.

13. Hand tools: loose head (dried handle; wedge or replace handle); blunt edge (use; sharpen with file and whetstone); rust (moisture; steel wool and oil); cracked handle penetrating half cross-section (stress or misuse; replace immediately); bent tine (misuse; blacksmith straightening if ductile, or condemn). Spraying equipment: blocked nozzle (dried chemical; soak and soft-brush clean); leaking tank (cracked or worn gasket; repair or replace gasket); pump not building pressure (worn seal; replace pump cup); chemical corrosion (failure to rinse; flush with washing soda or vinegar then triple-rinse); spray drift (high wind or fine nozzle; spray in calm conditions, use coarser nozzle). Harvesting and storage: drum blockage (overfeeding or wet crop; stop, clear, reduce feed rate, ensure dry crop); grain cracking (high moisture or worn pegs; dry further, replace pegs); hermetic bag holes (puncture; replace bag or move grain immediately); silo rust (moisture at seams; wire-brush, prime, repaint); rodent damage to crib (gnawing; repair wood and install metal guards).

## Answers to Pilot Questions [Series 3]

Part 3.1: Principles of Correct Use

1. Any three: use the right tool for the right job; apply force in the direction the tool is designed to work; maintain the correct operating pressure, speed, or flow rate for equipment; inspect before each use to confirm safe working condition.
2. Task-to-tool matching means selecting the tool or equipment whose design capabilities best match the specific requirements of the task. Example: soil preparation on compacted clay soil requires a mattock or powered cultivator rather than a garden hoe, because the mattock's heavy pick end can break the hardpan that a light hoe blade cannot penetrate effectively.

3. Ergonomics in farm tool use means designing the way tools are used to fit the physical capabilities of the operator, reducing unnecessary physical strain, fatigue, and the risk of musculoskeletal injury. It includes adjusting handle length, using body weight rather than arm strength for hoeing, gripping without excessive tension, and organising work systematically.
4. Any two: adjust the handle length so the operator can stand in an upright or slightly bent position when working, avoiding the deep stooping that strains the lower back; use the weight and downward momentum of the hoe head to drive the blade into the soil rather than pulling hard with the arm and shoulder muscles, which fatigue rapidly.
5. Improvised use forces the tool into conditions of stress it was not designed to withstand, causing rapid damage (a cutlass used as a lever may crack at the blade-handle junction), reducing the tool's useful life, and putting the operator in an uncontrolled situation where the tool is more likely to slip or break suddenly and cause a serious injury.

Part 3.2: Maintenance of Farm Tools

1. Remove all soil and plant material from the tool surface using a cloth, brush, or scraper. Wipe all metal parts thoroughly dry to prevent rust formation. Apply a thin coat of waste engine oil or vegetable oil to all exposed metal surfaces. Check the tool head for looseness by holding the handle and shaking firmly. Hang or rack the tool correctly in the tool store with the blade or tines safely positioned.
2. Inspect all cutting edges for bluntness and sharpen as needed using a file and whetstone. Check all tool heads and tighten or re-wedge any that have become loose. Inspect wooden handles for cracks, splinters, and rot; sand down rough spots. Apply linseed oil or engine oil to wooden handles to prevent drying and cracking. Oil all metal surfaces. Remove any rust spots with steel wool before they deepen. Record the condition of each tool in the maintenance register.
3. Secure the hoe blade in a vice or on a stable surface. Select a flat bastard file suited to the blade metal. Hold the file at the existing bevel angle (approximately 25 to 35 degrees). Push the file forward along the blade from heel to tip in smooth, even strokes,

maintaining the angle consistently. After every five to ten strokes, test sharpness by pressing the edge lightly against the thumbnail. When the bevel is fully restored, use a whetstone on the back face of the blade to remove the wire burr and produce a clean, durable cutting edge.

4. Remove the damaged handle from the tool head by driving it out with a punch and hammer if needed. Obtain a replacement handle of the correct length, diameter, and species (hardwood). Insert the new handle through the eye of the tool head from the bottom until it protrudes slightly at the top. Drive a hardwood or metal wedge firmly into the kerf at the top of the handle to expand it inside the eye. Test by striking the head firmly on the ground to confirm it is secure. Sand the new handle smooth and treat with linseed oil before use.
5. Accountability (shows which tools are in service and which are damaged, preventing disappearance without documentation); planning (enables the teacher to anticipate replacements and budget accordingly before the season); quality control (patterns of repeated breakage of a particular tool type prompt investigation of misuse or inadequate quality).

Part 3.3: Maintenance of Farm Equipment

1. Prevention is better than cure (scheduled maintenance prevents most failures); follow manufacturer's instructions (correct lubricants, torques, and adjustments as specified); use only genuine spare parts or approved equivalents (inferior substitutes fail prematurely and damage other components); train operators correctly (most failures result from operator error, not genuine mechanical failure).
2. Triple-rinse the tank and lance with clean water after every use. Remove, disassemble, and clean the nozzle with a soft brush. Check all rubber seals and O-rings for cracks and replace damaged ones. Lightly grease all rubber seals to preserve flexibility. Inspect the pump mechanism for wear. Store the sprayer empty, disassembled, and in a locked, dry store.

3. Brush all grain, crop residues, and dust from the threshing drum, sieves, and collection trays. Lubricate all bearings and rotating shafts with the correct lubricant. Check and tighten all bolts and fasteners. Inspect sieves for holes or deformation and replace damaged ones. Oil all unpainted metal surfaces to prevent rust during storage.
4. Equipment name and identification number; date of acquisition and purchase cost; scheduled maintenance intervals from the manufacturer's manual; dates on which maintenance was performed; description of work done at each service; parts replaced and their cost; and current operational status (serviceable or requiring repair).
5. A maintenance schedule is a calendar that specifies the date on which each maintenance task is due for each piece of equipment on the school farm. It should be posted in the tool store so that the agriculture teacher and farm supervisor can see at a glance what maintenance is due, tick off completed tasks, and reschedule any that were missed. Without a posted schedule, maintenance tends to be done reactively after a failure rather than proactively to prevent one.

Part 3.4: Troubleshooting Common Faults

1. Cause: the wooden handle has dried and shrunk inside the tool head eye, creating a loose fit that allows the head to move during use. Remedy: drive a new hardwood or metal wedge firmly into the kerf at the top of the handle to expand it inside the eye; if the handle is too worn or cracked to re-wedge securely, replace the entire handle.
2. Remove the nozzle from the lance. Soak the nozzle in a container of clean water for several minutes to soften any dried chemical residue. Use a soft brush (a small bottle brush or toothbrush) to clean the nozzle orifice, filter screen, and external surfaces. Hold the nozzle up to the light to confirm the orifice is clear and the spray pattern holes are unobstructed. Refit the nozzle and test with clean water before resuming chemical use. Never blow through the nozzle with the mouth, as this directly exposes the mouth to pesticide residue.
3. A crack that penetrates more than halfway through the handle cross-section has removed more than half of the structural material at that point. Under the repeated bending stress

of normal hoeing or digging, the remaining material will fail without warning, causing the head to separate from the handle suddenly while in motion. The high-energy impact of a flying tool head is a serious injury risk to both the operator and nearby workers. The risk of sudden failure is too high to continue using a handle in this condition, regardless of how slight the crack appears externally.

4. Cause: the operator is feeding too large a quantity of crop into the threshing drum at once, or the crop being fed is too wet (high moisture content), causing the material to compact rather than flow through the drum. Remedy: stop feeding immediately; manually reverse the drum if possible to release the compacted material; reduce the rate of feeding to small, steady bundles; if the problem persists, allow the crop to dry further before threshing and verify that the crop moisture content is within the recommended range for the equipment.
5. Any two: hole in a hermetic storage bag (puncture during loading or storage allows oxygen to enter, destroying the hermetic environment); remedy: inspect all bags before loading; if a loaded bag develops a hole during storage, transfer the grain immediately to an intact bag or begin chemical treatment. Rust at metal silo seams (moisture penetrates the seam seal and causes internal rusting that contaminates grain and weakens the structure); remedy: at the end of each season, inspect all seams, wire-brush rust spots back to bare metal, apply anti-rust primer, and repaint before the structure is reloaded.

## References and Attributions [Series 3]

Textual References (Books and External Sources)


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Figures, Plates, Tables, and Boxes

- Table 3.1: Task-to-tool matching guide Attribution: AI generated. Suggested OER search string: "task tool matching guide school farm operations hoe sprayer OER table".
- Figure 3.1: Hoe blade sharpening diagram Attribution: AI generated. Suggested OER search string: "sharpening hoe blade file angle bevel whetstone deburr diagram OER".
- Table 3.2: Maintenance schedule for sprayer and thresher Attribution: AI generated. Suggested OER search string: "knapsack sprayer hand thresher maintenance schedule table OER".
- Box 3.1: Knapsack sprayer troubleshooting guide Attribution: AI generated. Suggested OER search string: "knapsack sprayer troubleshooting faults nozzle pump leak OER box".
- Table 3.3: Harvesting and storage equipment faults Attribution: AI generated. Suggested OER search string: "harvesting storage equipment faults thresher silo hermetic bag OER table".

**Course code: AGE 208**

**Course title: Farm Tools and Equipment**

**Course credit load: 2 Units**

# Series 4: Types of Farm Machines and Their Uses

- **Part 4.1: Introduction to Farm Machines**
  - Sub Part 4.1.1: Definition and classification of farm machines
  - Sub Part 4.1.2: Importance of farm mechanisation in Nigeria
  - Sub Part 4.1.3: Power sources for farm machines
- **Part 4.2: Tillage Machines**
  - Sub Part 4.2.1: Types and functions of tillage machines
  - Sub Part 4.2.2: Primary tillage: ploughs
  - Sub Part 4.2.3: Secondary tillage: harrows, ridgers, and cultivators
- **Part 4.3: Planting, Crop Protection, and Harvesting Machines**
  - Sub Part 4.3.1: Planting machines
  - Sub Part 4.3.2: Crop protection machines
  - Sub Part 4.3.3: Harvesting and processing machines
- **Part 4.4: Water Management and Post-Harvest Machines**
  - Sub Part 4.4.1: Irrigation and water management equipment
  - Sub Part 4.4.2: Post-harvest processing machines

- Sub Part 4.4.3: Importance and limitations of farm mechanisation in Nigeria

## Introduction

Farm machines are powered implements, usually tractor-drawn or engine-driven, that carry out agricultural operations at a scale and speed far beyond what hand tools and simple equipment can achieve. Understanding the types, uses, and operational principles of farm machines is an important component of agricultural education, even for students whose immediate farming context is smallholder and hand-tool based. Knowledge of machines prepares students for future roles in commercial farming, agribusiness, and agricultural extension.

This Series covers the definition and classification of farm machines, the importance of mechanisation in Nigeria, the major power sources, and the types and uses of machines for tillage, planting, crop protection, harvesting, irrigation, and post-harvest processing. We conclude with an honest assessment of the benefits and limitations of mechanisation in the Nigerian context. All content connects to the course learning outcomes on the importance and application of agricultural machinery and equipment.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** define farm machines and classify them by type and power source (Linked to Part 4.1),
- **SLO 4.2** explain the importance of farm mechanisation in Nigeria (Linked to Part 4.1),
- **SLO 4.3** describe the major power sources used for farm machines in Nigeria (Linked to Part 4.1),
- **SLO 4.4** describe the types and functions of primary and secondary tillage machines (Linked to Part 4.2),

- **SLO 4.5** describe the types and functions of planting machines (Linked to Part 4.3),
- **SLO 4.6** describe the types and functions of crop protection machines (Linked to Part 4.3),
- **SLO 4.7** describe the types and functions of harvesting and processing machines (Linked to Part 4.3),
- **SLO 4.8** describe irrigation and water management equipment and post-harvest processing machines (Linked to Part 4.4), and
- **SLO 4.9** evaluate the importance and limitations of farm mechanisation in the Nigerian agricultural context (Linked to Part 4.4).

## 4.1 Introduction to Farm Machines

### 4.1.1 Definition and classification of farm machines

A farm machine is a mechanised implement powered by an engine or motor that performs one or more agricultural operations at a scale and speed not achievable with hand tools or animal draught. Farm machines are distinguished from simple farm equipment by their mechanical complexity, their dependence on an external power source (combustion engine, electric motor, or power take-off from a tractor), and the technical skill required to operate and maintain them. They are classified by function: tillage machines (ploughs, harrows, ridgers), planting machines (seed drills, transplanting machines), crop protection machines (boom sprayers, dusters), harvesting machines (reapers, combine harvesters, threshers), and post-harvest/processing machines (driers, mills, shellers).

Farm machines are also classified by power source and mobility: tractor-powered machines (implements drawn or driven by a tractor via the drawbar or power take-off shaft), self-propelled machines (with their own engine and drivetrain, such as a combine harvester or motorised transplanter), and stationary machines (fixed in position and driven by a dedicated engine or electric motor, such as a grain mill or rice huller). Students should be able to classify any named machine by both its function and its power/mobility type.

Fill in the blank: Farm machines are classified by function (tillage, planting, crop protection, harvesting, post-harvest) and by power source (_________ powered, self-propelled, or stationary).

| **Function** | **Manual Power** | **Animal Power** | **Mechanical Power** |
|---|---|---|---|
| **Land Preparation** | Hand hoe, cutlass | Ox-drawn plough | Tractor-mounted plough (e.g., Massey Ferguson in Nigeria) |
| **Planting** | Hand dibbler | Animal-drawn planter | Mechanical seed drill (e.g., John Deere seed drill used in Nigerian farms) |
| **Weeding** | Hand weeder | Animal-drawn cultivator | Mechanical rotary weeder |
| **Harvesting** | Sickle, hand knife | Animal-drawn cart for transport | Combine harvester (e.g., New Holland harvester in Nigeria) |
| **Processing** | Hand thresher | Animal-powered grinding stone | Rice milling machine, cassava grater (locally fabricated in Nigeria) |
| **Storage & Handling** | Manual bags, baskets | Animal-drawn carts | Grain silos, mechanized conveyors |

Table 4.1: Classification of farm machines by function and power source with Nigerian examples

### 4.1.2 Importance of farm mechanisation in Nigeria

Farm mechanisation is important in Nigeria for five reasons. Timeliness: machines allow land preparation, planting, and harvesting to be completed within the narrow optimal weather window, reducing yield losses from delayed operations. Labour saving: Nigeria faces an increasing rural labour shortage as young people migrate to cities; machines substitute for labour that is no longer available or affordable. Scale: machines enable farmers to cultivate areas far larger than is possible with hand tools, making commercial farming viable. Quality: mechanised operations (uniform planting depth, consistent pesticide coverage, precise threshing) produce more uniform, higher-quality output.

Post-harvest loss reduction: mechanised threshing, milling, and drying reduce the losses that occur when harvesting and processing are done manually over a prolonged period. Despite these benefits, the level of mechanisation in Nigerian agriculture remains low compared with other sectors: estimates suggest that tractor density in Nigeria is fewer than one tractor per 1,000 hectares of arable land, compared with 20 or more in developed countries. Addressing the mechanisation gap is a priority of Nigerian agricultural development policy under various government programmes.

Fill in the blank: Farm mechanisation improves ________ by allowing land preparation, planting, and harvesting to be completed within the narrow optimal weather window, reducing yield losses from delayed operations.

### 4.1.3 Power sources for farm machines

The main power sources for farm machines in Nigeria are: animal draught (oxen, donkeys, and horses used in the drier northern states to draw simple tillage and planting implements), diesel or petrol engines (used in tractors, motorised threshers, water pumps, and processing machines; the most common power source in mechanised Nigerian agriculture), electric motors (used for stationary processing machines such as grain mills and rice hullers in urban and peri-urban areas where grid power is available), and solar-powered pumps (increasingly used for small-scale irrigation in off-grid rural communities).

The tractor is the central power unit of mechanised farming, providing both drawbar pull for trailed implements and power take-off (PTO) drive for implements that require rotating shaft power (such as mowers, balers, and rotary tillers). A standard agricultural tractor has a PTO speed of 540 or 1,000 revolutions per minute. The four-wheel-drive tractor performs better on soft or wet soils than the two-wheel-drive version. Two-wheel tractors (power tillers or walking tractors) are used for small-scale mechanisation on plots of 0.5 to 5 hectares and are more affordable and fuel-efficient than full-sized tractors.

Fill in the blank: The tractor provides both drawbar pull for trailed implements and ________ drive for implements requiring rotating shaft power such as rotary tillers and mowers.

## Pilot questions 4.1

1. Define a farm machine and state three ways in which it differs from simple farm equipment.
2. Classify farm machines by both function and power source and give one Nigerian example of each type.
3. State five reasons why farm mechanisation is important in Nigeria.
4. Name four power sources for farm machines in Nigeria and give one machine that uses each.
5. Explain the difference between drawbar pull and power take-off (PTO) drive on a tractor.

## 4.2 Tillage Machines

### 4.2.1 Types and functions of tillage machines

Tillage machines mechanise the loosening, turning, and preparation of the soil for planting. They are classified as primary tillage machines (which perform the initial deep breaking of the soil) and secondary tillage machines (which refine the seedbed after primary tillage by breaking clods, levelling, and firming the soil). The need for tillage depends on the soil type, previous land use, and the crop to be grown. Minimum tillage and zero tillage are increasingly practised where soil compaction and erosion risk are high, and where the goal is to reduce fuel and labour costs.

The selection of the correct tillage machine and tillage depth is critical: tillage that is too shallow fails to control weeds and break compacted subsoil; tillage that is too deep exposes infertile subsoil and wastes fuel. Soil should be tilled to the depth of the crop's root zone (typically 15 to 30 cm for most annual crops). Tillage should be done when the soil is at the correct moisture content: neither too dry (hard and resistant, causing excessive wear) nor too wet (soil smears rather than crumbles, destroying structure and creating a plough pan).

Fill in the blank: ________ tillage machines perform the initial deep breaking of the soil, while secondary tillage machines refine the seedbed by breaking clods, levelling, and firming.

### 4.2.2 Primary tillage: ploughs

The mouldboard plough is the most widely used primary tillage implement in Nigeria. It consists of a share (the cutting edge that slices through the soil horizontally), a mouldboard (the curved plate that lifts, turns, and inverts the furrow slice), and a landside (which stabilises the plough in the furrow). The mouldboard plough inverts the soil to a depth of 15 to 30 cm, burying crop residues and weeds and exposing the lower soil layer. It is most suitable for virgin land, heavy weed infestations, and soils with a surface-compacted crust.

The disc plough uses concave rotating discs to cut and turn the soil; it is more suitable than the mouldboard plough for hard, dry, stony, or sticky soils where the disc can roll over obstructions rather than catching on them. The subsoiler (chisel plough) penetrates to depths of 40 to 60 cm to break up a hardpan or compacted subsoil layer without inverting the topsoil; it is used to improve deep drainage and root penetration. Animal-drawn ploughs (ox-drawn single-bottom mouldboard ploughs) are common in the savanna zones of northern Nigeria.

Fill in the blank: The mouldboard plough consists of a share, a ________, and a landside; the mouldboard lifts, turns, and inverts the furrow slice to bury weeds and crop residues.

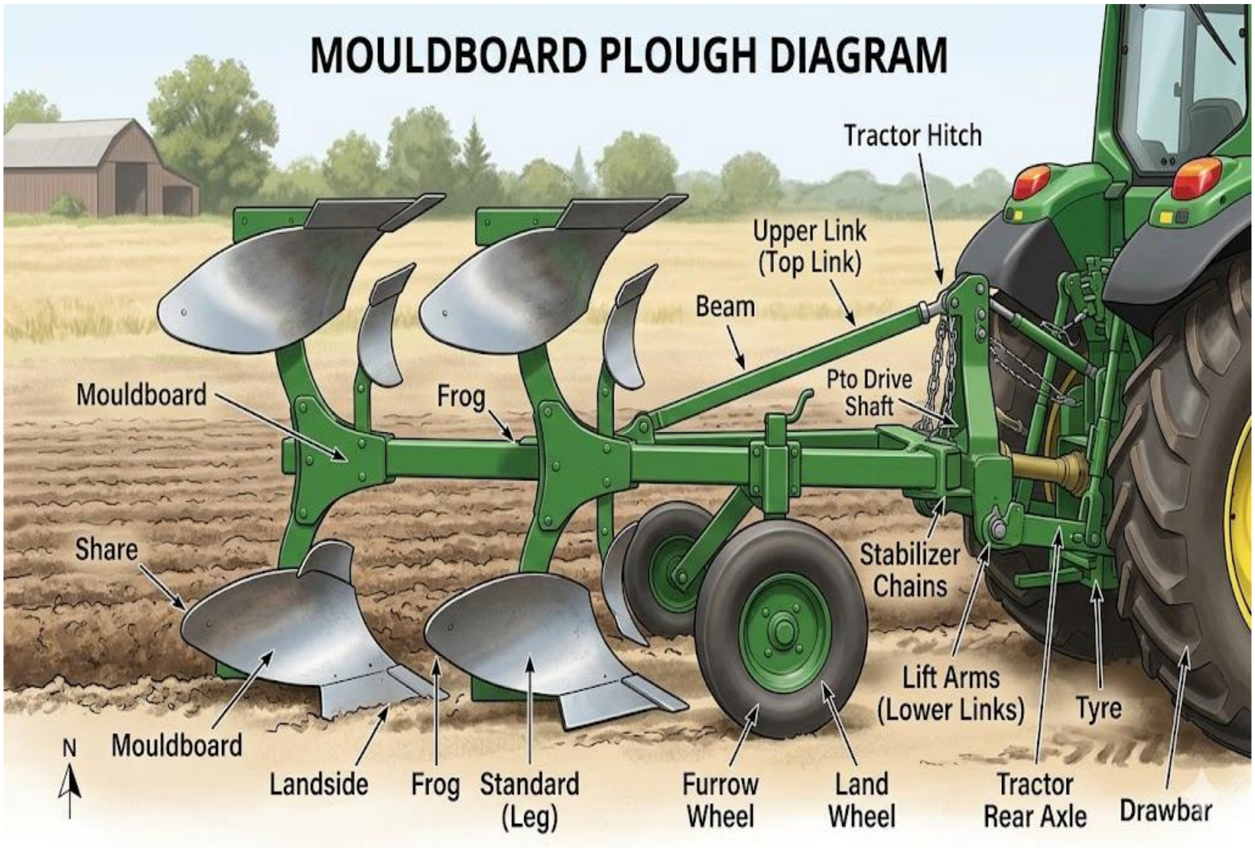


Figure 4.1: Diagram of a mouldboard plough showing its main components

### 4.2.3 Secondary tillage: harrows, ridgers, and cultivators

Disc harrows are the most commonly used secondary tillage implement in Nigeria. They consist of rows of concave steel discs that cut and break the soil to a depth of 10 to 15 cm, breaking up ploughed clods and incorporating crop residues. The offset disc harrow operates at an angle to the direction of travel to create a more aggressive cutting action. Tine harrows (spike-tooth and spring-tooth) use rigid or spring-loaded tines to break clods and level the seedbed. Chain harrows consist of interlinked iron links dragged across the field to level, firm, and smooth the surface.

The ridger (lister or furrower) is a tractor-drawn implement used to form raised beds or ridges for planting root crops (yam, cassava), vegetables, and some cereals in Nigeria's high-rainfall zones. The ridger creates a furrow on either side and throws the soil up into a ridge between them. The rotary cultivator (rotovator) uses power-take-off driven rotating L-shaped blades (tines) to till, break up clods, and incorporate organic matter in a single pass; it produces a very fine tilth suitable for vegetable seedbed preparation and is commonly used in market garden operations.

Fill in the blank: The ________ cultivator uses PTO-driven rotating L-shaped blades to till the soil, break up clods, and incorporate organic matter in a single pass, producing a fine tilth.

### Pilot questions 4.2

1. Distinguish between primary and secondary tillage and give one example of each.
2. Describe the three main components of a mouldboard plough and the function of each.
3. Explain when a disc plough is preferred over a mouldboard plough.
4. Describe two secondary tillage implements and the seedbed conditions each produces.
5. Explain what a ridger is and state the crops for which it is most commonly used in Nigeria.

## 4.3 Planting, Crop Protection, and Harvesting Machines

### 4.3.1 Planting machines

Planting machines deposit seeds into the soil at the correct depth and spacing, replacing the slow and inconsistent process of manual planting. The seed drill is the most widely used planting machine; it consists of a seed hopper, a metering mechanism that releases seeds at a controlled rate, seed tubes that guide seeds to the furrow openers, and a covering device (press wheel or drag chain) that closes the furrow over the seed. Seed drills are configured for different row spacings and seed sizes; a universal seed drill can be adjusted for cereals (maize, sorghum, rice) by changing the seed plate.

The transplanting machine (rice transplanter) is used to transplant pregerminated rice seedlings from nursery trays into a flooded paddy field at precise spacing; it reduces the labour cost of transplanting by up to 80 per cent compared with manual transplanting and produces more uniform crop stands. The fertiliser broadcaster (spreader) is used to apply granular fertiliser uniformly across a field; it can be mounted on a tractor or carried as a centrifugal hand-held unit.

Precision planters for vegetables and groundnuts deposit individual seeds at prescribed intervals, eliminating the thinning labour required after broadcast planting.

Fill in the blank: The seed ________ consists of a seed hopper, metering mechanism, seed tubes, furrow openers, and a covering device that deposits seeds at the correct depth and spacing during planting.

### 4.3.2 Crop protection machines

Crop protection machines apply pesticides, fungicides, herbicides, and foliar fertilisers over large areas at controlled rates. The tractor-mounted boom sprayer consists of a tank (200 to 1,000 litres), a pump driven by the tractor PTO, a boom with multiple nozzles spanning 6 to 18 metres, and a pressure regulator. It can cover 5 to 15 hectares per hour, far exceeding the knapsack sprayer's capacity. Correct boom height (50 cm above the crop canopy) and forward speed are critical for achieving uniform coverage; boom sections can be switched off to avoid overlapping on irregular field shapes.

The air-blast sprayer (mist blower) uses a high-speed air stream from a fan to carry fine droplets deep into dense crop canopies such as orchards, plantations, and tall crops; it is used for cocoa, citrus, and oil palm pest management in Nigeria. Granule applicators deposit dry granular pesticides or fertilisers into the soil or onto the crop canopy; they are used for soil insecticide incorporation and slow-release fertiliser application. Unmanned aerial vehicles (drones) equipped with spraying systems are an emerging technology for large-scale precision crop protection in Nigeria.

Fill in the blank: The tractor-mounted ________ sprayer uses a boom with multiple nozzles spanning 6 to 18 metres and can cover 5 to 15 hectares per hour.

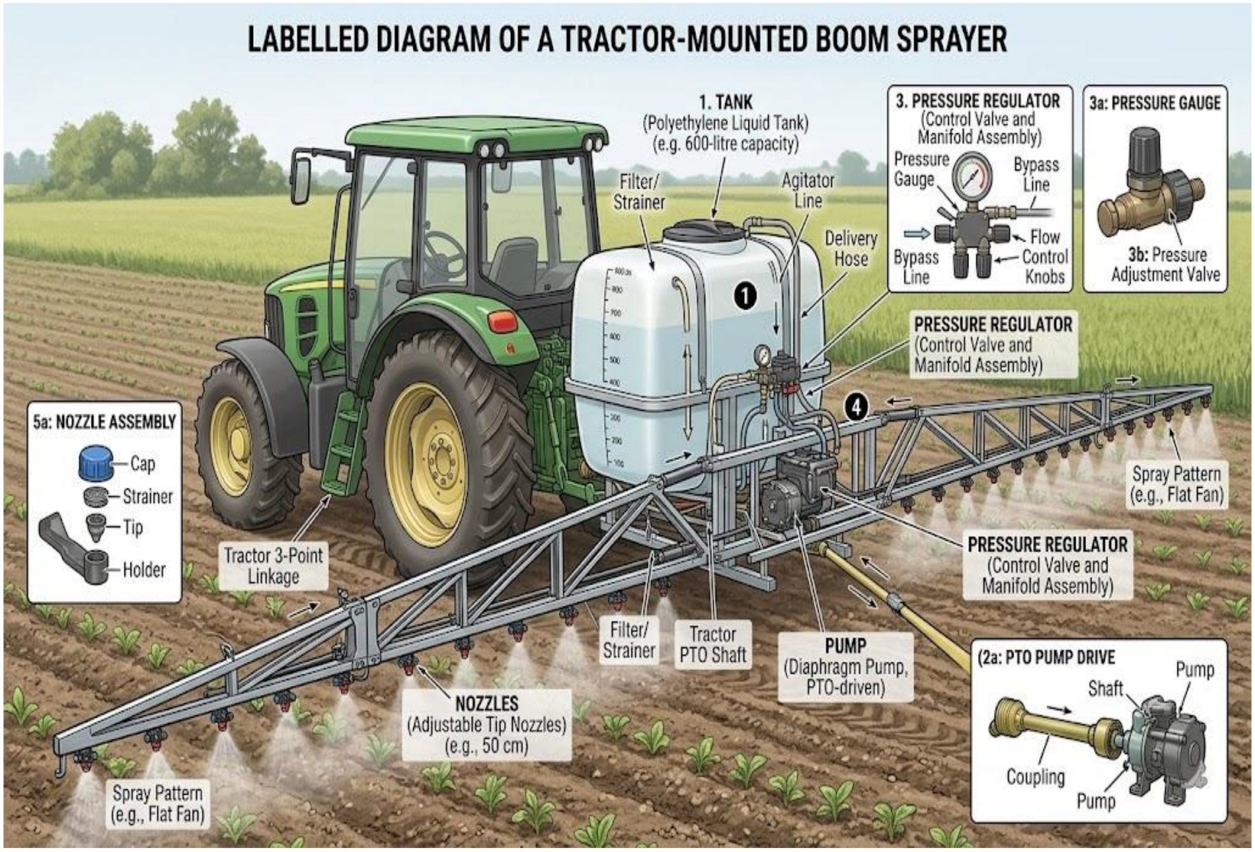


Figure 4.2: Diagram of a tractor-mounted boom sprayer showing its main components

### 4.3.3 Harvesting and processing machines

The combine harvester performs reaping (cutting the standing crop), threshing (separating grain from straw), cleaning (removing chaff and light material by air blast), and grain handling (conveying grain to a tank) in a single continuous operation. It drastically reduces harvest labour and post-harvest loss but requires large flat fields, dry crop conditions, and expensive fuel and maintenance. In Nigeria, combine harvesters are used mainly on large-scale rice and wheat farms in the north; they are hired out by contractors to smallholder groups at harvest time.

The motorised thresher (stationary or portable) uses a PTO-driven or engine-driven rotating drum to thresh rice, sorghum, millet, and soybeans in a few hours compared with days of manual threshing; it is the most widely adopted harvesting machine among Nigerian smallholders because of its affordability and applicability to small-scale farms. The groundnut picker removes pods from the vine mechanically; the rice huller removes the husk from paddy rice; the maize shelling machine shells large quantities of dried maize; and the cassava processing machine (grating, pressing, and sieving unit) processes cassava into garri. These post-harvest machines reduce drudgery and post-harvest loss significantly.

Fill in the blank: The combine harvester performs reaping, threshing, ________, and grain handling in a single continuous operation, drastically reducing harvest labour and post-harvest loss.

### Pilot questions 4.3

1. Describe the components of a seed drill and explain how it deposits seeds in the soil.
2. Explain how a tractor-mounted boom sprayer operates and state its coverage rate.
3. State the four operations performed by a combine harvester in a single pass.
4. Explain why the motorised thresher has been more widely adopted than the combine harvester among Nigerian smallholders.
5. Name three post-harvest processing machines and state the crop and processing operation for each.

## 4.4 Water Management and Post-Harvest Machines

### 4.4.1 Irrigation and water management equipment

Irrigation equipment delivers controlled quantities of water to crops during periods of insufficient rainfall. The main types of irrigation systems used in Nigeria are: surface irrigation (water delivered by gravity along furrows or borders; lowest cost but least efficient, with water losses of 40 to 60 per cent through evaporation and deep percolation), sprinkler irrigation (water pumped through pipes and distributed through rotating or fixed sprinkler heads; more efficient than surface, suitable for most soil types), and drip irrigation (water delivered directly to the root zone through emitters in surface or buried drip lines; the most efficient system, with water use efficiencies of 85 to 95 per cent, but also the most expensive).

The water pump is the central piece of irrigation equipment in most Nigerian smallholder irrigation schemes. Petrol or diesel centrifugal pumps are the most common type; they draw water from rivers, boreholes, or reservoirs and deliver it through hoses or pipes to the field. Solar-powered pumps are increasingly used in off-grid areas. The pump must be matched to the water source, head (vertical lift), and discharge volume required by the irrigation system. A pump with insufficient capacity leaves part of the field unirrigated; an oversized pump wastes fuel and may erode furrows.

Fill in the blank: Drip irrigation is the most ________ irrigation system with water use efficiency of 85 to 95 per cent; water is delivered directly to the root zone through emitters in surface or buried drip lines.

### 4.4.2 Post-harvest processing machines

Post-harvest processing machines convert harvested produce into market-ready or storable products. The grain drier (flat-bed or batch drier) uses heated air to reduce grain moisture content rapidly and uniformly after harvest; it is used for rice, maize, and sorghum in wet-season harvests when solar drying is not possible. The rice milling machine (huller and whitener) removes the husk (hulling) and bran layers (whitening) from paddy rice in one or two passes, producing milled white rice; it is the most widely used processing machine in Nigeria's major rice-producing states.

The hammer mill grinds dried grain (maize, sorghum, millet) into flour by high-speed impact of rotating hammers against the grain; it is the standard machine for producing maize flour (for ogi and tuwo) and guinea corn flour across Nigeria. The oil palm fruit processor (digester, press, and clarifier) extracts crude palm oil from palm fruit bunches; it has transformed small-scale palm oil production in the south by replacing the labour-intensive hand-pressing method. The cassava processing line (grater, hydraulic press, and sifter) processes cassava to garri efficiently and at larger scale than traditional hand methods.

Fill in the blank: The ________ mill grinds dried grain into flour by high-speed impact of rotating hammers; it is the standard machine for producing maize and guinea corn flour across Nigeria.

| Machine | Crop Processed | Product Produced |
| --- | --- | --- |
| **Rice milling machine** | Rice | Polished rice grains |
| **Cassava grater** | Cassava | Cassava mash for gari or fufu |
| **Palm oil press** | Palm fruits | Crude palm oil |
| **Groundnut oil expeller** | Groundnut | Groundnut oil and cake |
| **Maize sheller** | Maize | Shelled maize grains |
| **Soybean oil extractor** | Soybeans | Soybean oil and meal |
| **Cocoa depulper/fermenter** | Cocoa pods | Fermented cocoa beans |
| **Threshing machine** | Sorghum, millet | Clean grains |
| **Hammer mill** | Maize, sorghum, cassava | Flour or animal feed |
| **Fruit juice extractor** | Citrus, pineapple | Fresh juice |

Table 4.2: Post-harvest processing machines used in Nigeria with the crop and product each produces

### 4.4.3 Importance and limitations of farm mechanisation in Nigeria

Farm mechanisation is important in Nigeria because it increases agricultural productivity, reduces drudgery and labour costs, improves the timeliness of operations, reduces post-harvest losses, and enables farmers to cultivate larger areas for commercial production. Mechanisation is also a driver of rural economic activity: machinery hire services, spare parts dealers, mechanics, and fuel suppliers all benefit from increased mechanisation. Government programmes such as the National Agricultural Mechanisation Policy and various tractor subsidy schemes have attempted to accelerate mechanisation.

The limitations of mechanisation in Nigeria are equally important to understand. High capital cost of machines is a barrier for smallholder farmers. Poor rural road infrastructure limits access to machinery hire and spare parts. The shortage of trained mechanics means breakdowns often cause prolonged downtime. Imported machines are not always adapted to Nigerian soil conditions, crop varieties, or field sizes. Fuel unreliability and high cost increase operating expenses. Fragmented land holdings make it uneconomical to use large machinery on individual plots. These limitations mean that mechanisation strategy in Nigeria must be graduated and context-sensitive, combining hand tools, simple equipment, and machines in proportions appropriate to local conditions.

Fill in the blank: A major limitation of mechanisation in Nigeria is that fragmented ________ holdings make it uneconomical to operate large machinery on individual smallholder plots.

| Importance | Limitations |
|---|---|
| **Increases productivity and efficiency** | High cost of machines makes them unaffordable for smallholder farmers |
| **Reduces drudgery and manual labor** | Poor access to credit facilities limits acquisition |
| **Enhances timely farm operations** | Inadequate rural infrastructure (roads, electricity) hinders use |
| **Improves quality of produce and reduces losses** | Shortage of skilled operators and technicians |
| **Promotes large-scale farming and food security** | Dependence on imported machinery and spare parts |

Box 4.1: Importance and limitations of farm mechanisation in Nigeria

### Pilot questions 4.4

1. Name three types of irrigation systems used in Nigeria and state the water use efficiency of each.
2. Explain the role of the water pump in smallholder irrigation in Nigeria.
3. Name four post-harvest processing machines used in Nigeria and state the product each produces.
4. State five reasons why farm mechanisation is important in Nigeria.
5. State five limitations of farm mechanisation in Nigeria.

## Series Summary

This Series covered the types and uses of farm machines in Nigeria. We defined farm machines and classified them by function (tillage, planting, crop protection, harvesting, post-harvest) and by power source (tractor-powered, self-propelled, stationary). We explained the importance of mechanisation (timeliness, labour saving, scale, quality, post-harvest loss reduction) and described the main power sources (animal draught, diesel and petrol engines, electric motors, solar pumps) with the tractor as the central power unit providing drawbar pull and PTO drive.

We covered primary tillage machines (mouldboard plough, disc plough, subsoiler) and secondary tillage machines (disc harrow, tine harrow, ridger, rotary cultivator), then planting machines (seed drill, transplanter, broadcaster), crop protection machines (tractor-mounted boom sprayer, air-blast sprayer), and harvesting machines (combine harvester, motorised thresher). We concluded with irrigation systems (surface, sprinkler, drip) and processing machines (grain drier, rice mill, hammer mill, oil palm processor, cassava line), and evaluated the importance and limitations of mechanisation in the Nigerian context. By completing this Series, you should be able to achieve all nine Series Learning Outcomes (SLO 4.1 to SLO 4.9).

## Glossary of Terms

- **Air-blast sprayer (mist blower):** a crop protection machine that uses a high-speed fan-generated air stream to carry fine spray droplets deep into dense crop canopies such as orchards and plantations.
- **Boom sprayer:** a tractor-mounted crop protection machine with a tank, PTO-driven pump, and a boom carrying multiple nozzles spanning 6 to 18 metres; used for large-scale pesticide or herbicide application.
- **Combine harvester:** a self-propelled machine that performs reaping, threshing, cleaning, and grain handling in a single continuous pass through the crop.

- **Disc harrow:** a secondary tillage implement with concave steel discs that cut and break the ploughed soil to a depth of 10 to 15 cm.
- **Disc plough:** a primary tillage implement using concave rotating discs; preferred over the mouldboard plough in hard, dry, stony, or sticky soils.
- **Drip irrigation:** the most water-efficient irrigation system (85 to 95 per cent efficiency), delivering water directly to the root zone through emitters in surface or buried drip lines.
- **Farm machine:** a mechanised implement powered by an engine or motor that performs agricultural operations at a scale and speed not achievable with hand tools or animal draught.
- **Hammer mill:** a stationary processing machine that grinds dried grain into flour by high-speed impact of rotating hammers; widely used for maize and guinea corn flour production in Nigeria.
- **Mouldboard plough:** the primary tillage machine most widely used in Nigeria, consisting of a share, mouldboard, and landside; inverts the soil to bury weeds and crop residues.
- **Motorised thresher:** a PTO-driven or engine-driven machine that separates grain from straw by mechanical beating; the most widely adopted harvesting machine among Nigerian smallholders.
- **Power take-off (PTO):** a rotating shaft driven by the tractor engine that transmits power to attached implements such as rotary tillers, mowers, and sprayer pumps.
- **Ridger (lister):** a tractor-drawn implement that forms raised ridges by throwing soil up from a central furrow; used for planting yam, cassava, and vegetables in high-rainfall zones.
- **Rotary cultivator (rotovator):** a PTO-driven tillage machine with rotating L-shaped tines that till, break up clods, and incorporate organic matter in a single pass.
- **Seed drill:** a planting machine with a seed hopper, metering mechanism, seed tubes, furrow openers, and covering device that deposits seeds at the correct depth and spacing.

- **Subsoiler (chisel plough):** a primary tillage implement that penetrates to 40 to 60 cm to break up hardpan or compacted subsoil without inverting the topsoil.
- **Tractor:** the central power unit of mechanised farming, providing drawbar pull for trailed implements and PTO drive for implements requiring rotating shaft power.
- **Two-wheel tractor (power tiller):** a small walking tractor used for small-scale mechanisation on plots of 0.5 to 5 hectares; more affordable and fuel-efficient than a full-sized four-wheel tractor.

## Concept Check Questions [Series 4]

Objective Questions

1. Farm machines are classified by function and by power source into tractor-powered, self-propelled, and ________ types. (Linked to SLO 4.1)
2. The tractor provides drawbar pull for trailed implements and ________ drive for implements requiring rotating shaft power. (Linked to SLO 4.3)
3. The mouldboard plough consists of a share, a mouldboard, and a ________; the mouldboard inverts the soil to bury weeds and crop residues. (Linked to SLO 4.4)
4. The combine harvester performs reaping, threshing, cleaning, and ________ handling in a single continuous pass. (Linked to SLO 4.7)
5. Drip irrigation is the most water-efficient system with efficiency of 85 to 95 per cent; water is delivered to the root zone through ________ in surface or buried lines. (Linked to SLO 4.8)

Short-Answer Questions

6. State five reasons why farm mechanisation is important in Nigeria. (Linked to SLO 4.2)
7. Describe the components and function of a seed drill. (Linked to SLO 4.5)

8. Explain the difference between primary and secondary tillage and give two examples of each. (Linked to SLO 4.4)
9. Name three types of irrigation systems in Nigeria and state the water use efficiency of each. (Linked to SLO 4.8)
10. State five limitations of farm mechanisation in Nigeria. (Linked to SLO 4.9)

Long-Answer Questions

11. Describe the types and functions of tillage machines used in Nigeria, explaining the components and use of the mouldboard plough, disc plough, and subsoiler, and the function of disc harrows, ridgers, and rotary cultivators. (Linked to SLOs 4.4)
12. Describe the planting, crop protection, and harvesting machines used in Nigerian agriculture, explaining how each type operates and identifying the scale of operation for which each is most appropriate. (Linked to SLOs 4.5, 4.6, 4.7)
13. Evaluate the importance and limitations of farm mechanisation in Nigeria, explaining the role of irrigation and post-harvest processing machines in improving farm productivity and reducing losses. (Linked to SLOs 4.8, 4.9)

## Answers to Concept Check Questions [Series 4]

Objective Questions

1. Stationary.
2. PTO (power take-off).
3. Landside.
4. Grain.
5. Emitters.

## Short-Answer Questions

6. Timeliness (operations completed within the optimal weather window); labour saving (substitutes for increasingly scarce and expensive rural labour); scale (enables cultivation of larger commercial areas); quality (uniform, mechanised operations produce higher-quality output); post-harvest loss reduction (mechanised threshing, drying, and milling reduce losses from prolonged manual processing).
7. A seed drill consists of: a seed hopper (stores seed); a metering mechanism (releases seeds at a controlled rate matched to forward travel speed); seed tubes (guide seeds from the metering mechanism to the furrow openers); furrow openers (cut a narrow slot in the soil at the correct depth); and a covering device (press wheel or drag chain that closes the furrow over the seed). Together these components deposit seeds at the correct depth and spacing, ensuring uniform germination and crop stand.
8. Primary tillage is the initial, deep breaking of the soil to a depth of 15 to 30 cm; examples: mouldboard plough (inverts the furrow slice), disc plough (cuts with rotating concave discs). Secondary tillage refines the seedbed after primary tillage by breaking clods, levelling, and firming; examples: disc harrow (breaks clods to 10 to 15 cm), rotary cultivator (produces fine tilth in single pass).
9. Surface irrigation (gravity-fed furrows or borders; efficiency 40 to 60 per cent); sprinkler irrigation (pressurised through rotating or fixed heads; efficiency 60 to 75 per cent); drip irrigation (emitters deliver water to root zone; efficiency 85 to 95 per cent).
10. High capital cost of machines; poor rural road infrastructure limiting access to hire and spare parts; shortage of trained mechanics causing prolonged breakdowns; imported machines not adapted to Nigerian soil conditions and crop varieties; fuel unreliability and high cost; fragmented smallholder land holdings making large machinery uneconomical per plot.

## Long-Answer Questions

11. Tillage types: primary (initial deep breaking, 15 to 30 cm); secondary (seedbed refinement). Mouldboard plough: share (horizontal cut), mouldboard (lifts, turns, inverts furrow slice), landside (stabilises in furrow); inverts soil to 15 to 30 cm, buries weeds and residues; best for virgin land and heavy weed infestations. Disc plough: concave rotating discs; preferred for hard, dry, stony, or sticky soils where discs roll over obstructions; less aggressive inversion than mouldboard. Subsoiler: penetrates 40 to 60 cm without inverting topsoil; breaks hardpan; improves deep drainage and root penetration. Disc harrow: rows of concave discs at 10 to 15 cm; breaks ploughed clods, incorporates residues. Ridger: throws soil into raised ridges; used for yam, cassava, vegetables in high-rainfall zones. Rotary cultivator: PTO-driven rotating L-shaped tines; tills, breaks clods, incorporates organic matter in single pass; produces fine tilth for vegetable beds.
12. Planting machines: seed drill (hopper, metering mechanism, seed tubes, furrow openers, covering device; deposits seeds at correct depth and spacing; adjustable for maize, sorghum, rice); transplanting machine (transplants pregerminated rice seedlings from nursery trays to paddy field at precise spacing; reduces transplanting labour by 80 per cent); fertiliser broadcaster (applies granular fertiliser uniformly by centrifugal spinning; tractor-mounted or hand-held). Crop protection: tractor-mounted boom sprayer (200 to 1,000 litre tank, PTO pump, 6 to 18 metre boom, multiple nozzles; 5 to 15 ha/hr; boom height 50 cm above canopy); air-blast sprayer (fan-driven fine droplets into dense canopies; cocoa, citrus, oil palm). Harvesting: combine harvester (reaping, threshing, cleaning, grain handling in one pass; large flat fields, dry conditions, high cost; used mainly in north on large rice and wheat farms; hired out by contractors); motorised thresher (PTO or engine-driven drum; most widely adopted smallholder harvesting machine; rice, sorghum, millet, soybeans; affordable and applicable to small farms).
13. Importance: timeliness, labour saving, scale, quality, post-harvest loss reduction; tractor density in Nigeria under 1 per 1,000 ha arable vs 20+ in developed countries; mechanisation gap is a national policy priority. Irrigation: surface irrigation (gravity furrows/borders, 40 to 60 per cent efficiency, lowest cost); sprinkler (pressurised, 60 to 75 per cent, most soil types); drip (emitters, 85 to 95 per cent, most expensive, smallholder scale increasing); centrifugal pump (central irrigation equipment, petrol or diesel, must match head and discharge to system requirements; solar pumps increasing in

off-grid areas). Post-harvest machines: grain drier (heated air, rapid moisture reduction for wet-season harvests); rice milling machine (huller and whitener, paddy to white rice); hammer mill (rotating hammers, grain to flour; standard for maize and guinea corn flour); oil palm processor (digester, press, clarifier; replaces hand-pressing in southern Nigeria); cassava processing line (grater, press, sifter; garri production at scale). Limitations: high capital cost, poor roads, mechanic shortage, unadapted imported machines, fuel cost and unreliability, fragmented land; mechanisation must be graduated and context-sensitive.

## Answers to Pilot Questions [Series 4]

Part 4.1: Introduction to Farm Machines

1. A farm machine is a mechanised implement powered by an engine or motor that performs agricultural operations at a scale and speed not achievable with hand tools or animal draught. Three differences from simple equipment: a machine has greater mechanical complexity (multiple moving parts, gear trains, transmissions); it depends on an external power source (combustion engine, electric motor, or PTO) rather than human muscle; and it requires greater technical skill to operate and maintain than simple equipment such as a knapsack sprayer.
2. By function: tillage (tractor-drawn mouldboard plough), planting (tractor-drawn seed drill), crop protection (tractor-mounted boom sprayer), harvesting (motorised thresher), post-harvest (rice milling machine). By power source: tractor-powered (disc harrow), self-propelled (combine harvester), stationary (hammer mill).
3. Timeliness (completes operations in the optimal weather window, reducing yield loss from delays); labour saving (replaces scarce and expensive rural labour); scale (enables cultivation of larger commercial areas); quality (uniform planting depth, consistent spray coverage, precise threshing improves output uniformity); post-harvest loss reduction (mechanised threshing, drying, and milling reduce losses from prolonged manual processing).

4. Animal draught (ox-drawn plough); diesel or petrol engine (tractor); electric motor (grain mill); solar pump (irrigation pump in off-grid community).
5. Drawbar pull is the pulling force the tractor exerts through the hitch on the rear to drag trailed implements (ploughs, harrows, seed drills) through the soil. PTO drive is the rotating shaft power transmitted from the tractor engine through the power take-off shaft at 540 or 1,000 rpm to implements that require rotational power to operate (rotary cultivators, mowers, sprayer pumps, balers).

Part 4.2: Tillage Machines

1. Primary tillage is the initial, deep breaking of the soil to 15 to 30 cm; it buries weeds and residues and loosens the root zone. Example: mouldboard plough. Secondary tillage refines the seedbed by breaking clods, levelling, and firming the soil to create suitable conditions for germination. Example: disc harrow.
2. Share: the cutting edge that slices horizontally through the soil, separating the furrow slice from the unploughed land; it determines the width and depth of the furrow. Mouldboard: the curved plate behind and above the share that lifts, turns, and inverts the furrow slice, burying weeds, crop residues, and surface soil to expose the lower soil layer. Landside: the flat plate on the right side of the plough body (opposite the mouldboard) that stabilises the plough against the furrow wall and prevents it from sliding sideways under the lateral forces generated by the mouldboard.
3. The disc plough is preferred over the mouldboard plough in hard, dry soils where the mouldboard share cannot penetrate effectively without excessive draught; in stony soils where rocks would catch on a rigid mouldboard share but the rotating discs roll over them; and in sticky clay soils that would cling to and block a mouldboard but slide off the curved disc surface.
4. Disc harrow: rows of concave steel discs that cut and break the ploughed soil to a depth of 10 to 15 cm, producing a rough, cloddy seedbed suitable for coarse-seeded crops; offset disc operates at an angle for more aggressive cutting. Rotary cultivator (rotovator): PTO-driven rotating L-shaped tines that till the soil and break up all clods in a single

pass, producing a very fine, crumbly tilth suitable for small-seeded vegetables and nursery beds.

5. A ridger is a tractor-drawn implement that runs a V-shaped body or wings through the soil, creating a furrow on either side and throwing the displaced soil up into a raised ridge between the furrow lines. It is most commonly used in Nigeria for yam (where seeds sets are planted on the top of ridges), cassava (stem cuttings planted on ridges to improve drainage around the stem base), and vegetables (raised beds on ridges improve drainage in high-rainfall areas).

Part 4.3: Planting, Crop Protection, and Harvesting Machines

1. A seed drill has: a seed hopper (stores the seed supply for the field run); a metering mechanism (a seed plate or roller that releases seeds one or a few at a time, at a rate matched to the forward travel speed to achieve the desired plant population per hectare); seed tubes (flexible pipes that carry seeds from the metering mechanism down to the furrow openers); furrow openers (shoe or disc openers that cut a narrow slot in the soil at the calibrated depth); and a covering device (press wheel or drag chain that closes the furrow and firms the soil over each seed). The result is seeds placed at a uniform depth and in-row spacing, giving uniform germination and a consistent plant stand.
2. The tractor-mounted boom sprayer operates as follows: the PTO-driven pump draws spray solution from the tank and delivers it under pressure to the boom; the pressure regulator maintains constant pressure regardless of pump speed variations; the solution flows along the boom pipes to each nozzle; the nozzles atomise the solution into droplets of the correct size for the target and coverage rate. The operator drives at a constant, calibrated forward speed with the boom set at 50 cm above the crop canopy for uniform coverage. Coverage rate is 5 to 15 hectares per hour depending on tank capacity, forward speed, and boom width.
3. Reaping (cutting the standing crop at stem level), threshing (separating grain from straw and ears by the rotating cylinder), cleaning (removing chaff and light material from the

grain by air blast from a fan and oscillating sieves), and grain handling (conveying cleaned grain by an auger to the grain tank on the machine).

4. The motorised thresher has been more widely adopted because it is significantly more affordable (purchase price is a fraction of a combine harvester's cost); it can be used on very small plots and in fields that are too small, wet, or irregular for a combine to operate in; it can be transported by bicycle or light vehicle to the farmer's field; it can be shared between multiple farmers or operated by a service provider on a fee-per-bag basis; and it requires less technical skill and less fuel to operate and maintain than a combine harvester.
5. Any three: rice milling machine (paddy rice; produces milled white rice); hammer mill (maize or sorghum; produces flour for ogi, tuwo, or feed); oil palm processor (fresh palm fruit bunches; produces crude palm oil).

Part 4.4: Water Management and Post-Harvest Machines

1. Surface irrigation (gravity-fed furrows or borders; efficiency 40 to 60 per cent); sprinkler irrigation (pressurised water through rotating or fixed heads; efficiency 60 to 75 per cent); drip irrigation (emitters deliver water directly to root zone; efficiency 85 to 95 per cent).
2. The water pump draws water from the source (river, borehole, or reservoir) and delivers it at sufficient pressure and flow rate to fill the distribution system (furrows, sprinkler lines, or drip lines) at the flow rate needed to irrigate the target area within the available irrigation time. Without a correctly matched pump, irrigation cannot be applied at the right time or in sufficient quantity; the pump is therefore the critical piece of equipment that determines whether the irrigation system can function as designed.
3. Any four: grain drier (maize, rice, sorghum; dried grain for safe storage); rice milling machine (paddy rice; milled white rice); hammer mill (maize, guinea corn; flour); oil palm processor (fresh palm fruit; crude palm oil); cassava processing line (fresh cassava roots; garri or cassava flour).
4. Increases agricultural productivity per unit of land and labour; reduces drudgery and the cost of human labour; improves the timeliness of land preparation, planting, and

harvesting; reduces post-harvest losses through faster, more uniform threshing, drying, and milling; enables farmers to cultivate larger areas and produce at commercial scale.

5. High capital cost of machines is a barrier for most smallholders; poor rural road infrastructure limits access to machinery hire services and spare parts; shortage of trained mechanics causes long breakdowns; many imported machines are not adapted to Nigerian soil conditions, field sizes, or crop varieties; fuel cost and supply unreliability increase operating costs; fragmented smallholder land holdings make large machinery uneconomical per individual plot.

## References and Attributions [Series 4]

Textual References (Books and External Sources)


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Figures, Plates, Tables, and Boxes

- Table 4.1: Farm machine classification by function and power source Attribution: AI generated. Suggested OER search string: "farm machines classification function power source Nigeria examples OER table".

- Figure 4.1: Mouldboard plough components diagram Attribution: AI generated. Suggested OER search string: "mouldboard plough components diagram share mouldboard landside OER".
- Figure 4.2: Tractor-mounted boom sprayer diagram Attribution: AI generated. Suggested OER search string: "tractor mounted boom sprayer diagram components tank pump boom nozzles OER".
- Table 4.2: Post-harvest processing machines in Nigeria Attribution: AI generated. Suggested OER search string: "Nigeria post-harvest processing machines rice mill hammer mill cassava OER table".
- Box 4.1: Importance and limitations of mechanisation Attribution: AI generated. Suggested OER search string: "farm mechanisation Nigeria importance limitations capital cost fragmented land OER box".

**Course code: AGE 208**

**Course title: Farm Tools and Equipment**

**Course credit load: 2 Units**

# Series 5: Maintenance of Farm Machines

- **Part 5.1: Overview of Farm Machine Maintenance**
  - Sub Part 5.1.1: Definition and importance of machine maintenance
  - Sub Part 5.1.2: Consequences of poor maintenance
  - Sub Part 5.1.3: The maintenance cycle
- **Part 5.2: Preventive Maintenance**
  - Sub Part 5.2.1: Definition and objectives of preventive maintenance
  - Sub Part 5.2.2: Preventive maintenance tasks and schedules
  - Sub Part 5.2.3: Lubrication, filters, and fluid checks
- **Part 5.3: Corrective and Routine Maintenance**
  - Sub Part 5.3.1: Corrective maintenance: definition and approach
  - Sub Part 5.3.2: Routine maintenance tasks
  - Sub Part 5.3.3: Maintenance records for farm machines
- **Part 5.4: Predictive Maintenance**
  - Sub Part 5.4.1: Definition and principles of predictive maintenance
  - Sub Part 5.4.2: Condition monitoring techniques
  - Sub Part 5.4.3: Predictive maintenance in the Nigerian farm context

## Introduction

Farm machines are expensive assets; their productive life depends almost entirely on the quality of maintenance they receive. A tractor or thresher that is regularly serviced will operate efficiently for ten to twenty years; the same machine neglected will fail within two or three seasons. For agriculture students and farmers, understanding the four types of machine maintenance is a core practical competency that determines whether mechanisation is economically viable or a costly failure.

This Series covers the four types of maintenance applied to farm machines: preventive (scheduled servicing before failure occurs), corrective (repairing a machine after it fails), routine (daily and operational checks), and predictive (monitoring machine condition to anticipate failure). We begin with an overview of maintenance and its importance, cover each type in detail, and conclude with practical maintenance records and the application of predictive maintenance in the Nigerian context.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** define farm machine maintenance and explain its importance (Linked to Part 5.1),
- **SLO 5.2** describe the consequences of poor machine maintenance (Linked to Part 5.1),
- **SLO 5.3** explain the maintenance cycle and how the four maintenance types relate to each other (Linked to Part 5.1),
- **SLO 5.4** define preventive maintenance and describe its objectives, tasks, and schedules (Linked to Part 5.2),
- **SLO 5.5** explain lubrication, filter servicing, and fluid checks as components of preventive maintenance (Linked to Part 5.2),

- **SLO 5.6** define corrective maintenance and describe the correct approach to repairing a failed machine (Linked to Part 5.3),
- **SLO 5.7** describe routine maintenance tasks for common farm machines (Linked to Part 5.3),
- **SLO 5.8** maintain a farm machine maintenance record (Linked to Part 5.3), and
- **SLO 5.9** define predictive maintenance, describe condition monitoring techniques, and explain how predictive maintenance applies to Nigerian farm machines (Linked to Part 5.4).

## 5.1 Overview of Farm Machine Maintenance

### 5.1.1 Definition and importance of machine maintenance

Farm machine maintenance is the set of actions taken to keep a machine in, or restore it to, a condition in which it can perform its intended function safely, efficiently, and reliably. Maintenance encompasses inspection, cleaning, lubrication, adjustment, replacement of worn parts, and repair of failed components. It is important for five reasons: it extends the working life of the machine, reducing the cost per hour of operation; it prevents unexpected breakdowns during critical periods such as planting and harvesting; it keeps the machine operating at its designed efficiency; it protects the safety of the operator; and it preserves the resale value of the asset.

In the Nigerian context, the importance of maintenance is amplified by the difficulty of obtaining spare parts quickly. A machine that breaks down in a rural area may be out of service for weeks while parts are sourced from a distant town or imported. Preventive maintenance reduces the frequency of such breakdowns. Students who develop good maintenance habits on the school farm carry those habits into their farming careers, improving the economic viability of mechanisation at the individual and community levels.

Fill in the blank: Farm machine maintenance is important because it extends machine ________ life, prevents unexpected breakdowns, maintains efficiency, protects operator safety, and preserves the resale value of the asset.

### 5.1.2 Consequences of poor maintenance

Poor maintenance has direct and indirect consequences. Direct consequences include: accelerated wear of moving parts (a poorly lubricated bearing wears in hours what a lubricated one wears in years); overheating and seizure of engines that are operated with insufficient oil or coolant; blockage and damage to fuel and hydraulic systems from dirty filters; and structural failure of components stressed beyond their design limits by misadjustment or neglect. Each of these failures results in costly repair bills, downtime, and reduced machine life.

Indirect consequences include: crop losses from delayed operations (a tractor that breaks down at planting time may cost more in lost yield than its repair cost); loss of farmer confidence in mechanisation (a machine that repeatedly breaks down discourages investment in future equipment); and safety accidents (a machine with a defective braking system, worn tyres, or a loose PTO guard exposes the operator to serious injury). In Nigeria, where machine downtime is prolonged by poor spare parts availability, the indirect cost of a breakdown often exceeds the direct repair cost.

Fill in the blank: Poor lubrication causes accelerated ________ of moving parts; a poorly lubricated bearing wears in hours what a properly lubricated one wears in years.

### 5.1.3 The maintenance cycle

The four types of maintenance form an integrated cycle rather than independent categories. Routine maintenance (daily checks and cleaning) is performed by the operator before and after every use. Preventive maintenance (scheduled servicing at defined intervals) is performed by the operator or a mechanic at fixed hours or calendar periods. Predictive maintenance (condition monitoring) is performed continuously or periodically to detect signs of developing faults before they cause failure. Corrective maintenance (repair) is performed when a fault or failure occurs despite routine and preventive efforts.

The goal of a well-designed maintenance programme is to maximise the proportion of time spent on routine and preventive maintenance and minimise the need for corrective maintenance. Predictive maintenance adds a layer of intelligence to the cycle by enabling the farmer to schedule corrective work at a convenient time before failure occurs, rather than dealing with an emergency breakdown. On the school farm, students should experience all four types of maintenance through structured practical activities integrated into the farm work programme.

Fill in the blank: The goal of a well-designed maintenance programme is to maximise routine and ________ maintenance and minimise unplanned corrective maintenance caused by unexpected failures.

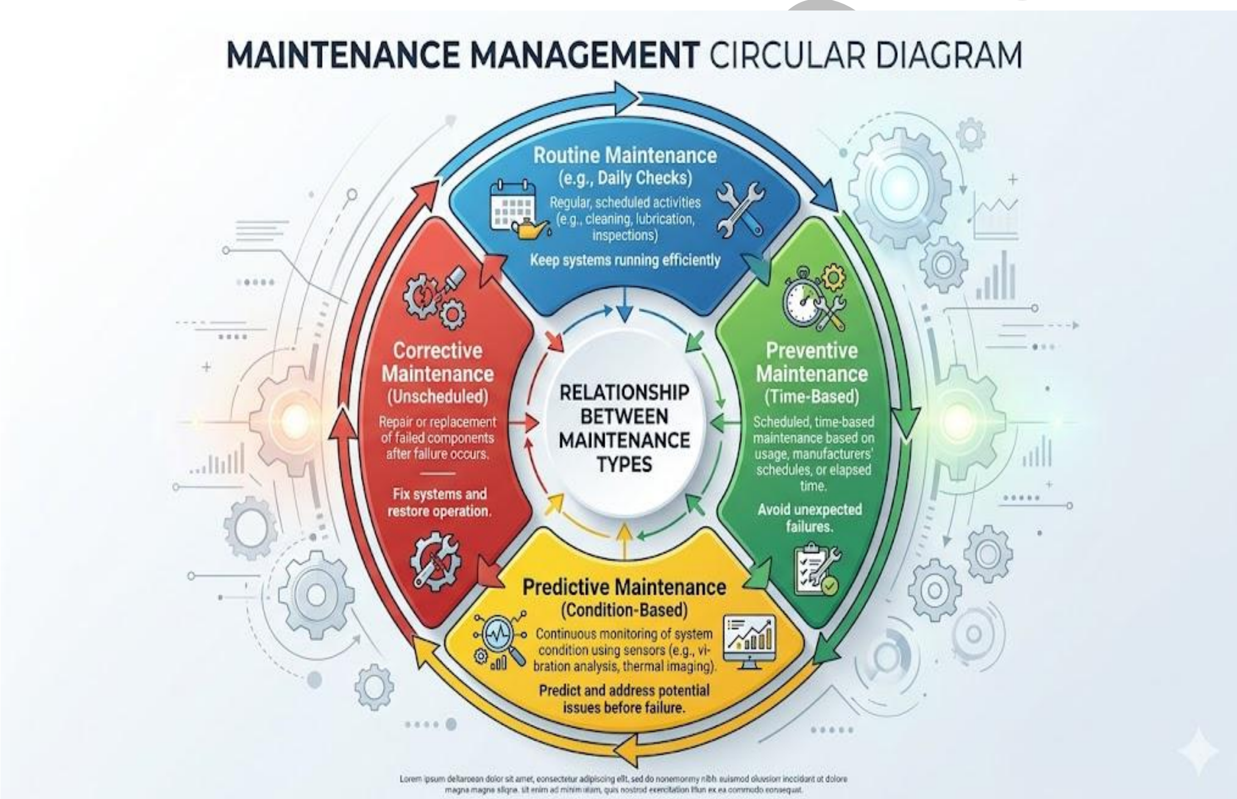


Figure 5.1: Diagram showing the four maintenance types and their relationship in the maintenance cycle

## Pilot questions 5.1

1. Define farm machine maintenance and state five reasons why it is important.
2. State three direct consequences of poor machine maintenance.

3. Explain two indirect consequences of poor maintenance that are particularly significant in Nigeria.
4. Describe the four types of maintenance and explain how they form an integrated cycle.
5. Explain what the goal of a well-designed maintenance programme is.

## 5.2 Preventive Maintenance

### 5.2.1 Definition and objectives of preventive maintenance

Preventive maintenance (PM) is scheduled maintenance carried out at defined intervals of time or machine use (operating hours) before a failure occurs, with the objective of preventing that failure. It is proactive rather than reactive: the machine is serviced whether or not it shows any sign of a problem. The primary objective of PM is to prevent unplanned breakdowns by replacing or servicing components before they wear to failure. Secondary objectives are to detect developing faults early (before they become costly failures) and to maintain the machine at its designed operating efficiency.

Preventive maintenance intervals are specified in the machine's operator manual and are expressed in engine operating hours (for example, every 50 hours, every 250 hours, every 500 hours) or in calendar time (every week, every month, every season). On the school farm and on smallholder farms, a simple PM schedule based on calendar time is more practical than one based on hour-meter readings, because many older tractors and machines in Nigeria do not have functioning hour meters. The PM schedule should be posted in the machine store and followed consistently.

Fill in the blank: Preventive maintenance is ________ maintenance performed at defined intervals before failure occurs, with the objective of preventing unplanned breakdowns and maintaining machine efficiency.

### 5.2.2 Preventive maintenance tasks and schedules

A tractor preventive maintenance schedule illustrates the general pattern for all powered farm machines. Daily (before each use): check engine oil level; check coolant level; check fuel level; check tyre pressures; check battery terminals; inspect for fluid leaks under the machine; check that all safety guards are in place. Weekly: check fan belt tension and condition; check air filter (clean or replace if dusty); check hydraulic fluid level; inspect all lights and instruments; grease all grease nipples on moving joints. Monthly: change engine oil and oil filter; check fuel filter; inspect and adjust brakes; check wheel bolt torques.

Seasonal or annual PM (every 250 to 500 engine hours): change hydraulic oil and hydraulic filter; replace fuel filter; flush and refill coolant; inspect and adjust valve clearances; check and replace spark plugs or injectors; inspect the clutch and adjust if needed; inspect and replace worn tyres; check all electrical connections; touch up rust spots on the body. The specific tasks and intervals vary by machine make and model; the operator manual is the authoritative reference. Students should practise reading and interpreting the PM schedule from an actual tractor or machine manual as a classroom exercise.

Fill in the blank: Daily preventive maintenance checks for a tractor include engine oil level, coolant level, fuel level, tyre pressures, battery terminals, fluid ________, and inspection of safety guards.

| Interval | Maintenance Actions |
|---|---|
| **Daily** | • Check engine oil and coolant levels • Inspect tires for pressure and damage • Clean air filter and radiator screen • Test brakes and lights |
| **Weekly** | • Grease moving parts (joints, bearings) • Inspect battery terminals and charge • Check hydraulic fluid levels • Tighten loose bolts and nuts |
| **Monthly** | • Change engine oil and filters • Inspect fuel system for leaks • Check transmission fluid • Adjust clutch and brake systems |
| **Seasonal (Before/After Farming Season)** | • Full servicing of tractor • Replace worn-out belts, hoses, and tires • Overhaul hydraulic system • Apply anti-rust coating and store in dry shelter |

Table 5.1: Preventive maintenance schedule for a farm tractor

### 5.2.3 Lubrication, filters, and fluid checks

Lubrication is the single most important preventive maintenance action for any farm machine. Moving metal parts in contact without lubrication generate heat through friction, causing rapid wear, scoring, and ultimately seizure. Engine oil lubricates the crankshaft bearings, camshaft, cylinder walls, and valve train; it must be checked daily and changed at the specified interval (typically every 50 to 100 engine hours or every 3 months) because it degrades through heat, oxidation, and contamination with combustion products. Grease is used for slower-moving joints (wheel bearings, steering linkages, PTO shafts) via grease nipples.

Filters remove contaminants from the fluids and air entering the engine and hydraulic system. The air filter prevents dust from entering the engine; in Nigeria's dry-season dusty conditions, the air filter may need daily cleaning rather than the weekly interval recommended for temperate climates. The oil filter removes metallic wear particles and combustion deposits from the engine oil; it is replaced with each oil change. The fuel filter removes water and particles from diesel fuel; contaminated fuel is a major cause of injector failure in Nigeria. Hydraulic fluid must be kept clean and at the correct level; contaminated hydraulic oil causes pump and valve failure.

Fill in the blank: The ________ filter prevents dust from entering the engine and may need daily cleaning in Nigeria's dry-season dusty conditions rather than the weekly interval recommended in temperate climates.

Pilot questions 5.2

1. Define preventive maintenance and state its primary and secondary objectives.
2. List five daily preventive maintenance checks for a tractor.
3. State three monthly preventive maintenance tasks for a farm tractor.
4. Explain why lubrication is the most important preventive maintenance action for a farm machine.
5. Explain why the air filter may need more frequent servicing in Nigeria than the manufacturer's standard interval.

## 5.3 Corrective and Routine Maintenance

### 5.3.1 Corrective maintenance: definition and approach

Corrective maintenance (CM) is the repair or restoration of a machine that has failed or developed a fault that prevents correct operation. Unlike preventive maintenance, CM is reactive: it is triggered by a failure or malfunction. The correct approach to CM follows a systematic diagnostic sequence: (1) identify the symptom (what exactly is wrong: the engine will not start, the machine vibrates excessively, the hydraulic system does not lift); (2) identify the probable causes by examining the system that controls the affected function; (3) test each probable cause systematically from the most likely and most accessible; (4) confirm the root cause; (5) repair or replace the failed component; (6) test the machine to confirm that the fault is resolved.

Effective corrective maintenance requires basic diagnostic knowledge, the correct tools, and access to spare parts. On the school farm, the agriculture teacher should be able to perform first-line diagnosis and simple repairs (replacing belts, hoses, filters, and fuses; re-tightening loose connections; adjusting brakes or clutches) and should know when to refer the machine to a qualified mechanic for major repairs (engine overhaul, hydraulic pump replacement, gearbox repair). Attempting repairs beyond one's competence can worsen the damage and create safety risks.

Fill in the blank: The correct approach to corrective maintenance follows a diagnostic sequence: identify the ________, identify probable causes, test systematically, confirm root cause, repair, and test to confirm resolution.

### 5.3.2 Routine maintenance tasks

Routine maintenance (RM) refers to the basic daily and pre-operational checks and cleaning performed by the machine operator before, during, and after each use. These tasks do not require specialist tools or knowledge; they are the operator's responsibility and form the first line of defence against equipment failure. Routine maintenance tasks for a tractor include: before use (check oil, coolant, fuel, tyre pressure, lights, and safety guards; walk around the machine looking for leaks or damage); during use (listen for unusual noises, watch for warning lights, monitor fuel gauge); after use (clean the machine, check for new leaks or damage, report any abnormality).

For other farm machines, routine tasks are similarly structured. For a motorised thresher: before use (check belt tension and condition, confirm that all guards are fitted, check that the feed opening is clear); during use (monitor feeding rate, listen for unusual sounds from the drum or bearings); after use (clean all crop residues from drum and sieves, check for bent or broken beaters, oil exposed metal). For an irrigation pump: before use (check oil level, check that the inlet strainer is clear, confirm that all connections are tight); after use (drain the pump if it will not be used for several days to prevent corrosion).

Fill in the blank: Routine maintenance tasks are performed by the machine ________ before, during, and after each use and form the first line of defence against equipment failure.

| Stage | Maintenance Actions |
| --- | --- |
| **Before Use** | • Check engine oil and coolant levels • Inspect tires for proper inflation and wear • Test brakes, lights, and steering • Ensure fuel tank is filled • Grease moving joints and linkages |
| **During Use** | • Monitor gauges (oil pressure, temperature) • Listen for unusual noises • Avoid overloading or overspeeding • Check hydraulic systems during operation • Ensure safe driving practices |
| **After Use** | • Clean tractor exterior and radiator • Refill fuel tank to prevent condensation • Inspect for leaks or damage • Park in a dry, sheltered area • Record usage and maintenance notes |

Box 5.1: Routine maintenance checklist for a farm tractor

### 5.3.3 Maintenance records for farm machines

A farm machine maintenance record documents every maintenance action performed on a machine, providing a complete service history. The record should contain: the machine name, make, model, and serial number; date of purchase and purchase cost; hour-meter or odometer readings at each service; date of each maintenance action; type of maintenance performed (routine, preventive, or corrective); description of work done; parts replaced with their cost; name of person performing the work; and next service due date. A separate record is kept for each machine on the farm.

Maintenance records serve four purposes: accountability (documents who maintained what and when); warranty (many equipment warranties require proof of scheduled servicing); planning (enables the teacher or farm manager to project future maintenance costs and schedule downtime away from critical farm operations); and resale (a complete service history increases the resale value of the machine and demonstrates responsible ownership). Records should be filed in a safe, dry location and reviewed at the start of each season to confirm that all machines are up to date with their PM schedules.

Fill in the blank: A complete maintenance record increases the ________ value of a machine because it demonstrates responsible ownership and confirms that all scheduled servicing has been performed.

Pilot questions 5.3

1. Define corrective maintenance and describe the six-step diagnostic approach.
2. Explain what routine maintenance is and state why it is the operator's responsibility.
3. List four routine maintenance tasks performed before using a motorised thresher.
4. State four items that should be recorded in a farm machine maintenance record.
5. State four purposes served by farm machine maintenance records.

## 5.4 Predictive Maintenance

### 5.4.1 Definition and principles of predictive maintenance

Predictive maintenance (PdM) is a condition-based maintenance strategy in which the actual state of a machine is monitored continuously or periodically, and maintenance is performed only when monitoring data indicate that a fault is developing or that a component is approaching the end of its service life. Unlike preventive maintenance (which services components on a fixed schedule regardless of their condition), predictive maintenance avoids both under-maintenance (servicing too infrequently, leading to failure) and over-maintenance (servicing too frequently, wasting resources on components that are still in good condition).

The principles of predictive maintenance are: most machine failures do not occur suddenly but develop gradually through identifiable stages (the P-F curve: from a potential failure point P, a defect develops progressively until it reaches the functional failure point F); if the developing fault is detected between P and F, maintenance can be scheduled before failure occurs; each type of failure has characteristic indicators that can be monitored (vibration, temperature, oil analysis, noise, visual inspection); and the cost of monitoring is justified by avoiding the larger cost of unplanned failure and emergency repair.

Fill in the blank: The P-F curve shows that most machine failures develop gradually from a potential failure point P to a functional ________ point F; detecting the fault between P and F allows maintenance to be scheduled before failure.

### 5.4.2 Condition monitoring techniques

Several techniques are used to monitor machine condition. Vibration analysis measures the amplitude and frequency of vibration at bearing housings and other rotating components; an increase in vibration level or a change in vibration frequency pattern indicates developing bearing wear, imbalance, or misalignment. Oil analysis (tribology) examines a sample of engine or hydraulic oil for metallic wear particles, viscosity change, water contamination, and acidity; increased metal particles indicate internal wear. Thermography uses an infrared camera to detect abnormal heat generation in electrical connections, bearings, and brake components.

Visual and auditory inspection is the most accessible condition monitoring technique for Nigerian farm operators: listening for unusual noises (knocking, squealing, hissing), observing exhaust smoke colour (black smoke indicates over-fuelling or air restriction; blue smoke indicates oil burning; white smoke indicates water in the combustion chamber), checking for fluid leaks, and monitoring performance changes (reduced power, increased fuel consumption, difficulty starting). These simple observations, made consistently during routine maintenance, can detect most developing faults in Nigerian farm machinery before they result in catastrophic failure.

Fill in the blank: Black exhaust smoke from a diesel engine indicates over-fuelling or air restriction; blue smoke indicates ________ burning; white smoke indicates water in the combustion chamber.

| Indicator | Fault Indicated | Recommended Action |
|---|---|---|
| **Unusual noise/vibration** | Worn bearings, loose bolts, misaligned parts | Inspect and tighten bolts, lubricate bearings, realign components |
| **Excessive smoke from exhaust** | Poor combustion, clogged air filter, worn engine parts | Clean/replace air filter, service engine, adjust fuel system |
| **Oil leakage** | Damaged seals, worn gaskets, cracked housing | Replace seals/gaskets, repair or replace housing |
| **Overheating** | Low coolant, blocked radiator, faulty thermostat | Refill coolant, clean radiator, replace thermostat |
| **Reduced output efficiency** | Blunt blades, clogged sieves, worn belts | Sharpen blades, clean sieves, replace belts |
| **Unusual wear on tires/tracks** | Improper inflation, misalignment, overloading | Adjust tire pressure, realign wheels, reduce load |
| **Irregular spray pattern (sprayer)** | Blocked nozzle or worn nozzle tip | Clean or replace nozzle, flush system |

Table 5.2: Condition monitoring indicators and their interpretation for common farm machine faults

### 5.4.3 Predictive maintenance in the Nigerian farm context

Advanced predictive maintenance tools (vibration analysers, oil analysis laboratories, infrared cameras) are expensive and require trained technicians; they are not currently practical for most Nigerian smallholder farms or school farms. However, the principles of predictive maintenance can be applied at low cost through structured operator observation. A simple observation log in which the tractor or thresher operator records daily observations of noise, smoke, performance, and fluid condition provides a basic predictive monitoring system that can detect developing faults weeks before failure.

The agriculture teacher should train students to use the observation log as part of routine maintenance. Key observations to record are: any new noise or change in existing noise; any change in exhaust smoke colour; any new fluid leak; any change in power, speed, or fuel consumption; and any warning light activation. When two or more of these indicators change simultaneously, the machine should be taken out of service and inspected by a qualified mechanic before the next use. This simple, low-cost predictive approach is achievable on every Nigerian school farm and smallholder operation.

Fill in the blank: A simple ________ log in which the operator records daily observations of noise, smoke, performance, and fluid condition provides a low-cost predictive monitoring system for Nigerian farm machines.

| **Date** | **Machine** | **Observation Indicator** | **Condition Status** | **Fault Suspected** | **Action Taken** | **Next Check** |
|---|---|---|---|---|---|---|
| **(Enter date)** | Tractor | Noise/vibration | Normal / Abnormal | Loose bolts suspected | Tightened bolts | Weekly |
| **(Enter date)** | Knapsack sprayer | Spray pattern | Even / Uneven | Blocked nozzle suspected | Cleaned nozzle | Next use |
| **(Enter date)** | Hand thresher | Grain separation | Good / Poor | Worn teeth suspected | Sharpened teeth | Weekly |
| **(Enter date)** | Storage bin | Moisture level | Dry / Damp | Mold risk suspected | Improved ventilation | Monthly |

Box 5.2: Simple observation log for predictive maintenance on the school farm

Pilot questions 5.4

1. Define predictive maintenance and explain how it differs from preventive maintenance.
2. Explain what the P-F curve represents and why it is important for predictive maintenance.
3. Name four condition monitoring techniques and state what each detects.
4. Explain what exhaust smoke colour can indicate about the condition of a diesel engine.
5. Explain how the principles of predictive maintenance can be applied at low cost on a Nigerian school farm.

## Series Summary

This final Series covered the four types of farm machine maintenance. We defined maintenance and explained its importance (extends machine life, prevents breakdowns, maintains efficiency, protects operators, preserves resale value) and described the serious direct and indirect consequences of poor maintenance in the Nigerian context. We explained how the four types form an integrated cycle in which routine and preventive maintenance reduce the need for corrective repairs.

We covered preventive maintenance in detail: its definition, objectives, tractor PM schedule (daily, weekly, monthly, seasonal), and the critical role of lubrication, filter servicing, and fluid checks. We described corrective maintenance as a six-step diagnostic process and routine maintenance as the operator's daily responsibility. We explained maintenance records and their four purposes. Finally, we introduced predictive maintenance based on the P-F curve, described condition monitoring techniques, and explained how a simple daily observation log makes predictive maintenance achievable on every Nigerian school farm. By completing this Series and the course, you should be able to achieve all nine Series Learning Outcomes (SLO 5.1 to SLO 5.9) and all three course learning outcomes.

## Glossary of Terms

- **Air filter:** a filter that prevents dust and particles from entering the engine intake; requires more frequent cleaning in dusty dry-season conditions in Nigeria.
- **Condition monitoring:** the practice of measuring indicators of machine state (vibration, oil analysis, temperature, noise, smoke) to detect developing faults before they cause failure.
- **Corrective maintenance (CM):** reactive maintenance performed to repair a machine that has already failed or developed a fault preventing correct operation.
- **Farm machine maintenance:** the set of actions taken to keep a machine in, or restore it to, a condition in which it can perform its intended function safely, efficiently, and reliably.
- **Fuel filter:** a filter that removes water and particles from diesel fuel before it reaches the injectors; contaminated fuel is a leading cause of injector failure in Nigeria.
- **Hydraulic fluid:** the pressurised oil that transmits power in the tractor's hydraulic system; must be kept clean and at the correct level to prevent pump and valve failure.
- **Oil analysis (tribology):** examination of an oil sample for metallic wear particles, viscosity change, water contamination, and acidity as a condition monitoring technique.
- **Oil filter:** a filter that removes metallic wear particles and combustion deposits from the engine oil; replaced with each oil change.
- **Observation log:** a daily record in which the machine operator notes noise, smoke colour, fluid leaks, performance changes, and warning lights as a low-cost predictive monitoring tool.
- **P-F curve:** the relationship between potential failure (P, where a defect first becomes detectable) and functional failure (F, where the machine can no longer perform its function); the interval between P and F is the window for predictive maintenance intervention.

- **Predictive maintenance (PdM):** condition-based maintenance in which the actual state of the machine is monitored and maintenance is performed only when indicators show a fault is developing.
- **Preventive maintenance (PM):** scheduled maintenance performed at defined intervals of time or operating hours before failure occurs, to prevent unplanned breakdowns and maintain efficiency.
- **Routine maintenance (RM):** daily and pre-operational checks and cleaning performed by the machine operator before, during, and after each use as the first line of defence against failure.
- **Thermography:** the use of an infrared camera to detect abnormal heat in electrical connections, bearings, and brake components as a condition monitoring technique.
- **Vibration analysis:** the measurement of vibration amplitude and frequency at bearings and rotating components to detect developing wear, imbalance, or misalignment.

## Concept Check Questions [Series 5]

Objective Questions

1. Farm machine maintenance extends machine working ________, prevents unexpected breakdowns, maintains efficiency, protects operator safety, and preserves resale value. (Linked to SLO 5.1)
2. ________ maintenance is scheduled maintenance performed at defined intervals before failure occurs to prevent unplanned breakdowns. (Linked to SLO 5.4)
3. The ________ filter prevents dust from entering the engine and may need daily cleaning in Nigeria's dry-season dusty conditions. (Linked to SLO 5.5)
4. The P-F curve shows that most failures develop gradually from a potential failure point P to a functional ________ point F. (Linked to SLO 5.9)
5. Black exhaust smoke from a diesel engine indicates over-fuelling or air restriction; blue smoke indicates ________ burning. (Linked to SLO 5.9)

Short-Answer Questions

6. State three direct consequences of poor farm machine maintenance. (Linked to SLO 5.2)
7. Describe the four types of maintenance and explain how they form an integrated cycle. (Linked to SLO 5.3)
8. List five daily preventive maintenance checks for a tractor. (Linked to SLO 5.4)
9. Describe the six-step approach to corrective maintenance. (Linked to SLO 5.6)
10. Explain how predictive maintenance can be applied at low cost on a Nigerian school farm. (Linked to SLO 5.9)

Long-Answer Questions

11. Explain the importance of farm machine maintenance, the consequences of poor maintenance, and how the four types of maintenance form an integrated maintenance cycle. (Linked to SLOs 5.1, 5.2, 5.3)
12. Describe preventive maintenance for farm machines, covering its definition, objectives, a tractor PM schedule, and the role of lubrication, filter servicing, and fluid checks. (Linked to SLOs 5.4, 5.5)
13. Explain corrective and routine maintenance, describe maintenance records and their purposes, and evaluate the application of predictive maintenance and condition monitoring in the Nigerian farm context. (Linked to SLOs 5.6, 5.7, 5.8, 5.9)

## Answers to Concept Check Questions [Series 5]

Objective Questions

1. Life.
2. Preventive.

3. Air.
4. Failure.
5. Oil.

Short-Answer Questions

6. Any three: accelerated wear of moving parts from poor lubrication; overheating and engine seizure from insufficient oil or coolant; blockage and damage to fuel and hydraulic systems from dirty filters.
7. Routine (daily operator checks, first line of defence); preventive (scheduled servicing at fixed intervals to prevent failure); predictive (condition monitoring to detect developing faults before failure); corrective (repair when failure occurs). Together they form a cycle: routine and preventive maintenance reduce breakdowns; predictive detects what routine and preventive miss; corrective addresses remaining failures.
8. Any five: check engine oil level; check coolant level; check fuel level; check tyre pressures; check battery terminals; inspect for fluid leaks; confirm all safety guards are in place.
9. (1) Identify the symptom; (2) identify probable causes by examining the affected system; (3) test each probable cause systematically from most likely; (4) confirm the root cause; (5) repair or replace the failed component; (6) test the machine to confirm the fault is resolved.
10. A daily observation log in which the operator records noise, exhaust smoke colour, fluid leaks, performance changes, and warning light activations. When two or more indicators change simultaneously, the machine is taken out of service for inspection before the next use. This requires no expensive equipment and is achievable on every school farm.

Long-Answer Questions

11. Maintenance defined as actions keeping a machine able to perform its function safely, efficiently, and reliably. Five reasons for importance: extends working life, prevents breakdowns, maintains efficiency, protects operator safety, preserves resale value. Nigerian context: spare parts hard to obtain quickly in rural areas; breakdowns may last weeks; preventive maintenance reduces frequency. Direct consequences of poor maintenance: accelerated wear from poor lubrication; overheating and seizure from insufficient oil or coolant; filter blockage causing fuel or hydraulic system damage; structural failure from neglected adjustments. Indirect consequences: crop losses from delayed operations; loss of farmer confidence in mechanisation; safety accidents from defective brakes, worn tyres, or unguarded PTO. Four maintenance types as integrated cycle: routine (daily operator checks, first line of defence), preventive (scheduled servicing, proactive), predictive (condition monitoring, detects developing faults), corrective (repair after failure); goal is to maximise routine and preventive, minimise corrective.
12. Preventive maintenance: proactive, scheduled before failure occurs; intervals in engine hours (50, 250, 500) or calendar time. Primary objective: prevent unplanned breakdowns. Secondary: early fault detection; maintained efficiency. Tractor PM schedule: daily (oil, coolant, fuel, tyres, battery, leaks, guards); weekly (fan belt, air filter, hydraulic fluid, lights, grease nipples); monthly (oil and filter change, fuel filter, brakes, wheel bolts); seasonal (hydraulic oil and filter, coolant flush, valve clearances, injectors or plugs, clutch, tyres, electrical connections, rust treatment). Lubrication: most important PM action; engine oil lubricates crankshaft, camshaft, cylinder walls, valve train; change every 50 to 100 hours or 3 months; grease for slow joints via nipples. Filters: air filter (dust entry prevention; daily cleaning in dry season); oil filter (metallic particles; replace with oil change); fuel filter (water and particles; contaminated fuel causes injector failure); hydraulic filter (keep fluid clean; prevents pump and valve failure).
13. Corrective maintenance: reactive, triggered by failure; six-step diagnostic approach (identify symptom, probable causes, systematic testing, root cause confirmation, repair, post-repair test); first-line repairs (belts, hoses, filters, fuses, connections, adjustments) by teacher; major repairs (engine, hydraulic pump, gearbox) by qualified mechanic. Routine maintenance: operator responsibility, daily; before use (check oil, coolant, fuel, tyres,

lights, guards, walk-around), during use (unusual noises, warning lights, fuel gauge), after use (clean, check for new leaks, report). Thresher routine: belt tension, guards fitted, clear feed opening; clean drum and sieves after use. Maintenance records: machine ID, service dates, hour readings, work done, parts and cost, next service due; purposes: accountability, warranty compliance, maintenance planning, resale value. Predictive maintenance: condition-based, monitor actual machine state; P-F curve (defect develops P to F, window for intervention); techniques: vibration analysis (bearing wear), oil analysis (wear particles), thermography (abnormal heat), visual and auditory inspection (noise, smoke, leaks, performance); Nigerian application: simple daily observation log recording noise, smoke colour, leaks, performance, warning lights; two or more simultaneous changes trigger pre-failure inspection; no expensive equipment needed; achievable on every school farm.

## Answers to Pilot Questions [Series 5]

Part 5.1: Overview of Farm Machine Maintenance

1. Farm machine maintenance is the set of actions taken to keep a machine in, or restore it to, a condition in which it can perform its intended function safely, efficiently, and reliably. Five reasons: extends working life (reducing cost per operating hour); prevents unexpected breakdowns during critical planting and harvesting periods; keeps the machine operating at its designed efficiency; protects the operator from accidents caused by mechanical failure; preserves the resale value of the asset.
2. Any three: accelerated wear of moving parts from inadequate lubrication (a poorly lubricated bearing wears in hours what a lubricated one wears in years); overheating and seizure of engines operated with insufficient oil or coolant; blockage and damage to fuel and hydraulic systems from clogged filters; structural component failure from misadjustment or neglect.
3. Any two with Nigerian context: crop losses from delayed operations (a tractor breakdown at planting time may cost more in lost yield than the repair itself; in Nigeria, the planting

window is narrow and delayed planting significantly reduces yield); prolonged downtime due to poor spare parts availability (a broken-down machine in a rural Nigerian area may be out of service for weeks while parts are sourced, a consequence far more severe than in countries with well-stocked dealers).

4. Routine maintenance: daily and pre-operational checks and cleaning by the operator; first line of defence. Preventive maintenance: scheduled servicing at fixed intervals before failure; proactive. Predictive maintenance: continuous or periodic condition monitoring to detect developing faults before failure; adds intelligence to the cycle. Corrective maintenance: repair of a fault or failure that occurs despite the other three. They form a cycle: routine and preventive reduce the frequency of failures; predictive detects what they miss and enables planned corrective work; corrective addresses remaining failures; the goal is to maximise the first three and minimise unplanned corrective work.
5. The goal of a well-designed maintenance programme is to maximise the proportion of time spent on routine and preventive maintenance (which are low-cost and keep the machine running) and minimise the need for corrective maintenance (which is disruptive, costly, and often occurs at the worst possible time during a critical farm operation). Predictive maintenance supports this goal by enabling faults to be corrected at a planned time before they cause an emergency failure.

Part 5.2: Preventive Maintenance

1. Preventive maintenance is scheduled maintenance performed at defined intervals of time or machine operating hours before a failure occurs, with the objective of preventing unplanned breakdowns. Primary objective: prevent failures by servicing components before they wear to the point of failure. Secondary objectives: detect developing faults early before they become costly; maintain the machine at its designed operating efficiency.
2. Any five: check engine oil level (dipstick); check coolant level in radiator or overflow bottle; check fuel level; check all tyre pressures; check battery terminals for corrosion;

inspect under the machine for fluid leaks; confirm that all safety guards (PTO guard, belt covers, rotating part guards) are securely in place.

3. Any three: change engine oil and oil filter; check and service fuel filter; inspect and adjust brakes; check and torque all wheel bolts.
4. Lubrication is the most important PM action because moving metal parts in contact without lubrication generate heat through friction, leading to rapid wear, scoring, and ultimately seizure of the component. Proper lubrication creates a film between the surfaces that prevents direct metal-to-metal contact, dramatically reducing wear rate and heat generation, and extending component life from hours (without lubrication) to years (with correct lubrication).
5. The manufacturer's standard air filter cleaning interval (typically weekly) is based on moderate dust conditions in temperate climates. In Nigeria's dry season, harmattan dust levels are extremely high; the air filter can become blocked within a day of operation, restricting air flow to the engine, causing a rich fuel-air mixture, excessive black smoke, loss of power, and increased fuel consumption. Cleaning the filter daily prevents these consequences and protects the engine from abrasive dust that bypasses a clogged filter.

Part 5.3: Corrective and Routine Maintenance

1. Corrective maintenance is reactive maintenance performed to repair a machine that has already failed or developed a fault preventing correct operation. Six-step approach: (1) identify the symptom precisely (what is wrong, when it occurs, under what conditions); (2) identify the probable causes by examining the system responsible for that function; (3) test each probable cause from most likely to least likely; (4) confirm the root cause through testing or direct inspection; (5) repair or replace the failed component using correct parts and procedures; (6) test-run the machine to confirm the fault is fully resolved and no new faults have been introduced.
2. Routine maintenance consists of the basic daily and pre-operational checks and cleaning performed before, during, and after each use. It is the operator's responsibility because the operator is with the machine during every use; the operator is the first to notice a new

noise, a new leak, a warning light, or a change in performance; these early signals, reported promptly, allow preventive or corrective action before a minor fault becomes a major failure. Routine maintenance requires no specialist tools or training and takes only minutes per session.

3. Any four: check belt tension and condition before use; confirm that all guards are fitted and secure; check that the feed opening is clear of blockages; confirm that the collection tray or bag is correctly positioned. (Also acceptable: listen for unusual sounds from drum or bearings during use; after use, clean all crop residues from drum, sieves, and collection tray; check for bent or broken beaters; oil exposed metal surfaces.)
4. Any four: machine name, make, model, and serial number; date of purchase and purchase cost; date of each maintenance action; type of maintenance performed (routine, preventive, or corrective); description of work done; parts replaced and their cost; name of person performing the maintenance; next service due date.
5. Accountability (documents who maintained what and when, enabling tracing of neglected maintenance); warranty compliance (many equipment warranties require proof of scheduled servicing to remain valid); maintenance planning (enables projection of future costs and scheduling of downtime away from critical operations); resale value (a complete service history increases the machine's market value and demonstrates responsible ownership to a potential buyer).

Part 5.4: Predictive Maintenance

1. Predictive maintenance (PdM) is condition-based maintenance in which the actual state of the machine is monitored and maintenance is performed only when monitoring data indicate that a fault is developing or a component is approaching the end of its service life. It differs from preventive maintenance in that PM services components on a fixed schedule regardless of their condition (which may result in unnecessary service of components still in good condition), while PdM services only when monitoring shows a genuine need, avoiding both under-maintenance (leading to failure) and over-maintenance (wasting resources).

2. The P-F curve plots the progression of a developing defect over time from its earliest detectable point (P, potential failure) to the point at which the machine can no longer perform its function (F, functional failure). It is important for predictive maintenance because it shows that most failures do not occur suddenly; there is a measurable interval between P and F during which the defect can be detected by condition monitoring. If monitoring detects the defect anywhere between P and F, maintenance can be scheduled before F is reached, avoiding an unplanned breakdown.
3. Any four: vibration analysis (measures amplitude and frequency at bearings; detects developing bearing wear, imbalance, or misalignment); oil analysis or tribology (examines oil samples for metallic wear particles, viscosity change, water contamination, and acidity; detects internal wear); thermography (uses infrared camera to detect abnormal heat in bearings, electrical connections, and brakes; detects developing overheating faults); visual and auditory inspection (observes exhaust smoke colour, listens for unusual noises, checks for new fluid leaks, monitors performance; detects a wide range of developing faults without specialist equipment).
4. Normal: light grey or near-invisible exhaust is normal for a well-maintained diesel engine at normal load. Black smoke: indicates incomplete combustion caused by over-fuelling (injector fault) or insufficient air (blocked air filter); the mixture is too rich. Blue smoke: indicates engine oil burning in the combustion chamber, caused by worn piston rings, worn cylinder bores, or valve stem seal failure; oil is passing from the crankcase into the combustion chamber. White smoke: indicates water or coolant in the combustion chamber, caused by a blown cylinder head gasket or cracked cylinder head; highly serious as water can cause hydraulic lock and catastrophic engine damage.
5. By using a simple daily observation log in which the machine operator records observations during routine maintenance: any new or changed noise; exhaust smoke colour (normal or abnormal with colour description); any new fluid leak and its location; any change in power output, speed, or fuel consumption; and any warning light activation. The log requires no instruments or specialist knowledge. When two or more indicators change simultaneously, the machine is removed from service and referred to a mechanic for inspection before the next use. This transforms routine maintenance into a basic predictive monitoring system at zero additional cost.

## References and Attributions [Series 5]

Textual References (Books and External Sources)


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Figures, Plates, Tables, and Boxes

- Figure 5.1: Four maintenance types cycle diagram Attribution: AI generated. Suggested OER search string: "farm machine maintenance cycle four types routine preventive corrective predictive OER".
- Table 5.1: Tractor preventive maintenance schedule Attribution: AI generated. Suggested OER search string: "tractor preventive maintenance schedule daily weekly monthly seasonal OER table".
- Box 5.1: Tractor routine maintenance checklist Attribution: AI generated. Suggested OER search string: "farm tractor routine maintenance checklist before during after use OER box".
- Table 5.2: Condition monitoring indicators and faults Attribution: AI generated. Suggested OER search string: "farm machine condition monitoring indicators vibration oil smoke noise OER table".

- Box 5.2: Predictive maintenance observation log template Attribution: AI generated. Suggested OER search string: "farm machine predictive maintenance observation log template school farm OER box".