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<th>ISBN: 978 – 2967 – 01 - 7</th>
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<td>Author 1</td>
<td>UGURU, Michael I.</td>
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<td>Author 2</td>
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<td>Author 3</td>
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Crop Production
Tools, Techniques and Practice

Michael I Uguru
Crop Production
Tools, Techniques and Practice

Michael I Uguru PhD
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Crop production in tropical West Africa is an outdoor affair. For training in this discipline to be meaningful and effective, the classroom must be well equipped with the fundamental requirements. It is difficult for the tertiary institutions to produce accomplished experts in this area within the short period of time they are in contact with the students. Yet they are expected to turn out graduates with a sufficient grasp of the fundamentals and the ability to begin their lifelong career either as practitioners or agricultural extension agents.

In the light of these considerations, Crop Production: Tools, Techniques and Practice is written to familiarize students and teachers of Agricultural Science with a wide range of features, potentialities, and limitations of actual crop production vis-à-vis recent scientific discoveries and innovations in agriculture. In addition to serving as a foundation tool, it is hoped that the book will help its users to relate the things taught in the classroom to actual practice. Concerted efforts have been made to ensure that the contents are adequately illustrated with diagrams.

To ensure precise information, reference was made to various sources. Principal among these is the Nigerian Institute for Oil Palm Research (NIFOR) manual. I hereby gratefully acknowledge the various sources. I am also grateful to the following persons: Professor R O Ogbuji and Professor I U Obi for obliging me with some photographs used in the text; Professor J O Uzo, whose encouragement initiated this book, and Mr E C Okoji for typing the manuscript.

I happily dedicate this book to my wife, Joy.
Introduction

Generally, plants are important to man. In olden days, man depended on wild plants that grew in his environment. He moved from place to place in search of food. In his nomadic habit, man picked up plants that appeared edible to him as food. Through this trial and error method, he was able to select the edible and non-edible plant materials. Gradually, he began to lose his nomadic tendencies for a more sedentary habit. As he settled down, he began to domesticate some crops within the immediate surroundings. Some plant remains that were deliberately planted also germinated. From this, man developed the idea of cultivation and growing crops through planting. From the domesticated stock, he began to select the plants that met his desire. However, man, especially in the developing countries, still wanders around his environment for food.

Crop

A crop is a plant that is deliberately grown with the intention that it will be harvested at some stage of its development. Roses grown without the intention of harvesting them at some stage of development are not strictly crops. Oil palms that have been wild but are harvested in groves cannot be regarded as true crops. But those that are deliberately planted in plantations and harvested at certain times are referred to as crops.

Crop production methods

Crop production methods can be classified on the basis of the following:

Degree of commercialization

Type of rotation

Water supply

Type of implement

Intensity of cropping

Degree of commercialization The degree of commercialization is determined by the percentage of sales in relation to the gross product. On this premise, a farm is classified either as subsistence, semi-commercialized, or fully-commercialized.

With subsistence farms, agricultural products are raised with the main
Introduction

The purpose of satisfying household needs; sales often less than 25% of the gross product are restricted to surpluses only. Semi-commercialized farms are improvements over subsistence farms as sales usually amount to 50-75% of the gross product. In fully-commercialized farms, more than 75% of the gross product is sold and less than 25% is consumed by the household.

Type of rotation: The type of rotation can be discussed under the shifting cultivation, fallow system, ley system, field system, perennial cropping, and the Taungya system.

Shifting cultivation: Shifting cultivation is a system that involves an alternation between a few years of cropping on a selected piece of land and a lengthy period of fallow. During the fallow period the land is rested and soil fertility regenerates naturally. Because of the long resting period, the system is commonly practised in regions that are thinly populated.

Shifting cultivation is of three forms, namely, migration, rotation and clearance.

Migration involves the continual movement of the farmer and the crops from established homesteads to new cropping areas where new homes, for proximity reasons, are established. The pattern of movement never allows the farmer to return to any abandoned homestead.

The rotational form of shifting cultivation is a characteristic feature of a permanent settlement as the farmer occupies a homestead without any intention to move. Cropping and fallowing alternate regularly or irregularly over the years. Normally, the system involves 2-3 years of cropping followed by 10 or more years of fallow.

The clearance form of shifting cultivation is dictated by the vegetational type, rainfall distribution and the type of tools available. The system can take any of the following forms:

- Cut burn sow
- Cut deep plough reuse sow
- Cut wait for one year sow
- Burn hoe cut sow
- Burn cut hoe burn
- Cut wait for one year sow
- Burn deep plough reuse sow
- Cut wait for one year sow

Ley system: The ley system describes the periodic alternation of cultivated and uncultivated short-to-long-term fallow. The vegetation is allowed to regenerate naturally. Soil nutrient replenishment due to the decomposition of leaves and twigs also occurs. The next cropping is supported by this naturally-generated fertility. However, the extravagant use of land resources and the prolonged unproductive fallow needed to restore soil fertility constitute the major defects of the system.

Ley system: The ley system describes the crop production method whereby grasses are allowed to establish on land that has carried arable crops for some years. The
Introduction

Grasses provide pasture for animals.

Field system In the field system, one arable crop is planted immediately after harvesting another.

Perennial cropping This describes all cases in which the crop planted grows and produces in the field for many years.

Taungya system This is a method of artificial regeneration in which forest crops are raised with temporary cultivation of field crops. The farmer, while preparing the site for the field crops, and in tending the crops provides better establishment conditions for the forest trees. The system is common in the rainforest zones particularly in regions where there is shortage of land for subsistence farming.

Water supply Crop production may depend solely on rainfall (rainfed farming) or on irrigation (irrigated farming). In the former, no attempt is ever made to conserve water to keep the soil moist.

Type of implement used Crop production is done in some countries with very simple farm tools such as hoes, spades, cutlasses or with tools of some degree of sophistication such as harrows and ploughs.

Intensity of cropping The intensity of cropping is categorized into three namely, mixed cropping (intercropping and relay cropping), phased cropping and alley cropping.

Mixed cropping Mixed cropping is the practice of growing two or more crops in the same field during the same year. At the peasantry level of production, the land is limited and simple tools dominate the production process.

Advantages
(1) It reduces disease and pest incidence.
(2) It reduces the chances of total crop failure.
(3) It ensures reasonable soil cover.
(4) The farmer receives cash from time to time as the crops mature at different times.

Disadvantages
(a) The differences in nutrient requirements and tolerance to pesticides make the use of agro-chemicals difficult.
(b) It discourages the use of machinery in the farm.
(c) It complicates any form of farm record.

Intercropping When two or more crops are grown simultaneously on the same plot of land, the term intercropping is appropriate. Different crops may be intercropped or they may be planted sole (pure stand) in alternating rows. The crops in mixtures use available resources and permit the farmer to maintain low but often adequate and relatively steady production.

Intercropping can take either of these forms, namely, strip planting, row planting, or mixed planting. The form chosen depends on the crops grown and on factors such as ease of planting, weeding, and harvesting. The practice is more
Introduction

suited to regions where labour is abundant and land is relatively scarce. The explanation behind the practice is that crops of different maturities have varying peak requirements for water, fertilizer, light, and space and, as such, there is less competition between such crops than there is in sole planting of plants of the same species. Infestation and ease of spread of pests and diseases are less in an intercropped field. Intercropping of some crop species, however, may be deleterious because of allelopathic effects. The common crop combinations are yam-cassava-maize; cassava-maize-melon; cassava-cocoyam-maize; maize-cowpea, maize-soya bean, etc.

Advantages

(a) The system is a good insurance against total crop failure.
(b) It provides protection against soil erosion.
(c) Resources are efficiently used by plants of different heights, rooting depths, and nutrient requirements.
(d) It provides labour, spreads harvesting over a time period during the growing season, and helps reduce storage problems.
(e) It helps to allocate space for crops required in small quantities and facilitates production of many commodities in a limited area.
(f) It inhibits or slows down the spread of diseases and pests.
(g) In cereal-legume mixtures, the cereals may benefit from the nitrogen fixed by the legume companion crop.

Disadvantages

(a) Mechanization is made difficult by intercropping.
(b) It is more difficult to apply the exact amount of fertilizer and other agro-chemicals when compared to sole cropping.
(c) Experimentation with intercropping is more complex and difficult to manage than sole cropping.

Relay cropping

When one crop is interplanted with a second crop as the first crop approaches maturity, the practice is termed relay cropping. It is a common practice in regions where the rainy season is not sufficiently long for two full season crops. For instance, maize may be planted as the rainy season crop, with cowpea interplanted as the maize approaches maturity. Because the first crop has reached maturity, it becomes physiologically inactive with minimal demand on soil moisture and nutrients. Thus competition with the later planting is highly reduced.

Phased cropping

Phased cropping is a special type of mixed cropping. Planting dates are systematically arranged to form a continuous sequence of planting, maturity, and harvesting. The system saves labour as two or more farming operations can be combined. Phasing of harvesting results in continuous supply of food and cash to the farmer and reduces storage losses.

Alley cropping

In alley cropping, field crops are grown in hedgerows of woody shrubs and tree species, preferably leguminous, that are periodically cut-back or pruned to prevent shading the field crops. The trees and shrubs in the hedgerows
recycle nutrients, suppress weeds, check erosion, and serve as a source of organic matter.

Classification of crops

Classification is simply the naming, identification, and orderly arrangement of objects. Plant classification involves the grouping of plants so as to make identification easy. Although many scientists have been credited for their roles in classification of plants and animals, the work of Linnaeus (1707-1778) is still the most universally acceptable. He is the father of taxonomic botany and zoology. He introduced the system of binomial nomenclature whereby a plant is given two names as the basis of its classification. The first is the generic name and the second the specific name. From an agricultural viewpoint, however, crops can be classified as follows: arable crops, permanent or plantation crops, forage crops, vegetable or market garden crops, and ornamental crops.
<table>
<thead>
<tr>
<th>Cereals</th>
<th>Legumes</th>
<th>Roots and tubers</th>
<th>Fibres</th>
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<td><em>Triticum vulgare</em></td>
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<td><em>Jute</em></td>
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<td><em>Kesarigelia geocarpa</em></td>
<td><em>Kapok</em></td>
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<td><em>Coleus alyssaeus</em></td>
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<td><em>Cucumis viscosus</em></td>
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<td>okra and marmalade</td>
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<tr>
<td>Acacia senegal</td>
<td>gum arabic</td>
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Crops in Nigeria

Miscellaneous
- Bambusa spp. - bambou
- Xylopia aethiopica - wala
- Acoa bartari - ohaba

Some garden
- Vernonia amygdalina - bitter leaf
- Telfairia occidentalis - fluted pumpkin
- Cucumis melo - watermelon
- Cucurbita pepo - pumpkin
- Lycopersicon lycopersicum - tomato
- Capsicum spp. - peppers
- Solanum melongena - eggplant (garden egg)
- Abelmoschus esculentus - okra
- Cenchrus ciliaris - jute
- Talinum triangulare - water leaf
- Amaranthus caudatus - African spinach
- Gourum africanum - wheati
- Allium cepa - onion
- Pergularia spp. - uzazi
- Colocynthis citrinus - egusi (melon)
- Jusema communis - castor (oil crop)
- Sesamum indicum - bennised (oil crop)
- Nicotiana tabacum - tobacco (drug crop)
- Succharum officinarum - sugarcane (sugar crop)
- Zingiber officinale - ginger (spice)
- Myristica fragrans - nutmeg (spice)
- Piper nigrum - uziza (spice)

vegetables
- Xylopia aethiopica - wala
- Telfairia occidentalis - fluted pumpkin
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- Jusema communis - castor (oil crop)
- Sesamum indicum - bennised (oil crop)
- Nicotiana tabacum - tobacco (drug crop)
- Succharum officinarum - sugarcane (sugar crop)
- Zingiber officinale - ginger (spice)
- Myristica fragrans - nutmeg (spice)
- Piper nigrum - uziza (spice)
Farm tractor

The general purpose tractor is adapted to all types of farming conditions. It is designed for an integral mounting of cultivating, harvesting, and planting equipment. The tractor consists of an engine, a hydraulic power system for controlling implements pulled by it, and a power-take-off system that supplies power to the implement.

The plough, harrow, planter and other field cultivators are usually hitched to the tractor that pulls them around in the field to do specific jobs.

Mouldboard plough

This is a primary tillage implement. It cuts the soil through its shear points as it is pulled by the tractor. The cut soil travels through the entire length of the plough blades. The plough is suitable for breaking many types of soil. It is also very useful in turning under and covering crop residues of the last cropping.

Chisel plough

The chisel plough is also a primary tillage implement. It consists of heavy rigid tines that make deeper penetrations into the soil. It can be operated in much harder and drier soils than the disc plough. Because of this, it can be used to cultivate the farmland before the rains thus ensuring maximum moisture retention of the soil. It reduces the incidence of soil erosion by retaining trash on the soil surface. Additionally, sub-surface moisture is retained in the soil because the implement does not expose it to evaporation. This allows early planting and a better farming schedule.

Unlike other types of ploughs, the chisel plough lacks the potential of turning under and covering crop residues.

Disc plough

The disc plough is the commonest primary tillage implement in use in the tropics. It is of robust construction and its rolling discs cope well with stones, tree roots, giant stumps, and abrasive soils. It is suitable for soils on which mouldboard ploughs cannot work efficiently, for example, soils with hardpan, sticky soils and dry hard ground. The disc plough is the desired tillage implement whenever deep ploughing is needed. Every disc has a scraper attachment which cleans the face of the disc of mud and also controls the way the furrow is turned and broken.
Tandem disc harrow. This is a secondary tillage implement. It is an excellent implement for breaking soil clods and consolidating the seedbed without dragging buried plant remains to the surface. Additional functions of the disc harrow include:
(a) cutting up of crop residues and mixing the fragments with soil; 
(b) putting the topsoil in a fine tilth; and 
(c) destruction of weeds on fallow lands. The discs also carry scraper attachments for cleaning the surfaces of the blades.

Spring-tooth harrow. This implement is used especially in regions where firm soil prevents good penetration of other types of harrows. It is very effective in stony soils and for destruction of deep-rooted weeds.

Planter - 4 - row. The planter is a farm implement specially designed to sow seeds at predetermined spacing and depth. The seed spacing or planting rate is determined by the seed plates used as well as by the combination of sprockets chosen while the depth of planting is controlled by the planter press wheels. It is a trailing implement pulled by the tractor drawbar. The line of drive is usually from the land wheel to the seed metering mechanism through the sprocket and chain. Seeds of many field crops are planted by this equipment.

Rotary mower. The rotary mower is an instrument for many bush cutting jobs. It is popular for industrial and pasture mowing and maintenance. Mowing of lawns and football fields is also done with rotary mowers. In agriculture, mowers are used to cut green grass for silage making.

Forage harvester. This is a trail implement with two wheels. It cuts silage through a fixed knife or bar and blows it out through the chute into a wagon. It is normally hitched to a tractor that pulls it as it does the harvesting. It is used to harvest forage crops - maize and grass. It makes a fine-cut for high-quality silage preparation.

Power thresher. Farmers in Nigeria thresh grains by traditional methods (beating ears against hard surfaces) except in large farms owned by the state or
cooperatives where rice and pulses are threshed using improved technology.
The power thresher is a dual purpose machine - it threshes and winnows simultaneously thus increasing the speed of farm operations. Its use also has the added advantage of releasing labourers engaged in the work to other farm activities.

**Fig. 3.7 Spring-tooth harrow**  
**Fig. 3.8 Planter-4-row**  
**Fig. 3.9 Rotary mower**

**Rice mill** As the name implies, the machine is used for milling rice. Just like the power thresher, the rice mill saves time and ensures a perfect finish of processed rice.

The machine consists of the hopper, hulling assembly, the hull discharge component, and the prime mover. The hopper holds the paddy for milling and the rate of feeding is controlled by setting the sliding gate installed at the bottom of the hopper. The milling assembly consists of a pair of drum type rubber roll hullers. Rice hulls are discharged by means of a centrifugal type blower. The milled rice is discharged at the other end through the grain outlet spout.

Rice milling is a very lucrative business particularly for young agricultural graduates who have no jobs. It is good to know the rice mill, identify it and possibly purchase it.

**Fig. 3.10 Forage harvester**  
**Fig. 3.11 Power thresher**  
**Fig. 3.12 Rice mill**
Electric chain saw  Quite unlike the other cutting instruments the chain saw is motorized. This imparts on it greater cutting power than the manually operated saws. It is mostly useful in forests to cut down giant forest trees. It is also used to cut the felled trees into logs. By virtue of its greater cutting power, it reduces the drudgery of the initial clearing of a full-grown forest.

Sprayers  Generally, sprayers are used to spray all forms of liquid pesticides such as insecticides, herbicides and fungicides, a function based on the following principles:

(a) sprayers break the liquid chemicals into droplets of effective size and distribute them uniformly over the surface to be protected;
(b) sprayers regulate the amount of pesticide to avoid excessive application that might either harm the crop or bring about wastage.

Motorized sprayer  The motorized sprayer is made of plastic tank. The nozzle can be made of nylon or brass. It usually has its own engine that may be either the petrol or diesel type. The engine produces its own power and through the blower attached to the engine crankshaft, a high volume of air is blown through the enclosure into the hand boom or spray gun. The air helps to spray out the chemical located at a point central to the air boom giving it its own spread pattern. Motorized sprayers provide the most satisfactory type of spray for commercial growers as the higher pressure often gives better penetration and coverage.

Knapsack sprayer  This is made of plastic tank usually carried on the back of the operator. The efficiency of its operation depends up on that of the operator because it is hand-operated. The up and down stroke of the hand operated lever is for the diaphragm to suck through the inlet valve and discharge, through the outlet valve into the spray gun. The operator directs the nozzle of the spray gun on the object to be sprayed.
Maintenance of farm machines

To reduce the wear and tear of farm machines and ensure longer service life the following maintenance tips should be observed.

(a) Adherence to the instructions in the assemblage, operation and service handbook or manual.
(b) Lubrication of the bearings and other units that are prone to friction.
(c) Daily search for loose bolts and nuts. These must be tightened or replaced if necessary.
(d) Very thorough cleaning of the blades and other units coated with mud. Such units may also be smeared with a thin film of grease after the cleaning.
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Soil
Soil is defined as the accumulated natural bodies, minerals, organic materials and living forms, on the earth surface that support plant growth.

Components of soil These are four main components of soil:
(a) organic matter
(b) mineral matter
(c) air
(d) water

Generally, soils comprise 50% solid (5% organic matter and 45% mineral matter) and 50% pore space (20-30% air and 20-30% water).

Soil profile The soil profile is simply defined as the vertical section of a soil which shows distinct horizontal layers (horizons) and a portion of the parent material. The horizons are collectively referred to as solum.

Factors of soil formation The kind of soil that develops in a region is largely controlled by five main factors, namely,
(a) climate
(b) nature of parent material
(c) topography of the region
(d) time
(e) living organisms

Climate The two main climatic elements that influence the rates of weathering are temperature and precipitation. Both elements dictate the amount of physical and chemical breakdown that eventually leads to the development of soil profile.

Nature of parent material The chemical, mineralogical content, texture and structure of the parent material influence, to a very great extent, the effectiveness of weathering forces and the mineral composition of the soil.

Topography Topography influences soil formation in the sense that it may either quicken or slow down the actions of weathering agents. For instance, a sloping surface encourages erosion that reduces the chances of deep soil development. As a result, very shallow soils with very low crop production potentials predominate in such an area. Similarly, a topography that encourages standing
16 Soil and plant nutrition

pools of water renders weathering forces less effective.

Time  The length of time that parent materials are exposed to weathering agents is important in soil formation. For instance, soils on alluvial materials will have less time to develop in contrast to the surrounding upland soils.

Living organisms Living organisms, particularly the soil inhabiting ones such as earthworms, play major roles in organic matter accumulation, profile mixing and re-cycling of nutrients in the soil. The vegetation of a location also has a profound influence in the formation of soil in a region.

Chemical elements in the soil that constitute plant food A good agricultural soil supplies mechanical support, air, water, favourable temperature and nutrients to plants growing on it. Enough nutrient elements are made available and in the right proportion for a maximum yield of crops by such a soil.

Seventeen nutrient elements have been identified as essential for good crop growth and yield. Three of these, carbon, hydrogen and oxygen are supplied from air and water. Fourteen are obtained from the soil solids. Six of the fourteen are needed in very large amounts and are referred to as macroelements. The remaining eight are required in small or trace amounts and are called microelements.

The macroelements are nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), and sulphur (S) while the microelements are iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), copper (Cu), zinc (Zn), chlorine (Cl) and cobalt (Co). However, in exhausted soils, supplementary additions in the form of fertilizers provide nitrogen, phosphorus, potassium and, to some extent, sulphur.

All essential elements are present in the soil as ions. For example, nitrogen may be present either as NH₄⁺, NO₃⁻, NO₂⁻, potassium as K⁺, phosphorus as HPO₄²⁻, manganese as Mn⁺², molybdenum as MoO₄²⁻ and so on.

Soil pH  The pH of a soil is simply defined as the acidity or alkalinity of the soil. The two terms acidity and alkalinity depend on the hydrogen ion (H⁺) and hydroxyl ion (OH⁻) concentrations in any soil sample.

At a higher hydrogen ion concentration (low pH) the soil is described as an acidic soil but when there is a higher concentration of the hydroxyl ion (high pH) the soil is referred to as an alkaline soil. Where both ions are present at equal concentration such a soil is said to be neutral.

Causes of soil acidity

1 Excessive precipitation Excessive rainfall leaches off exchangeable bases leaving the soil system completely dominated with hydrogen ion and oxides of aluminium and iron. These result in an increase in soil acidity.
2. Plant nutrient uptake

Plant uptake of more inorganic cations than inorganic anions with subsequent exchange of hydrogen ions from plant roots with the cations of the soil lowers the soil pH.

3. Excess use of inorganic fertilizers

Excess use of inorganic fertilizers that have acid residues when they are applied also results in increase in soil acidity. An example of such fertilizers is ammonium sulphate.

4. Weathering of soil organic matter

In most cases weathering of soil organic matter results in a build-up of hydrogen ions in soil thus increasing soil acidity.

5. Nitrification

Nitrification and sulphate oxidation in a soil increase its acidity.

Effects of high soil acidity (Low pH)

High soil acidity causes unavailability of soil nutrient elements to crop plants. An example in this respect is the reduction in the solubility of certain macronutrients such as nitrogen, magnesium, potassium, calcium and phosphorus.

It encourages the solubility and subsequent concentration of toxic inorganic substances such as iron and aluminium salts. Consequently soil micro-organisms are incapacitated. The root cells of the crop plants are equally affected and their physiological performances are reduced.

Determination of soil pH

In order to know the true situation of the soil before embarking on any conventional agricultural practice, it is very necessary to determine the pH of the soil. With respect to pH, soils can be grouped as in the Table below:

<table>
<thead>
<tr>
<th>pH</th>
<th>Soil reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 7</td>
<td>Alkaline</td>
</tr>
<tr>
<td>7</td>
<td>Neutral</td>
</tr>
<tr>
<td>6.0 - 6.9</td>
<td>Slightly acidic</td>
</tr>
<tr>
<td>5.2 - 5.9</td>
<td>Moderately acid</td>
</tr>
<tr>
<td>Below 5.2</td>
<td>Very acid</td>
</tr>
</tbody>
</table>

pH can be determined roughly with special dyes or indicator or more accurately by the use of a pH metre.

Use of special dyes or indicators

A solution of the soil sample is saturated with one or a mixture of indicators and allowed to stand in contact for a few minutes. One or two drops of the solution are smeared on a clean white sheet and the observed colour is compared with the colours on a suitable colour chart. After a critical observation, the approximate pH of the soil sample can be ascertained.

Use of pH metre

The pH metre consists of a glass electrode and a reference
electrode. A soil suspension is made with either water or KCl, and both electrodes are immersed in it. The electrode potential developed in the glass electrode is measured by the meter.

**How to reduce soil acidity** Less use of fertilizers with acidic radicals will reduce acidity because such fertilizers will add more exchangeable bases to the soil. Application of agricultural limes such as calcium carbonate (calcite) and calcium oxide (quicklime) will reduce acidity by knocking out hydrogen ions from soil colloids. The amount of lime required to raise the soil pH to about 6.5 in the top 15 cm layer of soil is referred to as the lime requirement of that soil. This is determined from chemical test in the laboratory. Lime requirements vary from one soil type to another. Clay soil and soils rich in organic matter require more lime to raise the pH than other soil types.

**Purpose of liming** Soils are limed primarily to supply calcium and correct acidity of the soil. Other beneficial effects of liming are: (a) to increase the efficiency of fertilizer use; (b) to reduce the toxic effects of manganese; (c) to stimulate the decomposition of organic matter and indirectly to improve the soil physical conditions.

**Causes of soil alkalinity** Soils that are neutral to alkaline are no longer rich in either hydrogen or aluminium ions. Such soils have most of their exchangeable sites occupied by exchangeable bases such as calcium, magnesium, and other bases. Thus any process that promotes high levels of these bases will contribute towards a decrease in soil acidity and an increase in alkalinity.

1. **Weathering** This process releases the exchangeable bases from minerals and makes them available to the soil. High concentrations of these bases as in arid and semi-arid regions often result in soil alkalinity.

2. **Overliming** The excessive use of lime and liming materials by farmers also results in soil alkalinity.

3. **Continuous irrigation** Water used for irrigation is often charged with various kinds of salts that deposit their cations in the soil, thus increasing soil alkalinity.

4. **Insufficient rainfall** Lack of sufficient rains to leach metallic cations that resulted from weathering in arid and semi-arid regions also causes a rise in soil pH and hence soil alkalinity.

**Role of nutrient elements in plants**

**Nitrogen** Nitrogen is important as a building block in the formation of protein which is usually a major component of the protoplasm and nucleus. It is therefore required for growth. Nitrogen forms an integral part of the co-enzymes NAD and NADP that play very important roles in plant metabolism. Together with Mg, N forms an important part of chlorophyll. Nitrogen supply is important in carbohydrate utilization. When there is an acute shortage of nitrogen, carbohydrate is deposited in vegetative cells resulting in a thickened cell wall.
Nitrogen also governs the utilization of K, P and other constituents. With cereals, it increases the grain plumpness and the percentage crude protein. **Phosphorus** Phosphorus is a major constituent of the nucleic acid and the phospholipids in plants and usually is a building block in the formation of nucleoprotein. It is a constituent of the cell nucleus and has been reported to be important in cell division. It is important in the development of reproductive cells and in the formation of seeds. It is also important in root development and it enhances greater straw strength in cereals. **Potassium** Unlike the other macronutrients such as N, P and S, potassium does not form an integral part of the plant. It is essentially catalytic in function and very important in enzymatic activities for synthesis of carbohydrates and breakdown of sugar. Potassium is an enzyme activator. Most enzyme systems will not function in the absence of K. Nitrogen uptake and metabolism and protein synthesis require potassium. Potassium is also very important in the water balance of the plant and in the production of high-energy phosphate molecules like ATP. It is important in cell division and in the formation of seeds. It is also important in root development and it enhances greater straw strength in cereals.

**Magnesium** Magnesium forms part of the chlorophyll molecule. It is observed to be essential in phosphate metabolism because it catalyses phosphorylation reaction. Magnesium is important in the citric acid cycle and in oil synthesis.

**Calcium** Calcium mainly plays a structural role in plants. It is a cell wall constituent where it exists as calcium pectate in the cell middle lamella. Calcium is also needed for some enzyme reactions.

**Sulphur** Sulphur is an important constituent of proteins hence there is usually a high demand for sulphur by plants that are rich in protein.

### Nutrient element deficiency symptoms

#### Nitrogen deficiency symptoms

1. Weak and stunted growth.
2. Small and yellowing leaves which tend to drop.
3. Red or purplish stem colouration due to excessive production of anthocyanin.
4. Chlorosis or yellowing of older leaves at the lower portion of the stem.
5. Because nitrogen is a very mobile element, the small amount in the plant is moved to the younger leaves which remain green.

#### Phosphorus deficiency symptoms

1. Stunted growth because P is always associated with growth.
2. Delayed maturity.
3. Poor grain, fruit or seed development.
4. In extreme cases, older leaves tend towards bluish-green with purple tinting; leaf margins show brown scotch.
Potassium deficiency symptoms
1. Initial dull greenish colouration of the older leaves.
2. Mottled chlorosis followed by the development of necrotic tips.
3. Downward curvature of leaves.
4. Curling, bronzing and scoring of leaves occur at advanced stages.
5. Stunted growth with reduced internodes.
6. Weak growth and stalk snapping in cereals.
7. Depressed photosynthesis and increased respiration.
8. Impairment of movements of assimilates from leaves to the storage organs.
9. Small fruits and shrivelled seeds.
10. Reduction in quality of fruits and vegetables.

Magnesium
Interveinal chlorosis of leaves. At advanced stages, the entire leaf becomes pale yellow and necrotic.

Calcium
Deficiency symptoms are not common except in very heavily leached soils. Visual symptoms include scorched leaf margins, distorted leaves, and poorly developed roots.

Sulphur
Sulphur deficiency rarely occurs. However, deficiency symptoms can be manifested in the form of spiny or stunted growth. Because it is immobile, the foliage symptoms occur mostly in the younger leaves. Deficiency in legumes impairs nodulation and in fruit trees, it delays maturity.

Microelements
Microelements are required by plants in trace amounts. Because of this, it was not necessary in the past to apply microelements as fertilizers. They were often present in sufficient amounts in the soil or inadvertently supplied as the fertilizers carrying the macroelements were being applied. Nowadays, the use of improved planting materials, intensive agriculture, and improved crop husbandry have made the application of micronutrient elements as fertilizers mandatory.

Zinc deficiency leads to a condition usually referred to as "lilac leaf disease" that is often associated with fruit trees.

Visual symptoms of molybdenum deficiency first appear as interveinal chlorosis especially with leguminous species. Rhizobia in leguminous species require molybdenum for nitrogen fixation.

Cobalt is required by rhizobia for the fixation of nitrogen hence it is important for the growth of legumes.

Copper deficiency symptoms are common in crops grown in sandy soils because of the excessive leaching in such soils. The importance of copper is more to livestock than plants. Hence its application to forages (especially for feeding
Soil and plant nutrition

sheep) should be done with caution. The swayback disease of sheep is due to the deficiency of copper in the diet.

Factors that influence nutrient element availability

Soil pH

Imbalance in the supply of the elements

Excessive precipitation

Crop removal

Nutrient oxidation and removal.

Soil pH most plants perform optimally at the near neutral pH (6-7). Within this range, most nutrient elements, except the trace elements, are available for absorption. The microelements are generally more available at low pH (i.e. acidic conditions).

Imbalance in the supply of the elements When the different nutrient elements are applied together they interact either positively to favour crop growth and yield or negatively to depress crop performance. The supply of one element could affect the uptake or utilization of another, a phenomenon often referred to as antagonism. This term can be discussed under three processes, namely, interference or competition in absorption, interference in utilization at the target points, and interference in translocation. For example, chlorine is antagonistic to phosphorus uptake; high rates of potassium can depress the uptake of Ca, Na and Mg and excessive application of phosphorus is antagonistic to Zn, Iron and Cu.

Excessive precipitation Excessive precipitation causes considerable loss of nutrient elements through leaching. When base elements are leached away there is a net preponderance of hydrogen ion which brings about a decrease in pH. At such low pH levels macronutrients become unavailable.

Oxidation Iron, copper and manganese occur in different oxidation states and are usually encouraged by low oxygen tension and a high moisture level. Hence acid soils which are poorly aerated and poorly drained often tend to supply toxic levels of micronutrients.

Crop removal Differential nutrient element removal by plants in the absence of a commensurate replenishment measure would cause a drop in the nutrient availability status of the soil and also bring about soil acidity.

Organic manures

All organic manures originate from living organisms, that is, they are derived from plant and animal remains. When applied they are subjected to the attack of microorganisms. They have very high reserves of plant nutrients and they play a more important role in ameliorating soil conditions. Organic manures influence the soil pH and the physical conditions of a soil which affect plant growth. They make soil more friable and easier to work by increasing pore spaces, drainage and water
retaining capacity. They increase soil nutrients status and stimulate microbial life in the soil. They increase availability of soil nutrient elements because of their influence on soil pH.

Farmyard manure This refers to the refuse from animals principally cattle, sheep, goats, horses and poultry. It consists of a mixture of three components — faeces, urine, and materials used as bedding. The bedding of animal houses is removed from time to time and left outside to rot and decompose completely before application. Farmyard manure is very rich in all the crop nutrient elements and it improves the soil physical and chemical properties and provides a favourable environment for growth and development of relevant soil microorganisms. Farmyard manure is identified with the peculiar farm animal urine and faeces smell.

Green manures These manures involve plants or herbage species grown with the view of incorporating them, while still green and succulent into the soil in order to enrich the soil. Such plant species should be capable of growing fast and establishing to very poor soils. They must be succulent and leafy as they serve initially as cover crops before they are finally ploughed into the soil. Leguminous plant like Calopogonium, Pueraria, Stylosanthes spp., and Mucuna spp are usually preferable.

Compost When plant and animal materials and household wastes are gathered together in a heap or pit, the rotted and decomposed left-over is referred to as compost.

The materials used for preparing compost include:
(a) Wastes swept out from homes: peelings, ashes and leaves
(b) Freshly cut grasses and twigs.
(c) Starter material— poultry dropping or cow dung.
A well-prepared compost is usually dark in colour, and it has no defined smell. The materials used are far more decomposed than those of the farmyard manure thus making their recognition more difficult.

Elemental composition of some common organic manures

<table>
<thead>
<tr>
<th>Source</th>
<th>N (%)</th>
<th>P₂O₅ (%)</th>
<th>K₂O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>2.0 - 4.3</td>
<td>4.5 - 6.0</td>
<td>1.2 - 2.4</td>
</tr>
<tr>
<td>Sheep</td>
<td>3.0 - 4.0</td>
<td>1.2 - 1.8</td>
<td>3.0 - 4.5</td>
</tr>
<tr>
<td>Pig</td>
<td>3.0 - 4.2</td>
<td>0.4 - 0.7</td>
<td>0.5 - 1.5</td>
</tr>
<tr>
<td>Cattle</td>
<td>0.6 - 2.1</td>
<td>0.7 - 1.1</td>
<td>2.5 - 3.6</td>
</tr>
<tr>
<td>Sewage</td>
<td>1.0 - 2.6</td>
<td>1.0 - 2.0</td>
<td>0.4 - 1.0</td>
</tr>
<tr>
<td>Blood</td>
<td>10.0 - 15.0</td>
<td>1.5 - 2.5</td>
<td>1.0 - 1.5</td>
</tr>
</tbody>
</table>
Inorganic fertilizers These fertilizers are chemical compounds that are mainly applied to supplement the amount of plant nutrients present in the soil so as to meet the crop requirement for maximum growth, development and yield.

Types of fertilizers

Single or straight fertilizers are simple materials which can supply only one primary nutrient element.

Examples

<table>
<thead>
<tr>
<th>Name</th>
<th>Main nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen fertilizers</td>
<td>%N</td>
</tr>
<tr>
<td>Anhydrous ammonia</td>
<td>82</td>
</tr>
<tr>
<td>Ammonium nitrate lime (Cal-nitro)</td>
<td>20.5</td>
</tr>
<tr>
<td>Calcium cyanamide</td>
<td>21</td>
</tr>
<tr>
<td>Diammonium phosphate</td>
<td>16-18</td>
</tr>
<tr>
<td>Sodium nitrate</td>
<td>16</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>34.5</td>
</tr>
<tr>
<td>Calcium nitrate</td>
<td>45.5</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>21</td>
</tr>
<tr>
<td>Ammonium sulphate nitrate</td>
<td>25</td>
</tr>
<tr>
<td>Phosphate fertilizers</td>
<td>%P₂O₅</td>
</tr>
<tr>
<td>Single superphosphate</td>
<td>18</td>
</tr>
<tr>
<td>Triple superphosphate</td>
<td>47</td>
</tr>
<tr>
<td>Basic Mgo</td>
<td>15</td>
</tr>
<tr>
<td>Ground rock phosphate</td>
<td>36</td>
</tr>
<tr>
<td>Potash fertilizers</td>
<td>%K₂O</td>
</tr>
<tr>
<td>Muriate of potash</td>
<td>60</td>
</tr>
<tr>
<td>Sulphate of Potash-magnesia</td>
<td>26</td>
</tr>
<tr>
<td>Sulphate of potash</td>
<td>50</td>
</tr>
</tbody>
</table>

Identification of some single fertilizers

<table>
<thead>
<tr>
<th>Muriate of potash</th>
<th>1 It easily cakes in its container.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 It is hygroscopic (capable of taking up moisture from the atmosphere).</td>
</tr>
<tr>
<td></td>
<td>3 The colour ranges from white to red, depending on the method of refining.</td>
</tr>
<tr>
<td></td>
<td>4 It may be powdery or granular.</td>
</tr>
</tbody>
</table>
Soil and plant nutrition

Sulphate of ammonia

1 It is white.
2 It is soluble in water.
3 It is crystalline and sugar-like.
4 It is non-hygroscopic (it does not readily absorb water from the atmosphere).
5 Its decomposition in soils usually leaves an acid residue hence the fertilizer is best for alkaline soils.

Simple calculation

If a farmer is applying 50 kg N/ha, what quantity of sulphate of ammonia does he require for 5 hectares?

Solution

Ammonium sulphate has 21% N (nitrogen is the active ingredient). This implies that 21 kg of N is contained in 100 kg of ammonium sulphate. Therefore

\[
50 \text{ kg of N} = \frac{21}{100} \times 50 \text{ kg of ammonium sulphate per hectare}
\]

For 5 ha

\[
= 238.095 \text{ kg of ammonium sulphate per hectare}
\]

\[
= 1190.5 \text{ kg}
\]

= 1.19 tonnes of ammonium sulphate.

Compound fertilizers

These fertilizers supply two or more primary elements such as nitrogen, phosphorus and potassium. They are usually prepared by mixing single fertilizers—a process referred to as fertilizer compounding.

Grade

is an expression that indicates the percentage of the different plant nutrients in a fertilizer.

A fertilizer with 25% N, 10% P₂O₅, and 10% K₂O is described as 25-10-10; and one without phosphorus, but contains 20% N and 15% K₂O is described as 20-0-15.

Example of a common compound fertilizer

15-15-15 fertilizer contains 15% N, 15% P₂O₅, and 15% K₂O. It is light-brown in colour and it is deliquescent hence it is granulated to ease handling.

Simple calculation

A student of agriculture has five experimental plots measuring 500 m² each for a research work. If he wishes to apply ammonium sulphate (21% N) to maize growing in these plots at the rates of 0 kg N/ha, 50 kg N/ha, 100 kg N/ha and 150 kg N/ha, calculate the corresponding amounts in kilogrammes of ammonium sulphate he will apply to his experimental plots.

Solution

21 kg N is contained in 100 kg of ammonium sulphate

0 kg N/ha will be supplied by (100×0) kg of ammonium sulphate

21 = 0 kg of ammonium sulphate/ha
50 kg N/ha will be supplied by \((100 \times 50)\) kg of ammonium sulphate
\[= 238 \text{ kg of ammonium sulphate/ha}\]

100 kg N/ha will be supplied by \((100 \times 100)\) kg of ammonium sulphate
\[= 476 \text{ kg of ammonium sulphate/ha}\]

150 kg N/ha will be supplied by \((100 \times 150)\) kg of ammonium sulphate
\[= 714 \text{ kg of ammonium sulphate/ha}\]

The amounts of ammonium sulphate calculated above are for one hectare. For the experimental plot of 500 m² the student will need:

\[
\begin{align*}
500/10,000 & \times 0 = 0 \text{ kg NH}_4\text{SO}_4 \\
500/10,000 & \times 238 = 11.9 \text{ kg NH}_4\text{SO}_4 \\
500/10,000 & \times 476 = 23.8 \text{ kg NH}_4\text{SO}_4 \\
500/10,000 & \times 714 = 35.7 \text{ kg NH}_4\text{SO}_4
\end{align*}
\]

That is, 0, 11.9, 23.8 and 35.7 kg of ammonium sulphate will be applied per plot for the four levels of treatment.

If a farmer in your village is supplied with ammonium sulphate (21% N), single superphosphate (18% P₂O₅), and muriate of potash (60% K₂O), state clearly by means of calculations how this farmer would use these carrier materials to compound 300 kg of 5:10:12 NPK mixture. Calculate the amount of filler material that will be added in the mixture.

Solution

5-10-12 mixture means that 5% N, 10% P₂O₅, and 12% K₂O are in the mixture.

\[\begin{align*}
\text{N} & = 5\% \times 300 = 15 \text{ kg N} \\
\text{P} & = 10\% \times 300 = 30 \text{ kg P}_2\text{O}_5 \\
\text{K} & = 12\% \times 300 = 36 \text{ kg K}_2\text{O}
\end{align*}\]

Percentage active ingredient (i.e. N) in sulphate of ammonia = 21%

This implies that for every 100 kg sulphate of ammonia there is 21 kg of N.

\[\begin{align*}
21 \text{ kg N} & = 100 \text{ kg sulphate of ammonia} \\
15 \text{ kg N} & = 100/21 \times 15 = 71.4 \text{ kg ammonium sulphate}
\end{align*}\]
Similarly, 18 kg P, @ 100 kg single superphosphate.

1 kg P₀₅ = 100/18 kg single superphosphate

30 kg P₀₅ = 100 x 30 = 166.7 kg single superphosphate.

60 kg K₂O = 100 kg muriate of potash
1 kg K₂O = 100/60 kg muriate of potash
36 kg K₂O = 100/60 x 36 = 60 kg muriate of potash.

Sum the three values

71.4 + 166.7 + 60 = 298.1 kg.

From calculation, 298.1 kg of mixture is obtained and to make this up to the desired 300 kg, a filler material which is either sand or any other approved inert material, weighing 1.9 kg is added.

Conversion factors for fertilizer materials

<table>
<thead>
<tr>
<th>Multiply</th>
<th>By</th>
<th>To obtain equivalent nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium nitrate</td>
<td>0.35</td>
<td>Nitrogen (N)</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>0.212</td>
<td>N</td>
</tr>
<tr>
<td>Borax</td>
<td>0.714</td>
<td>Boron (B)</td>
</tr>
<tr>
<td>Sodium nitrate</td>
<td>0.165</td>
<td>CaO</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1.399</td>
<td>CaCO₃</td>
</tr>
<tr>
<td>Ca</td>
<td>7.498</td>
<td>Ca(OH)₂</td>
</tr>
<tr>
<td>Calcium carbonate</td>
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<td>CaO</td>
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<tr>
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<td>0.741</td>
<td>CaO</td>
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<tr>
<td>Calcium carbonate</td>
<td>0.56</td>
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<tr>
<td>Calcium carbonate</td>
<td>0.403</td>
<td>MgO</td>
</tr>
<tr>
<td>Calcium hydroxide</td>
<td>0.756</td>
<td>CaO</td>
</tr>
<tr>
<td>Gypsum</td>
<td>0.326</td>
<td>CaO</td>
</tr>
<tr>
<td>Gypsum</td>
<td>0.186</td>
<td>S</td>
</tr>
<tr>
<td>Phosphoric acid</td>
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<td>P</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>0.524</td>
<td>K</td>
</tr>
<tr>
<td>Potassium sulphate</td>
<td>0.540</td>
<td>K₂O</td>
</tr>
<tr>
<td>Potassium sulphate</td>
<td>0.449</td>
<td>K</td>
</tr>
<tr>
<td>Potassium nitrate</td>
<td>0.387</td>
<td>K₂O</td>
</tr>
<tr>
<td>Potassium nitrate</td>
<td>0.466</td>
<td>K₂O</td>
</tr>
</tbody>
</table>
In West Africa, a considerable proportion of the land is still cultivated with very simple hand tools. Many of these tools are made by the local blacksmiths. They are easy to make and relatively inexpensive. Although they give many years of useful service, the amount of work achieved with the tools is rather small.

**Rake**

The rake has a wooden handle and a metal blade with strong tooth-like prongs. The tool is used for (a) levelling of seedbeds and (b) removing twigs, stones, and weeds from seedbeds.

**Shovel and spade**

Both tools are similar except that the blade of the shovel is broader than that of the spade. They are used for (a) lifting and turning soils during seedbed preparation; (b) digging holes during transplanting of tree crop seedlings; (c) moving soils, stones, and compost from one point to another in a farm; and (d) burying weeds.

**Garden fork**

This resembles the spade except for the forked blade. It is used for (a) working manures thoroughly into the soil on seedbeds; (b) digging and loosening hard and heavy soils; (c) moving mulch materials and compost from one point of the farm to another; and (d) clearing surface soil of rubbish.

**Cutlass (or Machete)**

The cutlass has a short wooden handle and a relatively long metal blade that performs the cutting function. The uses of the cutlass are so numerous that it has become the most handy of all tools to most peasant farmers. It is used for (a) clearing undergrowth and trimming forest trees; (b) digging holes
during transplanting of seedlings, (c) preparing stakes for yams, tomatoes and vegetable cowpea and, (d) removing deep-rooting weeds.

**Hand trowel**
At the name implies, it is a small and very simple tool. It has a small wooden handle and a slightly folded blade. It is used for (a) mixing manures needed for raising seedlings and (b) for planting rooted cuttings of ornamentals.

**Hand fork**
The hand fork is another small tool like the trowel except that the blade is prongs. It is used in many nursery operations such as (a) mixing manures for polybag and seed boxes (b) for loosening capped roots in seed boxes after watering; and (c) for removing weeds and for mixing organic manure or fertilizer with topsoil.

**Pruning saw**
Like other saws, the pruning saw has a grated cutting edge. In the absence of a chain saw it can be used to cut felled trees into logs. It is used for pruning main stems and branches that are of large diameters.

**Pruner**
As the name implies, it is used for pruning small twigs and for cutting flowers.

**Secateur**
The secateur is a pruning implement. It is essentially used for pruning twigs, for preparing stem cuttings in ornamental horticulture and for trimming hedges.
**Budding knife** The budding knife is a tool employed in budding operations. It is used for cutting and preparing bud woods used in budding and grafting. Additionally, the incision on the stem of the root stock is made with the budding knife.

**Field chain** Unlike the measuring tape, the field chain links are made of metal. Because of this, it is less prone to damage in thorny conditions of uncultivated fields. It is a measuring instrument used especially during field markings and establishment.

**Branch pruner** The branch pruner is used for cutting twigs and branches that are of small diameters. It is also used for preparing stem cuttings in ornamental horticulture.

**Watering can** The watering can is used for (a) watering very young plants and seedlings in boxes, (b) watering freshly transplanted crops in gardens, (c) broadcasting very tiny seeds, (d) fertigation.

**Seed tray** The seed tray is normally made of wood and of very simple construction. Because it can be transferred from place to place, planting in seed trays ensures higher success of nursery seedlings. The principal uses of seed trays are (a) for raising nursery seedlings, and (b) for rooting stem cuttings.
Farm tools

Wheelbarrow. The wheelbarrow is a very popular farm tool. The free moving wheel makes its use very easy. It is principally used to cart materials from one point of the farm to another.

Hand atomizer. The hand atomizer is useful in applying all-liquid pesticides to house plants, small gardens and experimental fields. It is also used in homes for fly sprays.

The pronged hoe is very similar to the conventional hoe except that the metal blade is divided into prongs. It is not very widely used. However, it is suitable for the cultivation of hard and concretionary soils.

Hand atomizer

The hand atomizer is useful in applying all-liquid pesticides to house plants, small gardens and experimental fields. It is also used in homes for fly sprays.

Hoe. Hoe are tools widely owned and used in many African countries. They are of two main types, the ordinary hoe (Fig. 5.20) and the Indian hoe (Fig. 5.21). Generally. hoes are used for (a) loosening surface soil in preparation for planting of crops on flat, (b) making mounds and soil heaps, (c) weeding, (d) preparing seedbed on heavy soils and (e) forming ridges, beds and earthing up soil around crops such as groundnuts.

Mattock. The mattock is stronger and heavier than the hoe. Because of this, it is used to cut stubborn roots of trees and shrubs, and also to plant some giant stumps.

Hoe. Hoe are tools widely owned and used in many African countries. They are of two main types, the ordinary hoe (Fig. 5.20) and the Indian hoe (Fig. 5.21). Generally, hoes are used for (a) loosening surface soil in preparation for planting of crops on flat, (b) making mounds and soil heaps, (c) weeding, (d) preparing seedbed on heavy soils and (e) forming ridges, beds and earthing up soil around crops such as groundnuts.
**Ranging pole** The ranging pole is principally a surveyor's tool. But it is used in agriculture for (a) farm survey, and (b) marking out the baseline needed for establishing plantation crops.

**Sickle** The sickle is a special type of knife with curved metal blade and a short wooden handle. It is used for harvesting grains and for cutting grasses needed for feeding confined goats.

**Weeding knife** This is a tool with double handles and a specially curved blade. It is not very popular but in areas where it is found, it is used mainly for weeding.
Irrigation is defined as any artificial means of supplying water to crops for its growth and development. In dry areas where there is little or no rainfall, irrigation provides the total water needs of the crop. In wet areas where there is rainfall in almost all the months of the year, crops are grown under natural rainfall (rainfed agriculture).

Measuring discharge

The discharge of water from a pipe or a channel is the volume of water flowing per second. It is measured in cubic metre per second (m³/s).

\[
\text{Discharge (m}^3/\text{s)} = \text{area (m}^2) \times \text{velocity of flow (m/s)}
\]

The simplest means to measure discharge from a pipe or a channel is to use a container (bucket) of known volume (Fig. 6.1). The bucket is placed directly in the channel and water is allowed to flow into it. The time taken to fill the bucket is recorded and discharge is calculated thus:

\[
\text{Volume of bucket (m}^3) \quad \text{Discharge (m}^3/\text{s)} = \frac{\text{Volume of bucket (m}^3)}{\text{time taken to fill the bucket (s)}}
\]

Irrigation methods

These are the methods used to supply water as uniformly as possible in crop lands. Irrigation methods range from the simplest form of water supply with watering cans to the more sophisticated processes of water application through channels and pipes under pressure. Simply put, irrigation can either be manual, surface, or pressurized.

Manual irrigation

This type of irrigation is very common in West African countries where the technology and energy allocated to agriculture are low. The pattern of water distribution is primitive and time wasting. Watering cans or long rubber hoses are used to supply water to vegetable crops.
Irrigation and drainage

Surface irrigation. The surface irrigation methods include:
(a) the basin irrigation; (b) the border irrigation; and (c) the furrow irrigation.

Basin irrigation—basin irrigation is the simplest and most common of the surface irrigation methods. The farmer simply divides his agricultural field after sound levelling operations into two or more basins using earth bunds. Because of these bunds, water is ponded and allowed to infiltrate into the soil. Basin sizes vary considerably depending on the type of soil, stream size, depth of irrigation, land slope, and the farm size. On clay soils, larger basins are made in contrast to sandy or loamy soils.

Similarly, a larger stream size requires a corresponding increase in the size of the basin. On sloping and undulating surfaces, the land has to be levelled and reshaped into flat basins.

Border irrigation. Border irrigation involves splitting of the farmland into strips with small earth bunds. Borders are quite similar to basins. There are, however, two major differences. While border slope uniformly away from the water entry points (farm channels) in the direction of water flow, basins are more or less flat with no defined slope. Also, borders are characteristically long and narrow while basins are usually short and broad in order to allow uniform water spread as they are flat and non-sloppy. For high irrigation efficiency, correct size and shape of the border and good water management must be adopted. The sizes vary considerably depending on the soil type, depth of irrigation, and land shape.

In most cases, a border length of 100 - 850 m and width of 3 - 35 m are used. With a given stream size, borders are longer in clay than in sandy soil. Steep slopes and undulating land surfaces do not allow the use of border irrigation because they encourage soil erosion. In such a situation, the land slopes are changed, by good land preparation to the recommended minimum slope of 0.1%. This ensures that water will flow down the border and any excess can easily be drained.

Furrow irrigation. Unlike the basin and border irrigation methods, water does not flow over the entire soil surface but is restricted to small channels between crop

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**Surface irrigation:**
- **Basin irrigation** is the simplest and most common method.
- **Border irrigation** involves splitting the farmland into strips.
- **Furrow irrigation** restricts water flow to small channels between crops.

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**Basin irrigation:**
- Divided using earth bunds.
- Water ponded and infiltrates into the soil.
- Sizes vary with soil type, stream size, and farm size.

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**Border irrigation:**
- Divides farmland into strips.
- Sides are usually flat and non-sloppy.
- Correct size and shape for high efficiency.

---

**Furrow irrigation:**
- Water restricted to small channels.

---

[Fig. 5.1: Measuring discharge]
[Fig. 6.2: Basin irrigation]
[Fig. 6.3: Border irrigation]
Irrigation and drainage

Irrigation methods are characterized by the single factor that they apply water to the points where water is needed. There are two main types, namely

(a) Sprinkler irrigation
(b) trickle or drip irrigation.

Sprinkler irrigation is of three types, namely, the rotating or rotary sprinkler, the spray-type nozzle, and the perforated pipe. The rotating sprinkler is the most common and because of the low level of technology in West Africa, it is still the type that is most widely used.

Advantages of sprinkler irrigation
1. Efficiency is greater than 75%
2. Saves labour
3. Easy to operate
4. Fertilization is done with sprinkler irrigation
5. Can be used on steep slopes
6. Water quality may drop particularly with mixed pipes
7. Salination is also possible.

Disadvantages
1. High initial cost
2. High pumping cost
3. Water quality may drop particularly with mixed pipes
4. Salination is also possible.

Sprinkler irrigation system consists of:
1. The pumping unit
2. The mainline pipe unit
3. The lateral pipe unit
4. The sprinkler unit

Water is moved from the source (river, well, tank or lake) under pressure, to the irrigation system by the pumping unit. The mainline pipe unit delivers the water from the pumping unit to the lateral pipe unit which finally delivers the water to the sprinkler. The sprinkler consists of the risers and the spray heads through which water is sprayed uniformly on the field. Generally, water movement in the pipes is controlled by the use of valves.
Irrigation and drainage

Drainage problems are caused by excess water either on the soil surface or in the root zone below the surface. This creates devastating effects on crop growth and development. Thus, the main purpose of drainage is to reduce the water content of the root zone and permit free oxygen movement around crop roots and diffusion of CO₂ from the roots. Drainage is very important in all regions that are prone to waterlogging either as a result of excessive precipitation or continuous irrigation.

**Consequences of poor drainage**

1. Plant roots have a limited column of soil in which to grow and exploit for nutrients.
2. Water that fills the soil pores displaces air in the soil.
3. Free oxygen becomes unavailable to plant roots since it is only confined to just a fraction of the top layer of the soil. Lack of free oxygen creates an environment conducive to the growth of fungi and disease pathogens.
4. Plant disease and pathogens become very active. Fungi growth is particularly prevalent.
5. No drainage in irrigated lands leads to accumulation of salts which eventually could convert a fertile area into a barren soil.

**Types of drainage**

1. Open or ditch drainage
2. Closed or tile drainage.

Open drainage ditches are dug to transport excess water resulting from precipitation or water from leaky streams, rivers or lakes. Two main
Advantages of open drainage system are: (a) its large carrying capacity, and (b) its low construction cost. The disadvantages include (a) its interference with and obstructing of farm operations, (b) high maintenance cost, (c) its serving as breeding grounds for nuisance organisms that cause diseases to man and his livestock, and (d) wastage of scarce farmlands due to the area allocated to the ditches.

Closed drainage: Closed drainage is achieved by the use of tiles that are 30 cm or more in length and varying diameters depending on the amount of water to be removed. These tiles are laid end to end in a sloping trench and finally covered with surface soil or straw. Water enters the tiles through the joints and for effective drainage over a long period of time, a good outlet is always available.

Another type of closed drainage is the ‘mole’ drainage which is an unwalled cylindrical channel, about 7.5 cm in diameter, dug through the soil at a defined depth. Water drains through the channel into a nearby stream or open ditch. Although it is inexpensive, its service lifespan is short.

Benefits of land drainage:

1. Lowering the water table
2. Warming of the soil
3. Soil aeration
4. Promotes useful biological, biochemical and microbial processes particularly those related to nitrogen availability to crops
5. Prevents soil structure determination
6. Permits early soil workability after rains

Lowering the water table: Excessive rainfall on continuous irrigation may cause a tremendous rise in the height of the water table. The root zone becomes flooded and waterlogged, thus bringing about anaerobic condition around the plant roots. By quickly lowering the height of the water table, drainage improves the crop root zone conditions for microbial activities and the nutrients absorbing capacity of the roots. Warming of the soil: At the peak of the rainy season, the soils become very wet. This causes a rise in the specific heat of the soil and surface evaporation. By removing the excess water in the soil, drainage lowers the energy needed to increase the soil temperature thereby reducing surface evaporation that has a cooling effect on the soil.

Soil aeration: Generally, a good drainage system improves the aeration in the soil. Oxygen moves freely to the plant roots while carbon dioxide released from the roots diffuses away from them. Microbial life is improved because of the aerobic conditions created by good drainage.
**Arable crops**

Arable crops are crops grown in well cleared fields. Ideally, the crops need elaborate land preparation and very good soil conditions. The main characteristic feature of arable crops is that harvest is normally done in one year or one cropping season. Even when the crop is a biennial, the harvesting is normally done within one cropping season. With the exception of the permanent crops, the difference between arable crops is not very clear. A crop such as maize can be grown as forage, vegetable, or arable crop.

**Classification of arable crops**

The classification can be based on (a) the family to which the crop belongs such as graminaceae (grass family) e.g. rice, millet, maize, guineacorn, wheat etc. or such as a leguminosae (e.g. cowpeas, groundnuts, Bambara groundnuts etc.), (b) the product for which the crop is grown as oil crop, fibre crop or food crop (c) the plant part that is harvested as root crop, grain crop, or forage crop.

**Yam**

- **Family**: Dioscoreaceae
- **Botanical name**: Dioscorea spp.

**Botany**: Yam belongs to the genus Dioscorea and is believed to be non-copulatory. Yams are trailing vines and the majority of these produce underground tubers that serve as storage organs. These organs form the harvestable portions.

**Origin**: There are a number of species of yam that are under cultivation and most of these are essentially tropical. Their origin has been traced to Africa, South America, and Asia. Some species are known to have their origin in Nigeria.

**Climatic and soil requirements**: Yam is a crop of the tropical rainforest but it has been found to grow best in areas with rainfall of about 1200mm at the growing period (3-4 months after sprouting). Yam requires good sunshine, fertile, deep
Amds crops

and well-drained soil as well as high relative humidity and temperature.

**Cultivated species** There are about six species of yam that are of economic importance.

**White yam** (*Dioscorea rotundata*) is the most important of the yam species that is cultivated in most parts of the yam-producing areas—Anio, Enugu, Aksumba, Delta, Edo, Benue, Abia, Adamawa, Taraba, and the southern sections of Kaduna state. The vines are cylindrical and they possess prickles (thorns). They thrive in sandy loam soil and other alluvial soils with high organic matter content.

**Yellow yam** (*D. cayenensis*) produces tubers that are deep yellow to chalky white in colour. The vines are about 20 to 30 feet long, they thrive in sandy loams and also possess prickles. The tubers are often characterized by their small head, maturity period is 10-11 months and the species tends to replace the white yam in areas where the soil is light and less fertile.

**Water yam** (*D. dactylium*) is the most important of the yam species that is cultivated in most parts of the yam-producing areas—Anio, Enugu, Aksumba, Delta, Edo, Benue, Abia, Adamawa, Taraba, and the southern sections of Kaduna state. The vines are 10-15 feet long and they possess prickles. The tubers are often characterized by their small head, maturity period is 7-8 months.

**Trifoliate yam** (*D. dumetorum*) produces trifoliolate leaves. There are two types namely:

(a) The thornless stem and tuber type
(b) The prickled stem and tuber type

The vines of all these species are circular and they thrive in sandy loams and other alluvial soils. The leaves are circular and in their yields are buds that enlarge to become the bulbil below the ground, small heart-shaped tubers are produced. These are normally not harvested. Maturity period is 9-10 months.

**Chinese yam** (*D. alata*) is an introduction from Asia and it is not very common in Nigeria. The vines are circular and they thrive in sandy loams and other alluvial soils.

**Land preparation** The land is cleared, and the trash is raked together and burnt. Big mounds or ridges are made with some spacings in between them.

**Planting materials**

(a) The seed yam (the miniature complete tuber)
(b) The set (the cut-up ware yam)
(c) Yam seeds are also being tried, but the only constraint is that not all yams produce flowers. With the seeds, the first
Arable crops

harvests are often of the wild type. This is planted to produce the seed yam which in the third cycle will produce the ware yam. Minisetts: These are more or less recent innovations. The ware yam or seed yam is cut into discs (Fig. 7.2c-d). These discs are further cut into segments which are treated with a fungicide preferably Aldex T. About 90,000 stands per hectare are planted when minisetts are used.

Planting of yam Usually, yam will open the land and will be the major crop in a mixed cropping system. This may not hold, however, in newly cultivated fields with lots of incompletely decomposed organic matter in the soil, and in areas where there is a shortage of spacing materials. In the latter case, sorghum is planted first with an additional aim of using the stem as stakes after harvest. Yams are planted either on very high mounds or ridges in areas prone to flooding or in dug-out holes in well-drained soils. "Seed" yams, each weighing 250-500 g, are planted at a depth of 10-15 cm.

Weeding Yam does not stand competition with weeds because
(a) it is very shallow rooted,
(b) it does not absorb nutrients very readily from the soil especially in the early stages of growth.

Weed control is therefore essential. Weeding is recommended. Weeding is normally manual.

Staking This simply means the provision of support on which the vine twines. The aim is to ensure that sufficient sunlight reaches the leaves. In the absence of light, yield may drop by up to 40%.

Types of staking
(a) Individual staking A stout stake (Indian bamboo, guinea corn or maize stubble) is placed vertically at close proximity and the yam plant is tied to the stake in the middle.
(b) Pyramidal or triangular staking In this case three or four yam stands are supported by one muger stick. Each stand is guided to the major or leader stake.
(c) Trellis staking Two very stout and strong poles are placed at both ends of...
Each row which runs the entire length of the farm. A metal wire is tied to both poles at a reasonable height above the ground. Just above each yam stand, a piece of rope is hung down from the wire. On emergence, the plant twines by means of the rope to the wire.

No staking. In some parts of northern Nigeria, farmers do not normally stake. They simply put twigs on the mounds and these help to expose the leaves of the plant to light.

Fertilization Normally, traditional farmers do not apply fertilizer but they ensure maximum fertility by opening the land with yams and by the addition of some manure to the planting site before planting. The response of yam to fertilizer application depends on the inherent fertility of the soil and on the cultivar in question. Yam does not respond very much to phosphorus because it can very efficiently remove the element from the soil reserve. To this end, yam responds well to nitrogen and potassium fertilizers.

Recommended fertilizer formulations:
(a) 20-0-20
(b) Ammonium sulphate only
(c) 10-10-20 for southwestern Nigeria.
(d) 12-12-18 for southeastern Nigeria.

The fertilizer is applied 15 cm from the base of the yam three months after planting. This period coincides with tuber bulking.

Maturity and harvest Yam is mature as soon as one notices that the leaves turn brown and dry up. Most farmers do not harvest as soon as the crop matures because they lack storage system. The harvesting is usually done with digging sticks in combination with matchets. The soil is carefully loosened and the tuber is pulled out. There are two types of harvests, namely: the double harvest and the single harvest. The double harvest involves early harvesting of the tubers (milling) between July and September after which the crown is reburied in the soil to produce another crop. In single harvest the tuber of the crop is harvested once between October and January as soon as the leaves of the crop dry up.

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![Fig 7.2c: Cross section of a 2cm disc](image1)

![Fig 7.2d: 'Nebi's cut from a disc](image2)
Yield: Yield of fresh tuber in West Africa ranges from 5 to 12 tonnes per hectare. In the West Indies, higher yields of about 20 tonnes per hectare have been recorded.

Storage: Storage is usually in yam barns (Plate 1).

Problems of barn storage: (a) There is normally a heavy wastage in weight due to hydrolysis of carbohydrate under storage. Usually, there may be up to 40% loss in weight under barn storage, (b) There is also loss of nutrients through sprouting, (c) There is a high incidence of rot (dry and wet rot) under barn storage. Because of these problems, other storage methods, namely, radiation, cold storage and use of chemicals have been tried. These are, however, still being tried in research stations.

Utilization: Yam tuber is a starchy staple food usually eaten as a vegetable in the tropics. It is served either boiled, baked, roasted or deep fried. A popular Nigerian preparation is pounded yam, a mashed, glutinous dough termed fufu that is served with soup or stew. The yam tuber contains about 70% water, 25% starch and 1-2% protein. In Nigeria, yams are used in marriages, burials and some religious activities.

Pests: A. Insects

i) The yam beetle (Heteroligus spp.)
Both the larvae and the adult beetles cause considerable damage to yam tubers. They cause distorted wounds which involve holes created all over the tuber. The control is by the use of Aldrin dust.

ii) The cricket
This often cuts the vine from the planted material and sometimes from developing new tubers. Crickets can also cause wounds similar to those caused by beetles. The control of crickets is by the use of Thiodan 5.
Nematodes

There are a number of nematode species that are pests of yams. The commonest is *Meloidogyne* spp. Nematodes normally penetrate the epidermis of the tuber and cause numerous physiological distortions ranging from gall formation to cracks and root proliferations (Plate 2) on the tuber. The cracks provide entry points for other pathogenic organisms and predispose the tuber to secondary infections. The best cultural method of control of yam nematodes is crop rotation. By planting other crops, yam nematodes are starved and their population will drop considerably. Soil sterilization by heat is also an effective means of nematode control. In large-scale production, chemicals such as Furadan, Nemagon, and Oxamyl are good for nematode control under field conditions.

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Diseases

The diseases that attack yam in the field are few. The four major diseases are:

(a) Tubers rot disease
(b) Leaf spot
(c) Anthracnose
(d) Witch's broom

Tuber rot disease This is a fungal disease. There are two types, namely, dry and soft rots. The soft rot is due to *Penicillium* or *Fusarium* spp. and the dry rot is caused by *Basidinia* or *Sphaerotheca*. These organisms cause tuber rots under storage or after planting.

The control is by treating setts with fungicide or alkaline materials such as wood ash.

Leaf spot disease This is also caused by fungi. It manifests as dark-brown spots on the leaves and stem of growing yam plants in the field. *Cercospora* spp. is the major cause of leaf spot in yam.

The control method is to spray with fungicide but since the disease is normally not a serious one. Preventative measures such as the sanitary disposal of crop residue will provide a cheap method of control.

Anthracnose In the past few years, there have been a number of reports of anthracnose disease particularly in *Dioscorea alata*. Some scientists believe it is a physiological disorder while others attribute it to fungal infection. The disease
causes the plant to dry up. Consequently, the tuber yield is reduced considerably. Not much work has been done on it and therefore no control measure has been suggested.

\textit{Witch's broom} This is a fungal disease that causes stunted growth of the vine, reduces branch formation and causes the leaves to be small and chlorotic.

The control is simply by cutting and burning the affected vines so as to prevent the fungus from producing spores.

\textbf{CASSAVA}  
Family: Euphorbiaceae  
Botanical name: \textit{Manihot esculenta}

\textbf{Botany} Cassava has just one species—\textit{Manihot esculenta}. \textit{Manihot utilissima} is synonymous with the aforementioned species. The crop is a dicot belonging to the family \textit{Euphorbiaceae} because of its latex production.

\textbf{Origin} Cassava is believed to have originated in northeast Brazil. Some authors have also pointed at Central America as another possible origin. From these centres, cassava has spread to various parts of the globe and it is today cultivated in all regions of the tropics including Nigeria.

\textbf{Climatic and soil requirements} Cassava is a crop of the lowland tropics. It requires a good amount of rainfall and humid climate with a temperature range of 23 to 29°C. The crop can tolerate drought and low soil fertility because of its feeder roots which grow vertically into the soil to a depth of about 1 metre. The best soil for cassava is a sandy loam soil of average fertility and sound drainage.

\textbf{Cassava cultivars and varieties} There are many cultivars of cassava in any area where it is grown. These cultivars are distinguished on the basis of morphology, leaf shape and size, branching pattern, height, growth habit, leaf lobes, stipules, tuber features, and the content of the hydrogen cyanide. Using the last characteristic, cassava can be classified into bitter and sweet types. The bitter cassava has very high cyanide distributed throughout the tuber while the sweet type has a relatively low cyanide which is mainly confined to the cassava peel. Thus, the flesh of the sweet type has very low cyanide content.

Most of the cassava varieties in Nigeria are given acquisition numbers such as 57301, 60206, 51644, 30555, etc. Furthermore, the TMS and U-series of IITA and Umudike, respectively, are also used to characterize cassava varieties.

\textbf{Land preparation} Clear the area (well-drained loamy soil), stump, burn the thrash and make mounds or ridges that are 1 metre apart.

\textbf{Planting date} Although cassava can be planted at any time in the year, planting...
with the early rains is highly recommended.

**Plants of cassava** are highly recommended. Planting materials

Because of the incidence of mealy-bugs, it is important to
select healthy cuttings free of any form of biotic contamination. Improved varieties
of cassava like TMS 30572, TMS 30555, U-41044 available in National Root Crop
Research Institute, Umudike, can meet the desired standard. The stems are cut 25

cm long from 10-12-month old plants. Shorter stakes under poor growth
conditions will produce weak plants due to the low carbohydrate reserve. Overly
long stakes may produce more top growth than root growth with low harvest
index. Cassava stakes dehydrate during storage, particularly when they are stored
in open air, exposed to direct sunlight. To reduce storage deterioration, long stakes
are stored with an overhead shade. Before planting it is wise to check for freshness
of the stalk and this is achieved by scratching the stalk with the fingernail. If latex
exudes from the lesion, it is an indication that the stalk is still viable.

**Method of planting**

Plant a single cutting of 25 cm long in a slanting position
with a small portion containing about 3 nodes sticking out. The practice is the same
on the ridge except that a spacing of 1.0 m is maintained between two stands.

**Weeding**

As a sole crop, cassava will need about three weeding:

(a) 3 - 4 weeks after planting,
(b) 12 weeks after planting;
(c) 5 - 6 months after planting.

However, with varieties that form heavy canopy, the shading from the canopy trees
reduce weed population once the canopy is established. Weeding is done either
manually using the hoe or chemically using herbicides such as Primexra or
Prosogram at the rate of 50 kg/ha. These are pre-emergence herbicides that are
applied soon after planting the cassava cuttings <em>Egusi mato</em> can be interplanted
soon after cassava as a cultural means of weed control.

**Fertilization**

A good crop of cassava takes quite some amount of nutrients from
the soil. When the soil is fertile, the growth is normal and this reflects in the yield.
Cassava needs a high amount of potassium for a good yield. However, potassium
should be applied as potassium sulfate rather than as muriate of potash. The high
potassium demand makes it a production plantable to traditional agriculture
where bush burning is incorporated. The <em>Egusi mato</em> should be applied at the rate of 50 kg/ha at about 6 weeks after planting.

On ridges, the fertilizer is applied in bands on both sides of the plants. On mounds
it is applied in rings around the base of the plant.

**Maturity and harvest**

Although early developmental events are similar for
many varieties, genotypes appear to have a wide maturity range depending on the
environment and season of planting. Early varieties form edible tubers in about
nine months. So in case of need such varieties may be harvested as from 9 months
but harvesting at 12 months normally gives a higher yield of fresh tuber and
extractable starch. Late varieties may be harvested at 15 - 18 months. Harvesting
is better when the soil is moist so as to minimize damage to tubers. With traditional farmers, the cassava is harvested piece-meal as required either by the household or market.

**Yield**

An average yield of 5 tonnes/ha with local cultivars or 15 tonnes/ha with improved cultivars is expected in farmers’ fields. However, yields up to 30 tonnes/ha are possible in research stations.

**Utilization**

Cassava is a major carbohydrate source in tropical Africa. The tuber contains about 62% water, 22% starch, 1.5% protein and 2% fibre. Both the flesh and the peels are used after processing for compounding animal feed.

**Processing**

Processing is essential so as to reduce the content of the cyanogenic glucoside or hydrogen cyanide and to make the extraction of starch and its allied compounds easier. Frying and fermentation are the readily available methods of achieving these. Cassava can be processed into garri, starch, fonio or flour, and livestock feed.

**Storage**

Cassava does not store well. Once harvested, it begins to deteriorate in the next 2 to 3 days if it is not processed. There are reports however that cassava can be stored in pits for some time with minimal deterioration.

**Major pests**

**Grasshoppers (Zonocerus variegatus)**

Both the adult and the nymph attack the plant at all stages of development and cause defoliation as well as the stripping of the bark of the plant. The damage is more during the dry season. An effective and cheap control measure is yet to be devised. But since the insect seems to show preference for some cultivars, the cheapest means of control would be by the use of the cultivars that are unattractive.

**Termites**

This pest attacks stored planting material. Cassava planted in the dry season is also attacked, in most cases, by termites. The notice of termite infestation

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*Fig. 7.7a* Adult male grasshopper (side view)  
*Fig. 7.7b* Head of grasshopper (lateral view)
Arable crops

will be remedied with the drenching of the soil around the plant using a combination of captan and carbendazim (2L of water each). While the fungicide (captan) kills the termites, the fungicide (carbendazim) prevents stake death.

Mealybug (*Phenacoccus manihotis*) This is a serious dry season pest of cassava. Infestation usually begins on the younger parts of the plants as the pest feeds on the young leaves. As feeding takes place, the pest sequesters toxic wastes into the plant and this retards the plant's growth. The intermediate becomes shorter resulting in bunchy tops. Leaves in such affected areas die and drop. The tips of the infected plant also dry up. Death and drying spread from the younger twigs on to the older parts of the plant and eventually the cassava plant becomes completely stripped — a condition often referred to as candlestick appearance. Tubers yield and quality are reduced. Planting materials become scarce and the cost of *garri* will rise in both the urban and local markets.

The control methods include (a) the use of resistant varieties; (b) planting of clean materials in the beginning of the rainy season; (c) burying the stem completely during planting; (d) dipping the stems in *Nuvacron* 40 mixed at the rate of 20 ml in 10 litres of water for 3 minutes and (e) applying Furadan in cases of late planting.

*mites* These are of two types — the green spider mite (*Tetranychus telarius*) and the red spider mite (*Mononychellus tanajoa*). The green spider mite infests the buds near the growing portion of the cassava plant. Leaves that emerge from such buds are deformed and spotted. Such leaves may drop thus reducing photosynthetic sites. Damage is essentially during the dry period. A uniform spray of *Rogor* often provides an effective control of the green spider mite.

The damage of the red spider mite is often noticed first on the lower leaves as yellow dots along the main vein. These leaves eventually become shrivelled and drop. A good spray with *Gamalin* 20 is the recommended control measure.

*Rats* Rat's dig up and eat the tubers. The control is usually by the use of traps.

**Diseases**

Pathological problems affecting cassava are able to induce total losses in susceptible clones, especially during the rainy season. The diseases of cassava that have assumed prominence recently include cassava mosaic, anthracnose, and the cassava bacterial blight (CBB).

**Cassava mosaic** The symptoms range from whitish to yellowish chlorosis of the young leaves. These results in distortions and reduction in the size of the leaves. The growth of the plant decreases and the yield eventually drops.

The causal organism is virus which is spread by the white fly (*Bemisia tabaci*).
The cheapest means of control is to use resistant cultivars. An example in Nigeria is the 392/08 cultivar. Another good check of the disease is the use of healthy cuttings during planting. Finally, a chemical control of the white fly indirectly controls the cassava mosaic virus.  

**Cassava anthracnose** This causes the wilting and death of the young stems and leaves. Stems may become weak and prone to breakage by wind because of cankers created on them by the disease causing organisms. Planting of clean cassava cuttings is currently the cheapest control method.  

**Cassava bacterial blight (CBB)** This is caused by a motiled bacterial species called *Xanthomonas manihotis.* Entrance into the plant is through wounds and the stomata. Once in the plant, it spreads through the xylem vessels. The symptoms appear as spots, wilting and blight on the leaves. The stem continues to secrete gum and eventually die back. There are the primary and secondary symptoms. The former are associated with the planting of infected materials and are characterized by the wilting of young leaves followed by die-back. The latter symptoms result from infection in the field and they take the form of leaf spots, blight, and die-back.  

The control measures include  

(a) planting of resistant cultivars, an example of which is 60506  
(b) planting of uninfected cuttings  
(c) planting towards the end of the rainy season since the disease is more severe during the rains  
(d) burning of diseased residues  
(e) crop rotation.  

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**COCOYAM**  
**Family:** Araceae  
**Botanical names:** *Colocasia esculenta* (taro)  
*Xanthosoma sagittifolium* (tania)  

**Botany** Cocoyam is a monocot. Two genera, *Colocasia* (taro) and *Xanthosoma* (tania), are particularly important and extensively cultivated. Like yam, cocoyam is not a true root. Rather it has the character of being an underground stem. However, it differs from yam as it is not a tuber but a corm.  

**Origin** *Colocasia esculenta* is believed to have originated in south east Asia while *Xanthosoma sagittifolium* is indigenous to tropical America and the West Indies.  

**Climatic and soil requirements** Cocoyams are warm-weather crops that need an average daily temperature of about 15°C. Cocoyam grows well in rich and alluvial soils with large quantities of moisture and organic matter. It also tolerates some degree of flooding and shade. An annual rainfall of about 200 cm is ideal.
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**Cultivated species** The species that are widely grown in Nigeria are *Colocasia esculenta* and *Xanthosoma sagittifolium*. The mode of attachment of the long petiole to the large lamina forms the main distinguishing feature of these species. Whereas the petiole in *Colocasia* is attached to the lamina at some point about the middle of the lamina, in *Xanthosoma* it is attached to the edge of the lamina at a deep indentation which divides the base of the lamina into two lobes.

Six cultivars of *Colocasia*, namely: T-1853-7-301 Mbidi, Cameroon, Akupe, Ninrbo, Coco India, and Ede ocha and Ede oye have been observed to be outstanding in Nigeria.

**Land preparation** For the upland culture, the land should be cleared, ploughed, and harrowed followed by the making of ridges and mounds. The flooded culture, on the other hand, demands among other things, the construction of embankment on all sides of the field to facilitate holding of impounded water. The field is finally ploughed and rotovated so that water percolation will be reduced to a minimum.

**Planting material** Cocoyam is propagated vegetatively (Fig. 7.9) using either of the following:

(a) small corms or setts cut from large corms
(b) small cormels or setts cut from large cormels; and
(c) the shoot made up of the apical portion of the corm and the lower portion of the petiole.

**Planting operation** Spacing will depend on the water regime of the soil. Where the water supply is adequate, closer spacings are normally recommended. A spacing of 30 x 30 cm will give a higher yield under an adequate soil moisture regime. In the upland cultivation, wider spacing of 50 x 50 cm on mounds or 50 cm apart on flat ridges will be ideal for a good yield. Planting depth should be 10 - 15 cm with the growing bud facing upwards.
Weeding The weeding of cocoyam is only necessary in the early stages of growth because as soon as the leaves expand, they provide enough canopy to shade off weeds.

Fertilization The young cocoyam depends on the food reserve of the planting material during the first 12 weeks after planting. Fertilizer should therefore be applied at about 14 weeks after planting when its growth is at the peak. Split doses of nitrogen at 6 and 12 weeks after planting have also been recommended. The rates are 60kg P₂O₅/ha and 60kg K₂O/ha applied at planting and 40kg N/ha applied split at 6 and 12 weeks after planting.

Maturity and harvest Cocoyam matures 8 - 12 months after planting and this is announced by the yellowing and the consequent die-back of the top. It is important to harvest as soon as the crop matures; otherwise the corms and cormels will begin to sprout or rot depending on the moisture content of the soil. Bruising the corms during harvest provides entry points for rot organisms. This is avoided as much as possible.

Yield The yield of cocoyam varies from one location to another depending on the weather and soil conditions under which they are produced. The yield of taro ranges from 2 to 10 tonnes/ha and the yield of tania is 10 - 25 tonnes/ha.

Utilization Cocoyam is eaten in various forms as food in West Africa. The tuber contains 80% water, 25% starch, 2% protein and some amounts of vitamin C, thiamine, carotene, niacin, and riboflavin.

Storage This is a problem area in cocoyam production because the corms and cormels tend to deteriorate very rapidly under storage. After harvest, corms and cormels should be kept in an airy shed for 2 - 3 days for any form of wound to dry and seal up. On the fourth day, the corms and cormels are transferred into pits or raised open rafters with overhead shade.

Processing Cocoyam is processed into:
(a) dry chips (achicha)
(b) flour, or
(c) boiled and pounded into a thick paste foofoo.

Major pests Rootknot nematode (Meloidogyne spp.) attacks and causes galls on the roots of taro. The outcome of the attack is irregular swellings on the corm and stunting of the plant. To reduce infestation, the soil is fumigated with fumigants such as Nemagon or nematode infested soils are avoided during planting.

Leafhoppers are major insect pests of taro which are controlled by spraying with any systemic insecticide.
Major diseases

One of the major diseases of cocoyam is the corm or collar rot caused by the fungus *Sclerotium rolfsii*. The disease is controlled by
(a) use of uninfected planting material
(b) crop rotation with maize
(c) deep planting of corms.

Leaf blight disease is caused by the fungus *Phytophthora colocasiae*. The pathogen causes lesions on leaves thus reducing photosynthetic surfaces. The disease is controlled effectively with any copper based fungicide.

In storage, corms can rot. There are three types of rots, namely, dry rot, wet rot and spongy rot. The best form of check of the rot diseases is to process the harvested cocoyam into some form of flour.

**Sweet Potato**

*Family*: Convolvulaceae

*Botanical name*: *Ipomoea batatas*

**Botany**

Sweet potato is a dicot. The crop has thin and long stems which trail on the soil surface putting out fibrous roots into the soil at the nodes. It produces root tubers that are harvested for human consumption.

**Origin**

The real origin of the sweet potato is unknown but it is known to have been grown in Mexico and parts of central and south America and the West Indies before the voyage of Columbus. Today, the crop is grown in nearly all parts of tropical and sub-tropical countries.

**Climatic and soil requirements**

The sweet potato is adapted to a wide range of altitudes ranging from sea level to 2,500 cm above sea level. It is a tropical crop, and therefore requires high temperature of up to 24°C. The sweet potato does not stand drought, rather it grows well in regions with 750 - 1,250 mm of rainfall and long sunny conditions without shade. Sandy loam soils and soils that are not prone to waterlogging provide good growing medium for sweet potatoes. Where the water table is high, the crop should be planted on mounds or ridges.

**Sweet potato cultivars**

There are a number of sweet potato cultivars which may vary in their leaves, colour of tuber as well as in texture of the flesh. On the basis of tuber texture, sweet potato cultivars include: those with firm, mealy and dry flesh soon after cooking, e.g. Nenagold; those that are gelatinous, soft and moist after cooking, e.g. Goldrute; and those that are coarse fleshed and unsuitable for human consumption. Meanwhile, eight cultivars have been isolated by the National Root Crop Research Institute, Umudike, for high yield of tubers. These cultivars include: TIS 146/3092, TIS 2534, TIS 2421, Dokobo, Anioma, BIS 23 and TT 2552.
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**Land preparation** Because the sweet potato does not tolerate waterlogging, all plantings are either on ridges or on raised beds.

**Propagating** The propagation of the sweet potato is vegetative. Terminal vine cuttings containing at least five nodes, sprouts (slips), and leaf bud cuttings form the major materials for propagation.

**Planting method** Vine cuttings are planted slanted at an angle of 45°, exposing at least two nodes. Sprouts (slips) are, on the other hand, planted erect. A spacing of 90 x 90 cm is ideal for a sole crop of sweet potato.

**Weeding** The sweet potato requires very little weeding because its growth habit helps to smother weeds. However, the farm is kept weed free for the first six weeks after planting.

**Fertilization** The sweet potato responds positively to complete fertilizers. NPK 10:10:20 at 700 kg/ha is the recommended rate in very poor soils. It is applied in bands on both sides of the ridge after weeding.

**Maturity and harvest** The sweet potato matures between 4 and 8 months depending on the variety. Maturation is announced by yellowing and withering of the leaves and as soon as such signs appear, the crop is harvested. During harvest, the vines are cut and the roots are carefully dug out.

**Yield** Yield varies from 5 to 16 tonnes/ha depending on the cultivar and location.

**Utilization** The sweet potato is a carbohydrate source for both man and his livestock. The tuber contains about 70% water, 20% starch, 1.5% protein, 1.5% sugar and vitamins and minerals in trace amounts. The starch is usually converted into maltose when the tuber is boiled and this gives the food its characteristic sweet taste.

**Storage** Clean tubers without bruises are cured in the sun for 5 hours, dusted with wood ash and stored either

- in pits lined with dry grass and finally covered lightly with dry grass and top soil
- in a sawdust heap at the corner of the house or
- in a tank placed in a store or kitchen.

**Major pests**

- **Sweet potato weevil**, *Cylas spp*. is a major pest of the crop. The weevil is culturally controlled by earthing up (covering all exposed roots with soil) or by spraying the affected plants with *Bandan 60EC* (Diazinon) at the rate of 0.6 litre in 300 litres of water.

- The sweet potato vine borer, *Omphisa anastomosalis*, attacks the potato at the larval stage. The larvae make a tunnel in the stem thus weakening and causing it to wilt. To check the pest, vine cuttings are dipped into a solution of an insecticide
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before planting.

Nematodes attack sweet potatoes causing lesions on roots, cracks on tubers, and general stunting of the plant. Resistant varieties such as Nemagold, are used in areas where nematodes constitute a problem. Preplanting treatments of the planting materials are also helpful in checking nematode attack. Rodents are also pests of the potato. They are controlled mainly by trapping or by the use of rodenticides.

Major diseases

The diseases of the sweet potato include the sweet potato virus, the soft rot and the stem rot diseases. The soft rot disease is caused by the fungus *Rhizopus* spp, while the stem rot is caused by *Fusarium* spp. The cheapest form of control of any of these diseases is to pull and burn infected plants. Additionally, resistant varieties (Dokobo and Anioma) are planted in areas where the diseases are endemic.

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**Cereals**

Cereals comprise the genera and species of the grass family whose seeds are harvested for human food and in some cases for livestock feed. The major cereal grains of the world are rice, wheat, maize, sorghum, millet, barley, and oats. However, only rice, maize, sorghum, and millet are of particular interest to us in West Africa. Wheat is primarily a temperate crop though some varieties are adapted to tropical conditions. Barley and oats have not been grown outside temperate countries.

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**Rice**

*Family: Gramineae*

*Botanical name: Oryza spp.*

**Botany** Rice is a monocot. It is the only major crop species that is aquatic. The crop successfully grows in standing water. However, it does not have to live in water throughout its entire life cycle. The stems are generally hollow and the number of nodes varies; late maturing cultivars have more nodes and are therefore usually taller than the early maturing types. Rice plants, depending on the cultivar and the growing conditions, tiller profusely and vary in height from 60 to 190 cm.
Different types of rice are recognized by the grain length: short-grain rice has kernels about 5.5 mm long; medium-grain rice has kernels about 6.6 mm long; and long-grain rice has kernels about 7 to 8 mm long.

Origin. The cultivated rice, *Oryza sativa*, belongs to the tropics and is generally grown in wet or waterlogged areas. It is believed to be one of the most ancient cultivated crops particularly in Asia. The other cultivated species in the genus is *O. glaberrima* or African rice. It is believed to have originated from around the swampy headwaters of the River Niger in West Africa.

Climatic and soil requirements. The cultivated rice belongs to the tropics. On the average, it requires a growing period of 110 - 180 days with a temperature range of 20 - 28°C. Because of its high water requirement, it is better grown in heavy clay soils that have high water retaining capacity. Rice tolerates acidic conditions and can withstand a pH range of 4.5 - 7.5.

Cultivated species. The species are divided into two types, namely
(a) *O. sativa* (Asian species); and
(b) *O. glaberrima* (West African species).

The two species can be differentiated from their ligules. In *O. sativa* the ligule is pointed while in *O. glaberrima* it is cut and flat. The panicle of the *O. sativa* is more complex than that of the *O. glaberrima*.

*O. sativa* consists of two types, the Japanese species (*O. sativa var. Japonica*) which is rather roundish and is characterized with very soft starch. The other type is the *O. sativa var. Indica* popularly known as the long grain endowed with hard starch.

Furthermore, *O. sativa* can be grouped into swamp and upland types. The main difference is that the upland varieties can produce under upland conditions but still do better in swamp or wet lands.

Water requirements. These vary with the stage of development of the crop. The juvenile stage (seedling - tillering), and the adult stage (tillering - flower initiation) need just enough water for normal growth. The peak of water requirement is at the reproductive stage (flower initiation - grain filling). At the maturation stage the water requirement of the crop drops.

Land preparation. The land preparation methods differ for the paddy and the upland rice. For the paddy, land preparation begins with the clearing and construction of embankment on all sides of the field which must be made as level as possible, so as to hold impounded water. The field is then ploughed, harrowed and puddled in order to minimize deep percolation losses of water; ease transplanting; reduce incidence of weeds and incorporate oxygen into the top section of the soil. Puddling is only essential for transplanted paddy. Where sowing is direct the practice is irrelevant; the soil is simply ploughed and harrowed to put it into a fine tilth.

Upland rice requires less elaborate land preparation. The land is cleared,
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The thrash and stumps are removed, and the soil is finally ploughed and harrowed at the onset of the rains.

**Planting materials**

Rice is propagated by seeds. Two upland varieties FARP-11 (Os6) and FARO-25 have been recommended for areas with adequate rainfall. The popular 1416 and IR-8 are good varieties grown in paddies.

**Planting method**

Broadcasting is a way of planting direct into the field especially in areas where labour is expensive. The danger in this practice is that rice seeds do not germinate in flooded soils because of lack of oxygen. In areas with cheap human labour, transplanting from a nursery is practised mostly in paddy production.

A nursery site is worked into a fine tilth to a depth of 10-12 cm for easy penetration of water. Manure and inorganic fertilizer are applied prior to sowing. Sowing in the nursery is either by broadcasting or dibbling. It is important to allow sufficient spacing in the nursery so as to ease the removal of seedlings during the transplanting operation. The nursery is kept weed-free and supplied with sufficient water for 4 to 6 weeks after sowing. The seedlings at this age are ready for transplanting.

Transplanting is done manually at a spacing of 30 x 30 cm. Closer spacing will help to smother weeds and suppress tillering while wider spacing will encourage tillering and more weed incidence.

**Planting date**

For the upland varieties, planting is done as soon as the rains have stabilized. Planting of paddy is not time dependent as long as adequate water for irrigation is available.

**Seed rate**

45 - 90 kg/ha.

**Weeding**

Rice cannot stand weed competition both at the nursery and at the field stages because of shading from the weeds, and competition for nutrients and water. Where there is water control, good flooding takes care of weeds. In upland conditions or in paddies without good water control, herbicides like Avisrosan (Dimethametryn), Stam F-34 (propanil) or Risane (propanil + Fluoradifen) control weeds in rice fields.

**Fertilization**

Rice responds in all conditions to nitrogen but the response to phosphate and potassium is variable. Sulphate of ammonia is the recommended nitrogen source because it is the most soluble and is easily absorbed. Application is at about 20 cm depth where it will not be oxidized. In areas with deficient potassium and phosphorus, 100 kg of 15-15-15 NPK compound fertilizer per hectare is applied between the rows of the seedlings. At flower initiation, 100 kg of sulphate of ammonia per hectare is also applied in bands between rows of rice.

**Maturity and harvest**

Maturity time of rice is a function of the variety. Some are early while others are late maturing. Maturity is determined by baihing a few grains between the teeth and a brittle break is a positive indication of readiness for harvest.
Arable crops

harvest.

Harvesting is either manual or mechanical; no matter the method, the moisture content of the harvested grains should not be more than 24%. As the rice grain is maturing, paddies are drained and the soil allowed to dry. This permits entrance of the labourers that will do the harvesting.

**Threshing** This is simply the act of knocking out the caryopsis from the panicle. The operation could be either mechanical or manual. In hand threshing, two big logs of wood are placed on a mat and rice sheaves are flogged on the logs to separate the rice straw from the paddy.

**Winnowing** This removes the pieces of rice straw and any other foreign matter from the paddy. The threshed paddy is put on a shallow tray and carefully thrown upwards against the wind. The straw material is blown away while the clean paddy is retained.

**Storage** The winnowed rice is properly dried to a moisture level of about 14% in the sun and finally put into jute bags and stored in a dry rat-proof store.

**Processing of paddy** One may mill rice directly to remove the glumes or parboil before milling. When rice is milled without parboiling, it does not store as well as that milled after parboiling.

- **Parboiling** consists of two operations, namely, soaking and steaming.

  **Soaking** The paddy is soaked in order to ensure that the rice is not coloured after milling. In the course of washing, the incompletely filled grains are removed. After washing, the grains are loaded into a drum and water is added to a level a few centimetres above the rice. The pot is covered and fired. As soon as bubbles begin to appear, the source of heat is removed and the grains are left in the pot till the next morning. If it is possible to heat in water to a temperature of 65 - 70°C, the post heating - soaking time may be reduced to 3 or 4 hours. Finally, the soaked grains are washed and steamed.

  **Steaming** A little quantity of water (5-8 litres) is added into a drum filled with the soaked grains. The top is covered with jute bags and heat is introduced. As soon as steam is noticed on the jute bags, the source of heat is removed. The drum is tipped over and grains are spread evenly on a mat while they are still hot. The parboiling is complete and drying commences.

**Drying** Initially, the grains are thinly spread under direct sunlight. As the drying progresses, the grains are heaped to some extent so as to avoid very rapid drying rate. The reason is to prevent sun cracks on the grains.

**Milling** This is simply the removal of the glume and parts of the embryo and the aleurone layers from the grain. The by-products of milling are: the husk and the bran. The bran consists of some parts of the embryo and the aleurone layer and it is very rich nutritionally. The rice grains are collected for consumption after milling.
Yield
The yield of rice depends on the variety grown. With improved varieties and under good husbandry, yields of about 4 tonnes/ha have been obtained. If the growth conditions are poor, the yield may drop as low as 0.5 tonnes/ha.

Utilization
Rice is a major staple in most countries of the world. In West Africa, it is boiled with some pulses and vegetables. The rice bran contains oil that can be used as cooking or salad oil and the rice hull serves as a good roughage for cattle.

Pests and diseases

Birds
At the grain production stage, rice is heavily attacked by birds. Bird-scaring is the cheapest means of reducing bird damage.

Stem borer
Sesamia calamistis is a major pest of rice in southern Nigeria. It attacks rice from seedling to maturity. The larvae bore into rice stalks, feed inside the stem and cause the plant to die. The control is to apply systemic insecticides like Furadan. Burning the rice stubble of infected plants is a cultural method of checking the further spread of the pest.

Armyworm
The larvae of Spodoptera exempta feed on the leaves causing obvious damage and reducing photosynthetic surfaces. The pest is controlled by a uniform spray with malathion.

Gall midge
This is a very recent pest of rice affecting mostly the rice fields of Anambra State. Research with respect to its bionomics and control is still in progress.

Rodents
Rice plants are also attacked by rodents. These are controlled either by trapping, fencing or the use of chemical poisons dropped at different points in the rice field.

Diseases

Blasts and rotten neck
The causal agent is the fungus 

Piricularia oryzae. It infects the leaves and the panicles. In severe cases, the whole leaf dries up.

The control measures include:
(a) use of resistant varieties
(b) infected plants are removed and burnt
(c) planting of clean seeds (i.e. seeds that are dressed).

Brown spot disease
This is caused by another fungus, 

Helminthosporium oryzae. It appears on the leaves as circular spots with light centres and broad margins. This symptom is common on the coleoptile and on the leaves.

The control also involves seed dressing before planting and burning of the thrash from infected plants.

Brown leaf spot
The disease is caused by another fungus, 

Cercospora oryzae and it causes a reduction in leaf area. The check is by the use of resistant varieties.
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Stem rot The fungus, Helminthosporium sigmoideum, causes the stem rot disease of rice.

Bacterial blight Bacterial blight is caused by Xanthomonas oryzae. The symptoms are the appearance of water soaked stripes on the leaves. Affected leaves wither and the plant may eventually die.

Family: Gramineae
Botanical name: Zea mays

Plate 4 Maize stalk. Fig 7.11 Zea mays

Types of maize Based on the endosperm characteristics, maize is often classified into seven groups, namely; dent maize (Zea mays var. indentata), flint maize (Z. mays var. indurata), sweet corn(Z. mays var. saccharata), flour maize (Z. mays var. amylica), popcorn (Z. mays var. praeocis), waxy maize (Z. mays var. ceratina), and pod maize (Z. mays var. tunicata).

Botany Maize is a large monoecious grass. The most outstanding characteristic of the crop is the separation of the sexes into different parts of the same plant, the male flower or the tassel is borne at the terminal part while the female flower in a modified lateral branch (cob) is borne in the leaf axil. Maize grows up to 4.5 m tall and has very little tillering potentials. The prop roots originate adventitiously from the lowest aerial nodes and provide support to the plant. The stem is solid with shorter internodes at the base, longer and thinner internodes towards the apex.

Climatic and soil requirements Maize is essentially a tropical crop. It thrives in a wide range of temperature. Above 35°C its metabolism becomes impaired. At soil temperature of 20°C, the germination will occur very rapidly between 3 and 6 days. There is also very rapid growth phase in the early stages at 20°C. Maize cannot stand drought and performs best on 400 - 900 mm of rain. The crop grows best in well-drained loamy or sandy loam soil that is rich in humus and available nitrogen.

Origin Maize is the only important cereal that is believed to have evolved in the New World, reportedly in Mexico. It was introduced into West Africa first in the 16th century; into Nigeria in the same century when the first white grain was introduced. In the 16th century the yellow and other colour types were introduced into Nigeria from Egypt and Turkey. Finally, the third introduction was in the early 50s when efforts were made to combat the maize rust disease of South America.

Land preparation Maize is planted on flat after clearing, ploughing and harrowing the land. However, in maize-cassava intercrop, planting on ridges
Arable crops yield better results than planting on the flat.

**Planting material** Maize is propagated only by seeds.

**Planting method** Maize is planted on ridges when intercropped with cassava and on flat when drilled as a sole crop. The crop's performance is affected when it is planted on stale seed beds, hence it is sown as soon as the beds are prepared to a depth of 5 - 7.5 cm, at an intra-row spacing of 25 cm and inter-row spacing of 75 cm giving a plant population of about 53,000 plants/ha.

**Weeding** Maize does not stand weed competition. Weeds are removed manually using a hoe or killed with herbicides.

**Fertilization** The first dose of NPK complete fertilizer is usually 10 - 14 days after sowing at the rate of 250 kg or five bags per hectare. The method of application is simply by side placement 15 cm away from each stand and 3 cm deep.

At tasselling (about seven weeks after sowing), sulphate of ammonia is also applied by side placement at the rate of 150 kg or three bags per hectare. Fertilizers application is however subject to the original soil fertility status of the farmland.

**Maturity and harvest** The maturity depends on the variety. For dry grain harvest, maize is mature as soon as the silk, leaves, and buds are completely dry. The moisture content of the grain at this stage is around 25%. If maize is to be harvested green (as a vegetable), the drying of the silk is enough indication for the harvest of the cobs.

**Fertilization** The average yield is around 2.5 tonnes/ha but in the local production, the average is often below 1 tonne/ha.

**Storage** Grains are dried to a moisture content of 13% before they are stored.

Shelled grains may be stored in
(a) earthen pots
(b) granary
(c) maize cribs; or in
(d) silos.

Storage in silos requires, in addition to the previous drying, fumigation to keep off weevils.

**Major pests**

**Stem borers (Busseola fusca)** Maize that is grown towards the end of the rainy season in Nigeria is often attacked by stem borers. The insects lay their eggs in the leaf axil and the larvae eat into the plant and destroy the stalks, flowers and ears. The feeding of the larvae on the young leaves of the funnel scarify and create small holes known as *window panes* on the leaves. These reduce photosynthetic surface of the plant. Consequently, the plant becomes stunted and deformed in shape and little or no yield is realized from severely affected stands. Furthermore, the holes made as a result of deep burrowing into the stem tissues make the plant...
Arable crops

prone to lodging.

The control is rather a problem since the pest burrows into the plant. However, the use of systemic insecticides such as Furadan has helped to minimize the damage done by stem borers. Farm sanitation through the burning of all maize stalks of the previous cropping helps to destroy hibernating stages of the insect.

Maize aphids (Rhopalosiphum maidis). These feed on the stems and leaves of maize plants. They are controlled by spraying with Diazinon.

Rodents Rodents attack and eat the basal portions of maize especially at the seedling stage. Consequently, the plant stands over and the stand is lost before it bears cobs. Control is by trapping and fencing.

Maize weevil (Sitophylus zeae). The maize weevil is a serious pest of maize.

Both the larvae and the adult attack maize in the store and by constant feeding on the grains, they reduce the quality of the farm produce and cause a big drop in farm income to the farmer.

To control the pest the farmer should ensure a very clean storage environment, remove all waste grains, dirt and weeds. Chemicals like Aluminium phosphide (Phostoxin), are very effective in checking the storage pest. This protectant liberates phosphine gas which is toxic to the pest and will finish off without leaving any residue capable of harming humans beings.

Traditional methods of control such as sunning, smoking and drying are also effective because these processes create an unfavorable environment for the adults than eventually fly away.

Birds Birds also attack maize especially during the dry period or when the plant is very small. They remove parts at the husk and feed on the grains before harvest. Bird scaring is the cheapest means of control.

Diseases

Corn smut. This is a fungal disease in which the cob is replaced with a mass of spores called a gall. It is caused by the fungus Ustilago zeae. Approved fungicides
Arable crops

afford a reasonable control of this disease. The disease is also controlled by rotating crops and by planting cultivars that are resistant to the fungus.

Corn leaf blight

The corn leaf blight disease is also a fungal disease caused by Helminthosporium turcicum. The attack is mainly on the leaves. The control method is to pull out and burn all infected plants. The use of resistant cultivars is a cheaper way of avoiding infection.

Maize rust

This is caused by the fungus, Puccinia polysora. Infected leaves show brown spots and eventually die. The disease is prevented by planting resistant varieties.

Maize streak

This is a virus disease that is mostly restricted to monocots. Yellow streaks are observed on the leaves. Severely infected plants show stunted growth, reduced photosynthesis, and a depressed yield. The only control measure is to plant resistant varieties. Any infected plant should be pulled out and burnt.

Guinea corn

Family: Gramineae
Botanical name: Sorghum bicolor

Botany
Guinea corn is an annual with solid erect stem supported by a large number of adventitious roots (harrow roots) which arise from the lower nodes of the stem. It has wide leaves that are similar to those of maize but these leaves are easily distinguished from maize by their toothed margins. The crop tillers much more than maize, and the height, depending on the type and cultivar, ranges from 0.6 to 3.6 m. The inflorescence of a sorghum plant is an spike. It may either be compact or branched, and in any of the cases, two spikelets, each having a single floret, are borne on each branch.

Climatic and soil requirements
Sorghum requires environmental conditions similar to those of maize. The crop cannot tolerate low temperatures but it can tolerate some level of drought. Sorghum is produced in soils with pH ranging from 5.0 to 8.5.

Origin
Sorghum is believed to have evolved in Africa because wild ancestors which resemble the commercial cultivars grown today are found in the continent.

Land preparation
For an excellent yield, the land should be well prepared. The best seedbeds are freshly prepared ridges constructed 90 - 100 cm apart. Where this is not possible, the seeds are planted in shallow row openings.
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Planted method

Seeds are planted direct into the prepared seedbeds or ridges. The ridges are spaced 1 m apart and the intra-row spacing between the crop is 30 cm. In mixed cropping, however, wider spacing becomes inevitable.

Weeding

Sorghum does not stand weed competition. The weed content is better done with herbicides such as Atrazine. This is because of the massive root system of sorghum that may be damaged by frequent weeding with hoes.

Planting material

Sorghum is propagated by seeds. Seed dressing is a very important practice because it helps to prevent seed decay before germination and smut disease after germination. The recommended seed dressing chemicals for sorghum are: Aldrex T and Fernasan D.

Planting

Seeds are planted direct into the prepared seedbeds or ridges. The ridges are spaced 1 m apart and the intra-row spacing between the crop is 30 cm. In mixed cropping, however...

Fertilization

The response of sorghum to fertilizer are affected by water availability. Where water is a limiting factor, sorghum does not appear to respond to direct application of fertilizer. The probable explanation is that the upper soil layer rapidly dries out and the fertilizer does not, therefore, go into solution for absorption. Where water is abundant, sorghum does not respond to fertilizer application if the inherent fertility of the soil is relatively high. Following these peculiar nutrient requirement habits, the fertilizer dosage for sorghum cropping is usually low. In Nigeria, the recommendation is 3-4 tonnes/ha of manure or compost or 60-125 kg/ha of single superphosphate worked into the soil before sowing and 100 kg/ha of sulphate of ammonia applied about 3 weeks from sowing. Sorghum does not seem to respond to potassium application. If NPK complete fertilizer is available, 125 kg or 2.5 bags per hectare are sufficient for a good crop of sorghum.

Maturity and harvest

Sorghum matures 85-105 days from sowing depending on variety and time of sowing. If sown around April, it takes a longer time because of the response to photoperiod. It will only flower during the short day period. The maturity of the crop is indicated by:

(a) the full development of glume and seeds (white, black or variegated colour); and as the case may be,
(b) easy detachment of the grain from the glume; and
(c) very hard grain when bitten between the teeth.

Particular harvest is the common practice and the stubbles are left for staking of yams.

Yield

The grain yield depends on the cultivar and location. Yields of 350-1,200 kg/ha have been reported.

Storage

The harvested panicles are either stored as such or threshed before storage. Grains are stored under the traditional system in barns and in the modern system in silos. The grains must be dried to a moisture content of 13% or less before storage.
Major pests

Sorghum midge These are flies which lay their eggs between the glumes and the grain. The larvae that hatch eat feed on the tissues of the developing seed. The symptoms of infestation is the production of empty spikelets.

- **The effective control measures are:**
  1. Early planting of the crop to escape the peak period of the flies
  2. Use of resistant varieties
  3. Destruction of all infested panicles
  4. Insecticides do not appear to be effective in the control of insect

Aphids These interfere with the emergence of the head. Aphids may cluster at the point of emergence of inflorescence and secrete honey dew which provide a good growing medium for mould. The mould produces spores that give a soapy appearance that completely prevent heading. Consequently, no grains are produced.

- **The use of resistant varieties and spraying to check the aphids are good control measures.**

Witch weed (Striga hermonthica) This is a plant pest. It is prevalent in northern Nigeria where its damage on sorghum is enormous. The pest penetrates and stops the feet of the crop by means of stolons.

- **The control is to prevent seeding of the pest through continuous weeding.**

Diseases

Sorghum grain smut The spores are seed borne hence they germinate with the seed. After germination, the fungus attacks the young seedling. Infected plants can hardly be differentiated from the non-infected ones until flowering.

- **The control is simply by planting of clean seeds achieved principally by seed dressing.**

Sorghum head smut This is different from the grain smut because it affects the entire head and it is soil borne. The control is by burning all infected plants and also by crop rotation with non-susceptible crops.

Bacterial blight This often occurs on seedlings that are exposed to long periods of wet weather. Infected seedlings show symptoms of yellow leaves that eventually wilt. Internally the stem turns yellow and finally collapses.

**Family: Gramineae**

**Botanical name:** *Pennisetum spp.*

**Botany** The cereal crops with very small grains and which are, with the exception of the pearl millet, smaller plants than sorghum or maize, are collectively called...
Arable crops

The principal millets are *Pennisetum americanum* (pearl millet), *Setaria italica* (foxtail millet), *Panicum milieum* (common millet), and *Echinochloa frumentacea* (green barnyard millet). Each of these species has its botanical characteristics.

**Climatic and soil requirements**: Millet is normally grown where rainfall is scanty and the soil is not particularly rich. It grows in any type of soil from sand dunes to lateritic clay but does best in well drained soils. It has a very shallow root system and as such does not stand prolonged water stress. Its ability to stand scanty rainfall appears to depend on its early maturation.

**Origin**: The cultivated *Pennisetum* are believed to have originated in the semi-arid savanna zone of Africa. The *Setaria italica* and *Panicum miliaceum* are reported to have their centres of origin as central and eastern Asia.

**Land preparation**: The land is cleared, ploughed and harrowed to loosen hard clods.

**Planting method**: Millet is planted in areas that are either too sandy or too dry for sorghum. The small seeds of millet are planted 4 to 6 cm deep in rows spaced 40 - 60 cm apart and 90 cm between rows. Planting is usually on the flat and rarely on ridges.

**Weeding**: Weeding may be done about 3 - 4 weeks from sowing. During this operation, the seedlings are thinned down to about 7 - 10 seedlings per stand.

**Fertilization**: Millet responds well to nitrogen. In places where composts or farmyard manure is used, an application of 4 - 5 tonnes/h has been sufficient for a good crop of millet. The fertilizer recommendation in northern Nigeria is 50 kg/ha of sulphate of ammonia and 50 kg of single superphosphate. In yield trials, NPK in the rate of 150 kg/ha was found to give an increase between 100 and 140 kg/ha of grain yield.

**Maturity and harvest**: Harvesting is done between 50 to 60 days after planting. The operation is best done while the lower part of the panicle is still green to avoid shattering.

**Yield**: Yield varies from 200 - 1,000 kg/ha. In organized cropping, yield up to 3,000 kg/ha can be obtained.

**Utilization**: Millet is a major staple in the arid regions of Africa.

**Storage**: The panicles are stored directly or after threshing. Whatever approach is adopted, drying to reduce the moisture content of the grain is necessary.

**Pest and diseases**: The pests are the same as those of sorghum. However, there is no record of striga or witch weed on millet.

**Diseases**: *Honey dew* is a fungal disease that is recorded in millet. The symptoms
Arable crops

Sweat appear after flowering and take the form of pink sticky liquid. The secretion which is sugary attracts small insects which crowd the inflorescence and distort its development.

COWPEA
Family: Leguminosae
Botanical name: Vigna unguiculata

Cowpea belongs to the genus Vigna. It is an annual herb with a great range of growth habits - climbing, decumbent and bushy. It is characterized with oval to heart-shaped trifoliate leaves and blue-purple to white flowers. The pods are flattened and range from 10 - 25 cm in length. The seeds of the grain cowpea do split at maturity under intense heat and disperse the seeds while the plants are still in the field. The vegetable cowpea, on the other hand, is indehiscent. Some seeds are black, speckled, white, brown, or chocolate. Some of the white coloured seeds have black heliots and these are generally referred to as the black eye cowpea.

Climate and soil requirements. As a tropical crop, it requires high temperature, intensive sunshiny with evenly distributed rainfall between 1500 mm and 1500 mm during the growing phase. Very heavy rainfall extends its vegetative growth phase. Cowpea is adapted to a wide range of soils. It grows almost equally well on sandy as well as on clayey soils and can stand poor soil conditions better than most crops.

Origin. The genus Vigna has about 170 species with the largest number endemic in Africa, several in India, Australia, and the New World. There is some evidence that cowpea (V. unguiculata) originated in West Africa, probably Nigeria.

Land preparation. The seedbed must be well tilled and worked to a fine tilth. State beds do not favour cowpeas and so, seeds should be planted as soon as the beds are prepared. Planting is either on flat or on raised beds.

Planting material. Cowpea is propagated by seeds. These are sown as from July to late August in Nigeria, as most of the local varieties are short day plants. This period also ensures that the growth phase coincides with adequate soil moisture regime and maturation occurs as the weather becomes drier. The spacing varies with the growth habit. Erect bush types may be spaced 30 x 30 cm while the trailing type may be spaced 30 cm within rows and 90 cm between the rows.

Sowing depth and seed rate: 3 cm; 34-56 kg/ha in sole cropping.
**Weeking.** There is usually about one weeding especially with the trailing type. If a clean seed bed is prepared at the time of sowing, one weeding will suffice to keep the land sufficiently weed free until the plant covers up.

**Fertilization.** Cowpea does not respond to fertilizer where the soil fertility is high. If adequate fertilizer had been applied to previous crop, there will be no need to apply fertilizers to cowpea. But where soil fertility is low, farmyard manure, single superphosphate or potash will give increased yield. Generally, nitrogenous fertilizers are not very necessary as they tend to inhibit nodulation. If the soil is deficient in nitrogen, a small dosage of nitrogen may be applied very early in the growth stage of the cowpea.

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**Maturity and harvest.** Flowering does not occur at the same time in cowpea. Depending on the variety and the time of planting, flowers will begin to open as from 40 to 70 days after planting. Two to three weeks later, the first pod will begin to mature. Because the flowers do not all emerge at the same time; pod development spreads over a period and consequently harvesting will also spread over a range of time. Only dry pods are picked at each harvest. The vegetable cowpea is harvested green and the mature of the pods appears to present as a good cowpea for canning.

**Yield.** On farm yields, ranging from 200 to 1,000 kg/ha under peas ground, yields up to 2,000 kg/ha are possible under very sound management.

**Utilization.** Cowpea is an important source of plant protein both for man and his livestock in tropical West Africa. It is also used as a cover cropland as a green manure.

**Storage.** Harvested pods are shelled and the seeds are stored in sacks or in tins with screw cap lids.

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**Major pests.**

Numerous insect pests particularly the gall midge cause much damage. Insect damage may be on the leaves, flowers, buds and developing pods. Attack is more devastating during the stage of pod development.

- **Bugs.** Major pests of cowpea in Nigeria. The common bugs are: Acanthoscelides obtectus, Acallesus incanescens, and Acallesus cucumeris (Plate 5), Necked weevil (Fig. 7.16) and Chionea solstitialis. The bugs feed on the seeds through the pods. Damaged pods become shrivelled and dry up prematurely.

- **Thrips.** That attack cowpea in West Africa are of two types, namely, Megachile species (plate 7) and Senticocpa occidentalis. The insects attack both the shoot and flowers leading to significant yield loss.

**Bean weevil (Callosobruchus maculatus).** The bean weevil is a small to medium sized insect with elytra that do not reach the tip of the abdomen. It is very important pest of stored cowpea, soybean and pigeon pea. Infestation starts in...
the field and builds up in the store hence it is usually described as a field-to-store pest. Very little damage is done in the field. Damage is mainly done by the larvae during metamorphosis within the seed. The adult does not feed within the seed. At full adult stage, the insect either leaves through the holes already created (Plate 6) or remains quiescent in the seed. It is common to find these adults while eating a plate of already cooked cowpea. The control is by either sunning the grains regularly or by heating or by the use of chemicals. The adults are activated by exposure to strong sunlight and they fly away. Heat promotes further drying thus reducing infestation. A very useful control chemical is Aluminium phosphide. Store fumigation is also a reliable method of killing insects that are in the store even before storage.

Other insect pests include: Ochthaea multipalpis and Aerata testudalis. While the former defoliates the plant, the larvae of the latter feed on the flowers, pods, and seeds.

**Major diseases**

*Fusarium* wilt caused by *Fusarium oxysporum* causes the plant to wilt even when there is abundant moisture in the soil. Powdery mildew is caused by *Erysiphe polygoni.* Application of benomyl solution as a soil drench around the plant provides a good check to the spread of the disease. Seedling blight is caused by *Corticium rossii.* It causes seedling blight and rot.

+Cercospora+ leaf spot caused by *Cercospora concepsis* is one of the most important cowpea diseases in Nigeria. Severe attack leads to total yellowing of leaves which eventually fall off.

Other diseases of economic importance include the bacterial blight caused by *Xanthomonas vignicola* and the cowpea mosaic disease caused by virus.
Arable crops

Groundnut

Family: Leguminosae

Botanical name: Arachis hypogaea

**Botany**

Groundnut is an annual, 25-50 cm high, with either spreading or bushy growth habit. The plant has a deep tap root system with numerous lateral roots endowed with good nodulating potentials. The flower stalk elongates after fertilization and the peg or gynophore curves and grows downwards into the soil so that the ovary is buried. Pods develop underground and contain 1 to 4 seeds. The seeds may either be red or light brown.

**Types of groundnuts**

On the basis of growth habit, groundnuts are classified into two main groups, namely, spreading or runner type (examples are the Valencia and Spanish types) and the bush type (the Virginia type).

The spreading type of groundnut produces branches that lie prostrate on the ground. The pegs are dispersed from the base of the plant to the terminal regions of the branches. The pods are, as a result, scattered underground about the entire circumference of the canopy.

The bush type grows erect and the pods cluster around the base of the plant. The harvest is easier but the yield is less than that obtained from the runner or spreading type.

**Climatic and soil requirements**

Groundnuts are reproducitively day-neutral plants. They grow well with rainfall of 750 - 1250 mm during the growing period. Many cultivars are drought-resistant. Soil pH of 7.0 with good content of calcium, potash, and phosphate is ideal.

**Origin**

The origin of the wild ancestors of groundnuts is unknown. But the crop has been in cultivation for over many centuries beginning from South America. Earlier it was believed to have originated in Brazil but the current thinking is that its origin or primary center of domestication is southern Bolivia and northern Argentina.

**Land preparation**

A loose and well tilled soil is essential for the penetration of the elongated flower stalk. This makes elaborate land preparation tedious and laborious. Heavy soils are generally unsuitable.

**Planting material**

Groundnut is propagated by seeds.

**Planting method**

Discreted seeds are sown in shallow drills 2.5 to 5 cm deep on slightly raised beds or low ridges at a spacing of 45 cm between ridges and 30 cm within the row. In Nigeria, the recommendation is to sow groundnuts not later than May 15 especially in the drier northern states.
Arable crops

Cultivars
The two groups of groundnut, the spreading and the bunch, mentioned earlier can further be classified into early, medium and late-maturing types. Examples of the commercially grown cultivars are: castle, Kano, Samam, and marais.

Weeding
Groundnuts require very careful weeding in the early vegetative period. As soon as pegs begin to penetrate the soil, weeding is no longer very possible without damage. Hence it is very important to have clean and loose seedbeds prior to pegging. Manual weeding with hoes is done with caution to avoid damaging the pegs.

Fertilization
Groundnuts seem to have considerable ability in utilizing residual fertilizer and this does influence the fertilizer use in their production. The crop needs calcium for its pod production. At flowering time it should be dusted with gypsum (CaSO₄) at the rate of 100 kg/ha. In very poor soils, liberal application of animal dropping or compost before sowing improves the crop performance. Where nitrogen is deficient, 100 kg of sulphate of ammonia is sufficient for a good crop of groundnuts.

Maturity and harvest
Maturity is indicated by yellowing and wilting of the leaves. However, it has been observed that some varieties produce mature pods even before the aerial maturity symptoms appear. Thus, maturity is a function of variety and may occur between 14 and 20 weeks after planting.

Harvesting is either manual using hoes or mechanical with harvesters. After harvest, the soil is normally shaken off the pods and the plants are laid in swaths. Later, the pods are detached.

Post-harvest handling
The pods are picked out from the haulm after drying. Sorage of the pods is done only after very proper drying, and after all damaged kernels have been removed. This is to reduce rancidity and chances of aflatoxin formation.

Yield
Depending on the cultivar, soil and weather conditions, yield of shelled seeds ranges from 500 to 4,000 kg/ha.

Utilization
At present confectionary and edible groundnuts are being emphasized in tropical West Africa as the seeds are gradually replacing lunch for most urban dwellers. The seed contains about 11% carbohydrates, 30% protein, 45% oil, 2% fibre, 2% ash and 5% water. Groundnut oil and butter are obtained from groundnuts. After oil extraction, the residues are good sources of protein useful in bakeries and in the manufacture of livestock feeds.

Major pests
Beetles—Beetles eat leaves and damage seeds. The control is to spray with malathion. Termites and centipedes are also potential pests of groundnuts.

Groundnut aphid (Aphis craccivora) These transmit the groundnut virus.
Arable crops

Rosette crop disease is caused by a virus which is carried by aphids (Aphis cracca). The symptoms are dark green foliage mottle on a light green background; reduced leaf size, stunted branched appearance and yellowing. The use of clean seeds, combined with early planting reduces infection. To minimize the spread, all infected plants are pulled out and burnt. Crop rotation and bush burning are also useful methods of control since these practices can reduce the population of the aphids. Good levels of resistance to the disease are available in long and medium duration cultivars developed by the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT).

Wilt disease. This is caused by Pseudomonas solanacearum. It affects plants, causing wilting and death. The use of resistant lines and good crop rotation have helped to reduce the incidence of the disease.

Root and stem rot. This is caused by the fungus Sclerotium rolfsii. The usual control measure is to grow groundnuts on soils with good drainage.

Leaf spot This is caused by a fungus, Cercospora arachidicola. The disease is characterized by leaf spotting and defoliation. Spraying with copper fungicide checks the disease effectively. Clean weeding and crop rotation are cheaper methods of keeping the disease incidence low.

Groundnut rust This is caused by the fungus, Puccinia arachidica. The attack is announced by the presence of dark-brown marks on the leaves. The affected leaves eventually drop. The control is to spray regularly with Zineb.

Aflatoxin is caused by the fungus (Aspergillus flavus). This affects nuts that were not properly dried before storage. The stored nuts are coated with a greenish mould. The pathogen liberates dangerous toxin (Aflatoxin) that can cause liver cancer. The best check is to ensure that nuts are dried properly before storage.
Arable crops

**BAMBARA GROUNDNUT**

**Botanical name:** *Vigna subterranea*

**Family:** Leguminosae

**Leguminoseae**

**Botany** The crop is a herbaceous short-lived annual of about 15 cm high. The stems branch freely and the foliage provides good ground cover. Flowers are generally paired and after fertilization, elongation and reaming of flower stalk causes developing pods to be pushed into the soil. Pods are oval or round in shape and they contain one to two seeds each. The seeds are spherical and vary greatly in colour.

**Climatic and soil requirements** Bambara groundnuts thrive in elevations up to 450 m. It is essentially a dry season crop that is resistant to drought. It thrives well in acidic and relatively poor soils.

**Origin** The crop is believed to have originated from Central and West Africa.

**Land preparation** The soil is well tilled to facilitate penetration and development of the pods. Well-drained soil, preferably sandy soil, if supplied with organic materials, favours the growth of the crop.

**Planting method** Seeds are sown direct on raised beds or on ridges towards the end of the wet season. Spacing of 75 cm between rows and 30 cm within rows is recommended.

**Weeding** Early weeding before pegging is an ideal practice. As soon as the crops cover up, the incidence of weeds is reduced.

**Fertilization** NPK complete fertilizer is applied before sowing. This is followed by occasional top dressing with sulphate of ammonia.

**Maturity and harvest** Bambara groundnuts mature 12 to 18 weeks from sowing. This is indicated by the yellowing and withering of the leaves. Harvesting involves the pulling out of the entire plant and the pods detached.

**Yield** Except under very good husbandry, shelled seed yield is usually less than 1 tonne/ha.

**Utilization** Bambara groundnuts are a cheap source of protein in the arid and semi-arid regions of Nigeria.

**Storage** The pods are dried and stored or shelled before drying.
Pests and diseases

Pests and diseases are yet to pose major constraints in the production of Bambara groundnuts.

**SOYA BEAN**

*Family: Leguminosae*

*Botanical name:* *Glycine max*

**Botany**

Soya bean is a bushy and rather leafy annual with an erect growth habit. It can attain heights of about 40-120 cm. The crop has well developed taproot and feeder root systems. Like other legumes, soya bean nodulates and the leaves are trifoliate. Both the leaves and stem are covered with fine grey hairs. The flowers are small and are borne on short stalks arising at the nodes. They are hardly noticed at the first glance on the crop. The short-statured hairy pods contain 1-5 seeds.

**Origin:** China

**Climatic and soil requirements**

Soya bean is a subtropical crop. It is sensitive to daylength and varieties differ in this respect. The plant requires 400-900 mm of rainfall during the growing period. Although it is grown on a wide range of soil types, the crop performs best on sandy or clay loam soils of good fertility.

**Land preparation**

Soya bean can be planted either on the flat, ridge or seedbed.

**Planting method**

Soya bean is propagated by seeds sown directly at a depth of 2-4 cm and at a spacing of 60 x 30 cm on seedbeds or 15 to 30 cm apart on ridges, that are 1 m apart.

**Weeding**

Soya bean is a very poor competitor with weeds, particularly during the early growth stages. Hoe weeding is ineffective due to large forests, broadleaf species such as *Chlorophanus*, control weeds effectively.

**Fertilization**

Nitrogen fertilizer is not required for a successful production of soya bean because it suppresses nodulation. There are, however, specificities that soya bean, under tropical conditions, has reduced ability to produce nodules. A fertilizer rate of 300-450 kg/ha of 0-20-20 commercial fertilizer is recommended for a good crop of soya bean. Calcium or magnesium is also added in soils where such salts are deficient.

**Maturity and harvest**

Maturity in soya bean is indicated by the yellowing and drying of the pods. To avoid attracting and loss of seeds in the field, the crop is better harvested as soon as the maturity sign become obvious.
Yield Cultivars with high yield potentials can be obtained from the International Institute of Tropical Agriculture (IITA), Ibadan. On the average, grain yield ranges from 0.5 - 2 tonnes/ha depending on the variety and crop husbandry.

Storage: Seeds meant for food are stored in sacks after shelling and drying. Rapid loss of seed viability in storage, under a warm and humid environment, is a major problem in storing seeds for future planting in Nigeria.

Utilization: Soybean oil is used for the manufacture of paints, printers' ink and soap. After oil extraction, the residual soybean cake is used for compounding livestock feed. Raw soybean contains trypsin inhibitors. Heating the seeds renders the inhibitors harmless. Today, soy beans is as popular as cow's milk in most African countries.

Major pests:
There are no major pests of soybean; many insects cause minor problems. Such insects include the stink bugs, leafhoppers and some caterpillars. Nematodes and rodents also attack and reduce soybean yield in the humid regions of the tropics.

Diseases:
Bacterial blight, caused by *Pseudomonas glycinea*, is common under very humid conditions. The disease is seed borne and symptoms include lesions on the leaves, stems, petioles and pods. The best control measure is to use resistant cultivars.

Wildfire, caused by *Pseudomonas tabaci*, causes plant defoliation. Resistant cultivars are planted in areas where the disease is endemic.

Downy mildew is a fungus disease caused by *Peronospora manshurica*. The leaves and pods are the primary areas of attack. Although some resistant strains are available, several infections are controlled by the use of fungicides. *Soybean mosaic* and *yellow mosaic* diseases, although severe, are controlled by the use of fungicides. Some root diseases, namely, *Rhizoctonia* root rot caused by *R. solani*, *Pythium* root rot caused by *P. ultimum*, and *Phymatotrichum* root rot caused by *P. omnivorum* are injurious to soybean. At the small-scale level of production, these diseases are overlooked but in large-scale production, their effects may be high enough to make them important.

Fibre crops: Fibre crops are very important crops because they are essential to man for the manufacture of much of his clothing, his cordage and coarse fabrics. The number of fibre crops with commercial importance is small as most of them are of ancient origin. Fibres are of three main types, namely, surface hairs, bast or soft fibres, and leaf or hard fibres.

Surface hairs are fibres that are associated with the fruits and seeds of the plant. Cotton, which is a member of this group, produces seeds whose coats are...
Arable crops

Endowed with the surface hairs, Bast or soft fibres are associated with the phloem of the stems of the plant. They occur in bundles up to 700 individual cells that provide mechanical support for the stem. These bundles are the harvestable parts that are commercially important for the manufacture of cordage and sacks. Jute and kenaf produce the bast or soft fibres. Leaf or hard fibres are simply bundles of sclerenchyma tissues located in the leaves of some monocotyledonous plants such as the New Zealand hemp and the sisal hemp.

Leaf or hard fibres are simply bundles of sclerenchyma tissues located in the leaves of some monocotyledonous plants such as the New Zealand hemp and the sisal hemp.

Botany
The various species of cotton vary from annual herbs to perennial trees. They bear alternate leaves that are usually palmately lobed. The cotton plant may grow to heights of 60-120 cm with deep taproot and a dense network of secondary root system. Two buds are produced in each leaf axil, a vegetative bud in the axil itself and an extra axillary flower bud that produces a fruiting branch. Flowers are borne on alternate sides of the fruiting branches. Flowers and bolls originate only from the fruiting branches. The fruit is a capsule with about 45 seeds per fruit. The mature fruit is the cotton boil. The cotton seed has two parts: the hull, from which the lint arises, and the kernel, from which the oil and meal are obtained.

Origin
The actual origin of cotton is unknown. Rather it is believed to have evolved from several different locations, namely, Indo-China, Africa and Central and South America.

Climatic and soil requirements
Cotton tolerates a wide range of soil conditions. However, the crop performs best in soils with sufficient depth and soils that allow easy percolation of water. It does not stand waterlogged conditions but requires enough soil moisture and a soil pH from 5.5. The crop requires considerable sunlight and relatively high temperature between 21 and 26°C. It is very sensitive to low temperature. However, during its flowering, it does well with low night temperature.

Land preparation
Cotton is planted either on raised beds or on flat. In either of the cases, the soil is well tilled and harrowed, and crop residues of the previous plantings are buried to raise the organic matter content of the soil.

Planting method
Cotton is always grown from seeds. These are planted at a spacing of 90-100 cm between rows and 22-30 cm within row. A sowing depth of 2.5 - 4.0 cm is recommended. The seed rate varies from 9 to 22 kg/ha.
Cultivated species

Two species of the New World linted cotton, *Gossypium hirsutum* (upland cotton) and *G. barbadense* (Egyptian cotton), are popularly cultivated. The varieties of *G. hirsutum* are normally small shrubby plants with few vegetative branches. The bolls (fruit) are large and rounded and the lint is not as shiny or as long as that of the *G. barbadense*. The staple (i.e., the material obtained from the cotton fiber) is of the short to medium type. The lint length ranges from 2 to 3 cm. *G. hirsutum* accounts for about 95% of the world cotton production. The *G. barbadense* is rather a taller plant in the range of 1.5–3 m. It branches profusely and the flowers do not open as widely as those of the *G. hirsutum*. The seeds are endowed with a copious coat of lint. The staple is of the long type and the lint length ranges from 3 to 5 cm. *G. barbadense* accounts for about 5% of the world cotton production.

Weeding

Weeding is a very important operation in cotton production. Weeds may not compete directly with the crop, but their indirect effect in acting as alternate hosts to most pests that damage cotton may not be ignored.

Fertilization

Cotton has a very high requirement for nitrogen in the first two to four months after planting. Sulphate of ammonia and single superphosphate are each applied at the rate of 120 kg/ha. The nitrogen fertilizer is better applied split; first dose at sowing time and the second at flowering. When there is potassium deficiency, 20:10:10 compound fertilizer at the rate of 112 kg/ha is applied by side placement 4 weeks from sowing.

Management of cotton farm

To ensure that the cotton crop is harvested clean (for the value depends on its cleanliness), there is the need to keep off insects that contaminate the lint. Cotton flower buds begin to appear about 6 weeks from emergence and the first set of buds open 2–3 weeks later. The production of flowers may continue for a period of 10–18 weeks from sowing. On the basis of this developmental pattern, a spray schedule, with an insecticide, beginning about 9 weeks after planting (just after the flower buds have appeared), is recommended. The spraying will continue at weekly intervals for 6 weeks. One to two kilograms of Vector 85 or 252 liters of water is used per hectare for each spraying.

Maturity and harvest

When the bolls begin to open, harvesting begins and it is continuous as the bolls mature at different times. If open bolls are left in the field, they will become discolored and the quality will drop. Cotton is picked clean and free from any form of contamination. To ensure this, harvesting is carried out in two stages:

Stage I: To pick bolls without damage and blemish, i.e., very clean bolls free from all forms of contamination. (Grade 1 cotton)

Stage II: To pick the remaining damaged bolls with blemish.
Yield  In Nigeria, 250-600 kg of seed cotton is produced per hectare. However, the world average yield is about 1.5 tonnes/ha. The yield of lint ranges from 112, kg/ha to 2.5 tonnes/ha in different countries.

Utilisation  After harvesting the lint is separated from the seed (ginning). All forms of dirt and contamination are removed from the lint before it is baled and taken away for spinning. Cotton lint is used for making clothing, household textiles, tissues and belts. Cotton lint is woven into fabrics, either alone or in combination with synthetics or with other fibres. The seed contains about 19% starch, 26% oil and 18% protein. The oil from the seed is a non-drying oil with some industrial potentials; it is used for the manufacture of soap, margarine and cooking oil. The residue left after the oil and lint extraction (cotton seed cake) is rich in protein and used in compounding livestock feed. However, the presence of a phytochemical, Gossypol, makes the feed made from cotton seed unsuitable for pigs and poultry except after some heat treatment.

Major pests  Insect attack on cotton may damage the bud or cause blemish of the fibre thereby, reducing the yield and the quality of the cotton produced. Some of the important insect pests are as follows:

Cotton stainer (Dysdercus spp.) These are insects of the subfamily, hemiptera. Both the adult and the nymph attack and damage opening bolls by sucking and feeding on the cotton seeds. As they feed, they deposit their faeces which stain the lint. The control of the insect is difficult as it has many alternative hosts. A good control measure is to begin spraying 2 weeks before the flower buds open and to continue the spraying at weekly intervals for 6 weeks.

Cotton boll worms (Heliothis spp.) These are the larvae of certain moths, that eat their way into the flower buds and cotton bolls causing damage with consequent premature dropping of the flowers and bolls. Spraying with methidathion checks the moths and serves as a good control measure for the menace of the boll worms.

Mirids  These are small insects that feed on young cotton tissues especially young flower buds and leaves causing them to drop prematurely. The leaves are discoloured thus interfering with photosynthesis. Frequent field inspection and spraying at the correct developmental stage of the insect check the spread.

Cotton stem borers  These are larvae that attack and weaken the stem of old cotton plants. Such plants lodge under stormy weather. The insect is controlled by spraying with a contact insecticide.
Arable crops

Other cotton pests include aphids (Aphis gossypii) (Fig. 7.22), whitefly, and the mosquito bug.

Diseases

The angular leaf spot or bacterial blight, caused by Xanthomonas malvacearum, is a disease that affects the leaves, petiole and stems of cotton. The disease is seed borne and the control measures include seed dressing, use of resistant varieties, and the complete disposal of the debris from infected plants.

Fusarium wilt caused by Fusarium oxysporum is another disease of cotton. The organism blocks the xylem vessels and causes the crop to wilt and show rather drought symptoms in the presence of sufficient soil moisture. The best control is to plant resistant varieties.

Verticillium wilt caused by Verticillium alboatrum leads to chlorotic mottling and stunting. The disease is seed borne and the cheapest control measure is pre-planting treatment with a fungicide.

Anthracnose caused by Colletotrichum gossypii causes reddish spots on the stem and leaves and rotting of the bolls. To check the disease, dress seeds meant for planting with captan.

Fig. 7.22 Aphid

Family: Tiliaceae
Botanical name: Corchorus spp.

Botany Jute belongs to the family Tiliaceae that is fairly related to the Malvaceae except that it has free filaments and two-celled anthers. It is a herbaceous plant that is up to 5m tall with straight, cylindrical stems branching only at its top especially with very close spacing. The leaves are alternate along the stem on short petioles. The flowers are solitary or in groups of two or three. There are two cultivated species—Corchorus olitorius and Corchorus capsularis. Both are distinguished
by their fruits. Those of *C. capsularis* are small, globular, ridged and wrinkled capsules, 1-2 cm in diameter with flat tops, they are dehiscent. On the other hand, the fruits of *C. olitorius* are cylindrical capsules up to 10 cm long. **Origin** There are disagreements as to the real origin of corchorus. Some believe that one of the species *C. olitorius* is African origin while *C. capsularis* is Indo-Burma. No matter the initial sources of these species the truth remains that the cultivated species of corchorus are tropical in origin. **Climatic and soil requirements** Jute is a tropical crop that requires a high temperature range of 15-38°C. It grows well in sandy loam or alluvial soils. An annual rainfall of about 1000-2250 mm favours a good crop of jute. **Land preparation** Jute can be planted under a flooded or an upland condition. The seedbed is normally deeply tilled and very finely pulverized. This allows for deep penetration of the root system. **Planting method** The very tiny seeds are better sown with sand or ash and broadcast in the field. The seed rate is usually 7-11 kg/ha. Thinning down the plant population to create a space of about 10-12 cm between seedlings becomes an important agronomic practice if the seedlings are clustered. However, a close spacing will be advantageous for good quality fibre production because it will help to suppress branching. **Weeding** Weeding is done simultaneously with the thinning operation. **Fertilization** Nitrogen improves the vegetative growth of jute but with a good supply of organic manure, jute does not seem to respond to further application. Some studies have recommended 121 kg/ha of sulphate of ammonia, 24 kg/ha of ammonium phosphate, and 36 kg/ha of sulphate of potash. **Maturity and harvest** Jute is grown to supply fibre for making jute bags and cords. If the crop is harvested prematurely, the fibre yield is low but the quality is higher. On the other hand, late harvest gives more yield of coarse and low quality fibre. Hence the harvesting must be designed to compromise both aspects. Harvesting is done by cutting the stems as low as possible because the lower sections appear to have lots of fibre. The stems are stored for about 1-2 days during which the leaves are shed. The stems are then tied to bundles for retting (a process of separating the fibre from the woody stem and from the extraneous green materials). The separation is brought about by the combined action of water, microorganisms, and enzymes. In traditional systems, retting is carried out by lying the bundles of stems flat in a stream, river or ditch. Under this condition, retting lasts for 3-4 weeks. But under controlled conditions, the stem bundles are put into tanks with water under regulated temperature. The right kind of micro-organisms (*Clostridium spp.*) are introduced and retting is completed in 3-5 days. As soon as retting is complete, the fibre is washed and dried.

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Arable crops
Major pests

Some beetles feed on the leaves and defoliate the plant. These are controlled by spraying with malathion. The root-knot nematode is a serious pest of jute. The control is simply by crop rotation.

Diseases

Jute is attacked by a number of root and stem diseases mostly fungal which cause lesions on stems and reduce the quality of the fibre. Resistant varieties appear to provide good checks to most fungal problems.

Oil crops store their food reserves as oils and fats in their seeds. These provide energy to the embryo during seed germination. The oils can be extracted either manually or by using specially designed machines. Oils can be classified into four main classes, namely, drying oils, semi-drying oils, non-drying oils and fats.

The drying oils absorb oxygen rapidly when exposed and dry to form a thin elastic film. The soya bean oil is a good example of the drying oil. As soya bean is a grain legume, it has been discussed under the legume crops. The semi-drying oils dry up rather slowly on exposure to air. Sesame, ricin, cotton and sunflower oils are the most important oils in this class. The non-drying oils remain liquid and do not form a film when exposed to air. Fats are oils that remain as solids at ordinary temperature. Palm oil, palm kernel oil and coconut oil fall within this class.

Botany

Benniseed is an erect hairy annual herb with foetid smell. It is about 1-2 m tall and it is supported with a pronounced tap-root and a dense network of feeder roots. The stem produces branches and the leaves are hairy on both surfaces. The flowers are zygomorphic and are borne in the axil of the upper leaves. The crop forms straight capsules with sharp pointed ends. The capsules are either dehiscent or indehiscent depending on the variety. The seeds are usually very tiny.

Origin

Benniseed is believed to have originated in Africa from where it was taken to India which is presently regarded as the secondary centre of diversity.

Climatic and soil requirements

Benniseed is a crop of the hot tropics and is usually grown in areas with an annual rainfall of 500 - 1000 mm. The crop is very sensitive to waterlogging and it tolerates some degree of drought after establishment. It does reasonably well on poor soils. However, sandy loam soil is preferred.
Arable crops

preferred. Benniseed is sensitive to daylength and both long and short day types exist.

Land preparation

The crop requires a seedbed that is weed-free and of good tilth.

Planting date

Benniseed is grown in the tropics as a rainfed crop. Planting with the early rains is a good agronomic practice as too much rain may lead to poor stands.

Planting method

In sole cropping, seeds are sown broadcast. For uniformity, the seeds are either mixed with sand or ash before broadcast. They are buried lightly. Seedlings are later thinned to maintain a spacing of 30 cm x 30 cm. The usual seed rate is 6 kg/ha.

Weeding

The seedling stage is critical and can be overwhelmed by weeds. Weeding is therefore very important during the early growth stage.

Fertilization

The use of organic manure is highly encouraged. A sufficient broadcast of poultry dropping during land preparation, for instance, would give a good crop of benniseed.

Maturity and harvest

Benniseed is ready for harvest when the capsules at the lower portions of the plant turn from green to yellow. Most cultivated varieties take 100 to 140 days to attain maturity. Harvesting is done before the capsules dehisce and disperse their seeds. During harvest, the stems are cut near the ground level, bundled, and stacked in the field to ripen the seeds. With the dehisced types, it is better to cut the heads and dry them in bunches hanging downwards on racks for 1-2 weeks. The seeds fall, as they ripen, on mats placed below the racks.

Yield

At the peasant level, seed yields of 224-670 kg/ha are obtained. But with good crop husbandry, yields of 896 - 2000 kg/ha have been reported.

Utilization

Benniseed is an industrial crop. The seeds contain 45-55% oil, 11% carbohydrate, 22% protein and 3% mineral. The oil is of high quality. It is odorless and it hardly becomes rancid. It is used as cooking oil and in the manufacture of margarines. It serves as a lubricant, illuminant and as a raw material for certain drugs and perfumes. After oil extraction, the residue is a good protein source in livestock feed.

Major pests

The major pests are the gall midge, Ageribusidae ament, that interferes with seed production by destroying the ovary and the caterpillars of Acastro cattalina, that destroy flowers and young fruits.

Diseases

Leaf spot diseases are either caused by Pseudomonas ament or Cercospora ament. Passport wilt is also a common disease of benniseed.
CASTOR PLANT
Family: Euphorbiaceae
Botanical name: Ricinus communis

Botany. As in other African countries, castor plant is cultivated and harvested as a perennial. The crop is endowed with a well-developed tap root system supplemented with a fine network of lateral roots that ramify the upper layers of the soil. The stem is erect, glabrous, becoming hollow with age. The branching habit differs from one cultivar to another. The leaves are large and palmately lobed. The inflorescence is a raceme with the male and female flowers borne separately. The female flowers occupy the upper 30 to 50% of the raceme and the male flowers the lower 50 to 70%. In some varieties, both flowers may be interspersed on the raceme. The racemes are produced sequentially. The first or primary raceme terminates the main stem. Branches that emerge from the main stem produce the secondary racemes. This sequence of raceme production continues until the plant is killed by adverse weather conditions. The fruit is a capsule and each capsule contains three shiny seeds. The seeds vary greatly in colour and the larger sized ones have the shape of a well-fed tick.

Climatic and soil requirements. Castor is a crop of the tropical and subtropical regions. Under temperate conditions, it is killed by frost. It requires a growing period of 140-180 days to produce satisfactorily. For optimal growth, it requires a temperature range of 25 to 30°C and an annual rainfall between 600 and 1200 mm evenly distributed during the growing period. Castor grows well on silty clay loam (medium textured soil) and is highly sensitive to a saline environment.

Fertilization. Conventionally, castor plants grown around homesteads are

Weeding. At the juvenile stage, castor plants are very poor competitors with weeds. But as they grow taller and their leaves begin to overlap, they shade the weeds and smother them.
nourished by large deposits of wastes from the household. Adequate amounts of nitrogen and phosphorus must be available to produce high yields of castor. Deficiency in nitrogen is corrected by the application of 140 kg to 260 kg per hectare of nitrogen. In farmlands where other crops respond to phosphorus, 60 to 130 P2O5/ha is applied.

Manure and harvest. The castor racemes mature at different times. The primary raceme matures first and is followed by the secondary, tertiary and the higher racemes in that sequence. The dehiscent varieties are harvested before they shatter. For the indehiscent varieties, harvest can be delayed until a good number of the ricins have matured.

Yield. The countries currently producing castor report average yields of under 1 ton/ha. In organized cropping, yields of 2-3 ton/ha can be obtained.

Storage. Castor seeds store well. Freshly-hulled seeds with little or no cracks will not deteriorate in storage for at least 2 years.

Utilization. Ricinum oil has excellent keeping quality. It does not turn rancid and its industrial uses are numerous. It remains viscous at high temperatures and liquid at low temperatures, a major reason why it is one of the best oils for the manufacture of lubricants. Only limited amounts of the oil are used in the raw state. A great proportion of the oil is subjected to one or more chemical processes to adapt it to a particular use. The excellent emollient property makes the oil a key material for the manufacture of body creams in cosmetic industries. The oil is also used in the production of Turkey oil used in cotton drying, printing, and leather industries. With a good extraction method, ricin is normally free of the ricin and the allergens. Both toxins remain in the cake. These make the cake unsuitable for compounding livestock feed. Cautions in poisoning and should not be fed to man or livestock without adequate processing.

Major pests. Infestation of thrips, corn earworms, armyworms, spider mites, and leaf miners has been reported in castor fields. None of these insects has, however, posed serious problems in castor farming in Nigeria.

Diseases. There are several diseases that can cause serious economic losses when conditions are optimum for their development. Damping-off disease is common in castor fields. It is controlled by fungicidal seed treatment. Alternaria leaf spot caused by Alternaria ricini causes defoliation. Bacterial leaf spot caused by Xanthomonas vignicola occasionally causes serious damage to castor plants.
Botany: Although the genus, *Nicotiana*, contains over 30 species, only two, *Nicotiana tabacum* from which tobacco products for smoking, chewing and snuffing are obtained and *N. rustica* from which nictine acid and ectic acid are extracted for the manufacture of drugs, are under cultivation. *Nicotiana* is a coarse, herbaceous, short-lived perennial cultivated as an annual, with a rosetting growth habit when young, later producing a stout, erect main axis around 1.5 m tall. The root system is made up of a tap root and a dense network of lateral roots. The stems are large, simple, ovate, and commonly pointed with short but somewhat undulate margins. The leaves are in terminal panicles of racemes and each has a short pedicle and is subtended by a bract. The fruit is a two-valved aovoid capsule which is almost completely covered by the calyx. It dehisces longitudinally to release as many as 8,000 minute dark-brown seeds.

Climatic and soil requirements: Tobacco is a warm-season herbaceous crop grown primarily for its leaves. Its seeds require a high temperature (21-30°C) for germination. However, average temperature of about 24°C is optimum for high leaf yield and quality. An annual rainfall of 100-115 cm is necessary for successful production of tobacco. Moisture stress lowers the quality and leads to an undesirable high level of nicotine and to low levels of potassium and soluble carbohydrates, which are essential for superior burning. Tobacco is favored by moderately acidic soils, with a pH ranging from 5.5 to 6.3.

Origin: Cultivated tobacco evolved in Mexico and Central America. It was unknown outside these areas of origin until the voyage of Columbus in 1492. The first production of tobacco in Nigeria was in 1915 when the Department of Agriculture imported some tobacco from Virginia.

Land preparation: Tobacco fields are normally planted with established seedlings, not seeded directly. This makes planting in a nursery a very important agronomic practice.

Nursery: The nursery site is ploughed, raked and sterilized with wood ash or chemical disinfectants. The seeds are mixed with sand or wood ash to allow uniform broadcast. After sowing, the nursery is shaded and watered just sufficiently to moisten the surface. Very heavy watering is a wrong agronomic practice because it encourages damping off disease. The shade is gradually removed as the seedlings
Arable crops

**Transplanting** This is done at 6-8 weeks after sowing in the nursery. At this period, the seedlings are about 15-20 cm high with 4 to 6 leaves.

**Field establishment** For best results and to assist in drainage, transplanting is done on ridges. Initially, these ridges are broad with fairly flat tops to allow for easy percolation during the early rains and with less danger of erosion.

**Planting method** Tobacco is propagated by seeds. Because these seeds are very minute, broadcasting is the planting method often adopted in nurseries. In Nigeria, the first nursery is established in February and transplanting of the seedlings is in April. The second crop is sown in the nursery in May and transplanted in late June or early July. To plant 1 hectare of field will require a nursery area of 4.18 m² and this can be platted completely with 14 grams of seeds. A field distance of 100 cm between rows and 45 cm within the row is ideal for transplanted tobacco.

**Weeding** Weeding is done at the early stages of the crop growth. It should be very deep to avoid damaging the roots. Herbicides are rarely used because of the damaging effects.

**Remoulding the ridges** There is need to remould the ridges so as to ensure that the buried portion of the stem is not exposed.

**Fertilization** Tobacco needs a considerable amount of nutrient in the soil. It is estimated that the average tobacco crop removes

<table>
<thead>
<tr>
<th>Nitrogen (N)</th>
<th>Phosphorus (P₂O₅)</th>
<th>Potassium (K₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 - 100 kg/ha</td>
<td>15 - 30 kg P₂O₅/ha</td>
<td>100 - 160 kg K₂O/ha</td>
</tr>
</tbody>
</table>

Fertilizer application begins from the nursery. In all instances, fertilizers containing chloride are never recommended for the production of tobacco because such fertilizers reduce the leaf quality. Tobacco leaves with high chlorine content have low burning quality and are unacceptable to smokers.

**Topping and suckering** These are two important operations that influence crop yield and quality. Topping is the breaking off of the topmost point with a section of the stem. It is done at the extended flower bud stage. If topping is done at the right stage, leaf weight and size are increased.

Suckering is the removal of suckers in leaf axils. This is normally done at weekly intervals up to the time of harvest.

**Maturity and harvest** The leaves of tobacco are ready for harvest when they turn light green or show light yellow patches. The best test for maturity is to fold the leaves. For a mature leaf, a crease is formed on the line of fold while the immature leaves will crack on folding. Harvesting begins about 30 days from
transplanting and the operation occurs over a range of time. The leaves closest to
the ground are usually the broadest but because of the proximity to the soil surface,
they are easily contaminated with soil or damaged by animals. These leaves are
referred to as "fugs." At the lower side of the stem are the cutters. Next to the
cutters are the laminae that are also of high quality. At the top of the plant are
small and are usually immature at the time of harvest. These are referred to as
"tips." Usually, the lower 3 to 4 leaves are harvested first and this may be
followed by 4-5 subsequent pickings.

Harvested leaves are bulked and left in a shed to complete the yellowing. The
yellowed leaves are threaded onto strings usually of raffia and the two ends
of each string of leaves are tied to two poles spaced some distance apart (Fig. 7.25).

Curing of tobacco: Curing is a process of drying and decomposition of
chlorophyll until the green colour disappears from the leaves. It follows the string
operation. There are three methods of curing: air curing, fire curing and flue
curing.

Air curing: This method adopts a natural process as the strung leaves are hung out
either in corridors of buildings or under roofs or in some form of sheltered areas and
the curing of the leaves is done at ambient temperature. It takes about 6-8 weeks
for complete curing. Cigar tobaccos are air-cured.

Fire curing: The leaves are allowed to yellow and wilt for 3-5 days after stringing
in a grass barn. After that, a slow open fire of hardwood is introduced. The
temperature is maintained at around 90-95°F until yellowing is complete. At that
point, the temperature is increased to 125-130°F. Altogether, fire curing is
completed between 6 and 10 days. Chewing tobacco is fire-cured.

Flue curing: This is usually done in brick barns in which heat from wood, oil, or
gas is supplied in closed flues. Absolute control of temperature and humidity in the
barn is essential. Curing is complete in 5 days. Cigarette tobaccos are flue-cured.

Sun curing: The tobacco leaves are hung vertically, closely spaced in each other
on a trellised arrangement and exposed to direct sunlight.

Yield: In Nigeria, the yields of cured leaves range from 350 to 1500 kg/ha,
depending on the level of husbandry and location.

Utilization: Cured tobacco is transformed into snuff, chewing or smoking
tobacco. The alkaloid, nicotine, is widely used as a contact insecticide in agriculture
and to synthesize nicotine acid, an important constituent of many
vitamin formulations. The health hazards associated with smoking (cancer of the
lungs, respiratory and other cardiac problems) are well known. Nicotine naturally
has narcotic and addictive effects. The narcotic component gives the satisfactory
feeling which habituated smokers appear to have after a few puffs of cigarette while
the addictive properties entice smokers to the habit of smoking and make it
considerably difficult for them to abandon the habit. In spite of these obvious consequences, no government has been able to ban smoking completely. The very large amount of revenue accruing to the state from taxes imposed on the manufacturers and users of tobacco products appears to have satisfied all attempts in this direction.

Major pests
As the leaves are the harvestable parts, insects that damage the leaves cause a reduction in the crop value. The most noxious pests are the hornworms (Protoparce spp.), the tobacco flea beetle (Epitrix parvula), and the cutworms (Agrotis spp.). Sometimes young leaves and terminal buds are attacked and damaged by budworms (Ileilothis spp.). Mole crickets and root-knot nematodes (Meloidogyne spp.) are also major problems in tobacco fields. Under storage, the tobacco moth, Ephestia elutella, can attack and reduce the leaf quality of tobacco. The white fly, Bemisia tabaci, transmits viruses that cause leaf curl and puckering in tobacco.

Major diseases
The diseases of tobacco are numerous but those of economic importance are the wildfire caused by Pseudomonas tabacum, the damping-off disease of tobacco seedlings caused by Corticium solani, and the white mold or mildew caused by Erysiphe cichoracearum. Other diseases include the blue mold caused by Peronospora tabacina and the brown spot caused by Alternaria brassicicola. Mosaic virus is very common on tobacco and it is cosmopolitan. The major symptoms are leaf spotting and scorching and, in some cases, dark green or yellowish mottling. Rosette which causes an abrupt termination of vertical growth and leaf distortions is another virus disease that can attack the tobacco plant. During curing, particularly under excessive moisture conditions, beam rot caused by Rhizopus arrhizus leads to rotting of the tobacco leaves.
Plantation crops

Plantation crops are perennial crops whose produce is processed for industrial use. They may also be used fresh in the form of fruits, nuts, and spices. The crops are left in the field for many years, a condition that makes protection against environmental hazards important.

Specific problems of plantation agriculture in Nigeria

1 Long gestation period: Gestation period refers to the period from planting to harvest. For most plantation crops, this period is above 4 years. Rubber, for instance, has a gestation period of 7 years.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Gestation period (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil palm</td>
<td>4</td>
</tr>
<tr>
<td>Cocoa</td>
<td>6</td>
</tr>
<tr>
<td>Rubber</td>
<td>7</td>
</tr>
<tr>
<td>Coffee</td>
<td>6</td>
</tr>
<tr>
<td>Cashew</td>
<td>6</td>
</tr>
<tr>
<td>Kola</td>
<td>8</td>
</tr>
</tbody>
</table>

2 Long and costly nursery period: All plantation crops are widely spaced in the field. Because of this, they are first grown in nurseries to standard sizes before they are moved into the field. The period required to grow them up to transplanting sizes ranges from 9 to 12 months. This long nursery period makes irrigation indispensable particularly during the dry season. This eventually adds to the production cost.

3 Wide spacing: All tree crops require wide crop spacing and consequently a large area of land. Take oil palm, for instance, that requires 9 m x 9 m, or 9 m triangular spacing; one hectare will accommodate about 142 stands.

3 Labour cost: Farm labour is completely unavailable now compared to the past when youths and women formed the bulk of farm labourers. The unending
increase in minimum wage has also contributed to the tremendous rise in labour cost.

**5. High initial establishment cost.** The initial cost of land preparation and provision of infrastructure is usually high. For instance, it costs more than $2,500.00 to prepare one hectare of field of any plantation crop.

**6. High cost of on-the-farm processing.** Most plantation crops require special machinery for processing the product. 

Cashew is a crop that grows in Nigeria with tremendous potential but receives very little attention. It was introduced around 1945 as an anti-erosion crop. Major plantations have been established in various places, namely Ojo River and Ogbu (Enugu State), Upper Ogun (Osun State), and Wogwa (Taraba State).

### CASHEW

**Botanical name:** Anacardium occidentale  
**Family:** Anacardaceae

It is very little known even though it received very little attention. It was introduced around 1945 as an anti-erosion crop. Major plantations have been established in various places, namely Ojo River and Ogbu (Enugu State), Upper Ogun (Osun State), and Wogwa (Taraba State).

**Types of production**

(a) Plantation/estate production which involved growing of the crop in very large plantations. This accounted for about 350 t/ha before the civil war in Nigeria.

(b) Small holder plantation accounted for 600 t/ha during the same period.

**Anacardaceae.** There are about 60 genera and a total of about 400 species in the family. These are all characterized by the production of resins. Members of this family include:

- **Anacardium occidentale**
- **Hog plum (Spindola mombuho)**

**Botany.** The cashew is an evergreen perennial with an erect stem and symmetrical canopy that is umbrella shaped. It can grow up to 15 m under favourable conditions at an average rate of 1 m/yr. The growth slows down with the initiation of flowering and fruiting. Branching starts very close to the ground with the low branches resting on the ground thus helping to control erosion. The canopy cross section could be as wide as 25 m. The average economic life is finished within 25 to 30 years.

Cashew produces a dense foliage under favourable conditions. The leaves...
are glabrous (shiny), hick, leathery, oblong, and ovate. They are rounded at the apex and range from 10 to 20 cm long and 15 to 20 cm wide. The leaves are simple, entire, and prominently veined. Each leaf has about 20 prominent veins. They are alternately arranged. Young leaves are reddish-brown; turn pale green with maturity and finally dark green at full maturity. Leaves mature within 20 days of formation. Cashew produces an extensive root system. The tap root grows deep into the soil. Lateral roots grow rapidly to form a dense colony and this gives the cashew its erosion control property.

Flower production is at the terminal ends of the new flush. Under favorable conditions, flowering and fruiting occur 2-3 years after planting. The peak production of flowers is attained 2 months after the appearance of the first two flowers. The shape of the inflorescence varies; it may be conical, pyramidal, or irregular. There may be up to 11 branches in each panicle and 40-100 individual flowers on each branch giving a total of about 1,100 flowers in one panicle. The flowers are small, white and scented and the colour turns pink in a few days after opening. On each panicle, pistillate and staminate flowers exist. The terminal flowers are the females while the lateral flowers are the males. The females are those that bear fruits. The males are simply pollinators.

Flushing: Flushing in cashew is a phenomenon by which the plant replaces old leaves with new ones. It is during the flushing process that the main shoot grows. There are about 2-3 flushes in one year. A major flush occurs at the beginning of the rains (March-April) while a minor flush occurs in July. From late October to late November there is another flush which terminates in January.

Pollination and fruit-set: Cross pollination is dominant; insects are the major pollinators. The activities of the insects are more in the morning hours, a period that also coincides with the peak of flower opening in cashew. After fertilization, certain physiological processes are initiated. These usually culminate into the production of fruits. The kidney-shaped nut is the true fruit of the cashew. Attached to this is the swollen juicy pedicel (cashew apple) that is 5-6 times heavier than the nut. Fruit production is not a function of a single factor but rather a function of interactions of a variety of factors - physiological, environmental, genetic, etc.

Hand pollination has given fruit-set as high as 55% of the total perfect flowers formed as against the 38% recorded for natural pollination. Fruit drop is rampant in cashew and this has been reported to be the reason why only 1.7% of the fruit-set attains maturity age. Several reasons ranging from insect attack, hormonal imbalance, nutrient deficiency, water stress to diseases have been highlighted as the causes of the premature fruit drop.

Cashew fruit development: The kidney-shaped nut is the true fruit to which a juicy pedicel is attached. It has a single seed. The shell in the nut has a leathery exocarp, a hard and brittle endocarp and a spongy mesocarp which contains the cashew nut shell liquid (CNSL).
The fruit is ripe for harvest at 65-70 days after the flower is pollinated. The kernel percentage varies from 20 to 30%. Kernel weight varies from 10 to 15 g. Kernel percentage and weight of kernel vary from 50 to 70%.

Climatic and soil requirements

Temperature Any drop in temperature below 7°C will hamper the physical growth of cashew. Hence, wherever the crop is cultivated at high altitudes, it takes a longer time for it to grow and produce. Maximum temperature is never above 40°C. Ideally, cashews grow and produce optimally at a temperature around 28°C.

Daylength There appears to be no real response to daylength. Rather cashew appears to respond more in early rain for flowering.

Cashesh nut shell liquid (CNSL). CNSL is pale yellow to dark brown in colour. It has a very bitter taste and very severe caustic properties. When it is heated, it produces pungent choking fumes. Fresh CNSL contains about 90% by weight of a substance called Anacardic acid—a derivative of phenol compound called oxo-carboxy phenol. The other 10% is cardol—a derivative of resorcin (methyl hydroxyphenol). It is the cardol that has the caustic or blistering effect on the skin.

The cashew apple. The cashew apple is really apple shaped. The ratio of the apple to the nut varies 8:1. The initial colour is purple; later it turns green with maturity and finally red or yellow at full maturity. The apple is juicy, fibrous, thin skinned and easily bruised. When fully ripe, the apple detaches from the tree and drops. This is an advantage for industrial usage. Hence, the ground surface below the tree must be cleaned before the dropping of the apples starts. Consumer preference could be for the yellow or the red. The choking taste of the juice is due to the presence of tannin. Generally, the apple is very high in vitamin C and riboflavin.
Rainfall. Cashew grows vegetatively in the humid areas. It thrives better in a rainfall range between 500 and 4,000 mm/year. Cashew does tolerate drought. Once the tap root can penetrate deep enough, it can do well without extensive rainfall. It suffers drought during the dry season when grown on (a) clayey soil; (b) too small soil volume/plant, and (c) soils of low water holding capacity. Generally dry conditions are needed during flowering, fruiting and harvest of the crop. With excessive precipitation during the ripening period, fermentation of the apple occurs. Heavy and evenly distributed rainfall throughout the year is not recommended for cashew. Under such weather conditions, the crop tends to grow very vegetative and suffer severe flower and premature fruit abortions. The ideal region for large cashew plantation should have 4-6 months of dry season and rainfall between 1,000 and 2,000 mm/year.

Relative humidity. Cashew can withstand long periods of low relative humidity provided the roots penetrated deep. Long dry harsamian wind causes drying and withering of the flowers. High relative humidity, on the other hand, brings about a high pest and pathogenic load on the crop.

Sunshine. Because the crop can adapt to a long dry season with low relative humidity, it is very logical to believe that best performance would be with a high number of hours of sunshine throughout the year. Cloudy weather, especially during flowering and fruiting, is often associated with a low yield because of the high incidence of the panicle withering.

Soil requirements. Cashew tolerates a wide range of tropical soils. Unfortunately, in Nigeria, only the worst soils where no other crop would grow well have been allocated to cashew. In any case, the crop performs best in rich rather than in poor soils. The best soil for the crop would be deep (5-10m) friable loamy soil or well-drained sandy loam that is not alkaline. Gravely soils, as long as they are not compacted, may delay but not impair cashew development. In shallow soils, cashew is likely to compete for water with weeds during the dry season.

Selection. The Cocoa Research Institute of Nigeria (CRIN) is charged with the responsibility of cashew research. Selection for high yields is based on the following parameters:

(a) Ability to fruit early
(b) Nut size
(c) Kernel value
(d) Juice content of the apple
(e) Management

The total nut yield/tree with good environmental conditions and management depends on a number of genetically controlled factors. Among these are:

(a) Tree vigour
(b) The number of panicles/tree
(c) The number of perfect (female) flowers

The total number of nuts/tree with good environmental conditions and management depends on a number of genetically controlled factors. Among these are:

(a) Tree vigour
(b) The number of panicles/tree
(c) The number of perfect (female) flowers
Planfarion crops

(d) percentage fruit set
(e) number of fruits/particle
(f) average weight/particle
(g) percentage premature fruit fall.

Planting materials There are no seed gardens in Nigeria. All planting seeds are obtained from locally available stock. Cashew seeds lose viability in a few months. Thus, seeds for planting should be stored for very brief periods.

Propagation The main process of propagation is by seeds. Vegetative propagation is however possible through cutting, budding, layering (air and ground layering).

Nursery Planting first in a nursery is recommended if large plantations are to be established, otherwise planting straight into the field will be appropriate at the peasant level.

1. Nursery site must be well drained.
2. It must be near a good source of water.
3. It must have a good access road.
4. It must be near the field.

Nursery practice
1. Soak the seeds for planting overnight.
2. Deep in calcium hypochlorite for a few minutes.
3. Plant in long polythene bags with the 3:2:1 soil mixture.
4. Fence round the nursery to keep off rodents.
5. Apply water to the seedlings when necessary.

Field planting
1. Clear the land usually at the end of the rainy season. Do not use a bulldozer to avoid disrupting the topsoil.
2. Leave to dry till February or March. Burn or remove trash.
3. Line the field and peg the planting points using the recommended spacing of 12 m x 12 m.
4. Dig the planting holes 60 cm x 60 cm x 90 cm.
5. Transplant during the rainy season.

Maintenance of the cashew field
1. Weed control For the first 3 years, growth of weeds should be checked either by slashing or by use of mechanical cultivators in between the plant rows. Cover crop could be used to suppress weeds and improve the soil organic matter status. Centrosema, Calapogonium, or Pueraria species will serve as good cover crops. Chemical weed control is also effective.
2. Fire prevention Fire could destroy the entire plantation. So at the beginning of the dry season, a fire check or break around the field is made. The field could also be split into blocks with clean parts separating the blocks.
3. Pest control (a) Grasshoppers attack cashew in large numbers and...
cause severe damage to cashew. Control is by use of any good insecticide. (b) Long horn beetle could cut an entire stem if left unchecked. It is controlled with systemic insecticides such as BHC (50%). (c) Root and stem borers cause very severe gomosis or evisceration of plant sap. Control is by the use of a systemic insecticide, (d) Tea mosquito attacks the leaves during flushing. Any foliar spray could check the insect and (e) The cashew apple beetle bores into the apple. Good sanitation and early spray before the apples are fully formed will check the beetle.

Disease control (a) Twig die-back attack the shoot tip and spread towards the base of the twig. Two pathogens, *Cylindrocladium mangiferae* and *Corticium vellicicolor*, have been incriminated. To control the disease, prune the diseased portion or spray with Dithane. (b) Cashew mildew is a fungus disease. It is controlled by spraying with any sulphur containing fungicide. (c) Damping-off disease is another fungus disease caused by *Phytophthora* *parasitica* or *Pythium species*. It is a disease of cashew seedlings. (d) Anthracnose is caused by the organism *Colletotrichum gloeosporioides*. Infection is brought about by the prior attack of the insect *Helopeltis spp.* on the crop. The control of the disease is by foliar spray with titch. 

Maturity and harvest At planting, the farmer is aware that harvest will be very likely by the fifth year. At the fruits drop at full maturity, they are picked up and de-applied. The nuts are dried on raised slabs. At full drying, the nuts are stored in jute bags in storage without windows to prevent re-absorption of moisture.

Processing Processing demands creating a condition that will influence quick breakage of the nuts without any risk of kernel contamination by the CNSL.

Steps: 
- Rendering the nuts brittle
- Shelling
- Grading
- Packaging

All these steps are possible manually. However, machines have been designed to handle most of the operations.

Procedure 
1. Soak the nut for twenty-four hours and roast to extract the CNSL. By roasting, heat is applied to the cashew nut in order to release the CNSL and render the shell brittle and easy to crack. This is achieved by, dipping the water soaked nuts into baths containing olive or peanut oil for 60 minutes at a temperature of 185°C. This causes the CNSL in the nut to be released. When the nuts are finally removed from the bath after one hour, they are CNSL free and are brittle and easy to crack. At this point, the cracking is done manually or mechanically using crackers and the kernel is separated from the shell. The clean kernels are dried for 15-20 minutes at a temperature of 150 - 180°C. This helps to remove the adhering testa. The kernels are roasted in hot oil for about 10 minutes.
salted and allowed to absorb a little moisture. They are finally graded and packaged.

Utilization The cashew nut shell liquid is used in the manufacture of ink and paints. It serves as a disinfectant and as an additive in the manufacture of lubricants.

Roasted kernels are sold for cash in most local markets as confectioneries. The kernels contain about 5% water, 20% proteins, 45% fats, 1.5% fibre, 2.5% minerals, and 25% carbohydrates.

The yellow gum that exudes from the bark of the tree after a machete cut is used as an adhesive. The cashew apple juice can be fermented and processed into wine.

Latex producing crops

Rubber is a constituent of latex, the milky juice obtained from the tree. The para rubber *Hevea brasiliensis* is an important latex producing plant and because of its singular ability to renew its bark after tapping, it permits repeated sustained harvests. The other latex producing plants lack this ability. Other latex producing plants:

(a) *Castilla elastica* (Family: Moraceae) The plant is closely related to the African breadfruit. The tree produces the Castilla rubber. It matures earlier and yields less latex than the para rubber. The latex is produced in tubes.

(b) *Manihot glaziovii* (Family: Euphorbiaceae) The plant is closely related to cassava. It produces the CAERA rubber. The latex is contained in the fleshy roots. The plant is killed in the course of harvesting the latex.

(c) *Ficus elastica* (Family: Moraceae) The plant produces the Indian rubber. The latex occurs in tubes. Injury made during harvest hardly heals and sometimes the plant dies.

(d) *Funtumia elastica* (Family: Apocynaceae) The plant produces the Lagos rubber and the latex occurs in tubes. In Cameroon, Funtumia elastica is still tapped.

(e) *Parthenium argentatum* (Family: Compositae) The plant produces the Guayule rubber. It is low growing, highly branched and the latex is contained in globules in different cells. Harvesting often leads to the death of the plant.

<table>
<thead>
<tr>
<th>Latex producing plants</th>
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<tbody>
<tr>
<td><strong>(a)</strong> <em>Castilla elastica</em> (Family: Moraceae)</td>
</tr>
<tr>
<td><strong>(b)</strong> <em>Manihot glaziovii</em> (Family: Euphorbiaceae)</td>
</tr>
<tr>
<td><strong>(c)</strong> <em>Ficus elastica</em> (Family: Moraceae)</td>
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<tr>
<td><strong>(d)</strong> <em>Funtumia elastica</em> (Family: Apocynaceae)</td>
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<tr>
<td><strong>(e)</strong> <em>Parthenium argentatum</em> (Family: Compositae)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>PARA RUBBER</th>
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<tbody>
<tr>
<td>Family: Euphorbiaceae</td>
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<tr>
<td>Botanical name: <em>Hevea brasiliensis</em></td>
</tr>
</tbody>
</table>

Botany The tree has a smooth trunk and rather slender branches. It can attain
Platation crops

a height of 20-30m if the growth is uninterrupted. The plant has a well-developed
tap root and lateral root system. The leaves are trifoliate and are spirally arranged
on the main stem and branches. The inflorescence is a panicle consisting of the
female flowers on the upper portion and the male flowers at the basal portion. The
fruit is a large, three-lobed and dehiscent capsule usually endowed with three seeds
that are mottled.

Origin Para rubber originated in the main forests of South America around the
basin of the Amazon River.

Varieties/clones grown in Nigeria

(a) Unselected seedlings - growth and yield vary considerably.
(b) RRIM 600- High yielding, good girth increment, good bark renewal and
average vigour; latex yield: 1651 kg/ha/yr.
(c) RRIM 501- High yielding and vigorous, average bark renewal and girth
increment, latex yield: 1626 kg/ha/yr.
(d) Nig. 800- Low branching, heavy canopy and fairly resistant to wind
damage; latex yield: 1679 kg/ha/yr.

Climatic and soil requirements. In regions where the dry season exceeds
3 months, rubber production may not be successful. An annual rainfall in the range
of 2,000 - 3,500 mm is ideal for the crop. The temperature for optimal growth and
latex yield is 24 to 32°C. The crop does well in deep, well-drained, non-
concretionary and permeable soil with a pH of about 5 - 6.

Nursery practice. Seeds selected from high yielding clones are planted in a
polythene bag (polybag) or ground nursery. This allows for proper maintenance
of the young seedlings before they are due for either transplanting or for bud-
grafting. The seedlings for transplanting are due when they are 2.5 - 3.0 m in
height. Budding is done when the seedlings are about 2.5 cm in diameter and this
is expected at about one year after seeding.

Propagation. The para rubber is propagated either by sexual (seed) or by asexual
(vegetative) means. Propagation by cuttings and marcotting is unsuitable because
trees arising from such materials lack a functional tap root system and are therefore
very vulnerable to wind damage.

Vegetative propagation. The para rubber is propagated vegetatively by bud-
grafting. Through this process, more uniform stands are produced. Bud-wood is
normally collected from trees that are cut back annually. Such trees are proven
superior clones and are resistant to some local diseases. Bud-grafting in rubber can
take any of the following forms: brown-budding or green-budding. Both forms are
similar except that green-budding is done earlier on younger stock seedling while
the bark of the seedling is still green. Transparent tapes are used to bind the graft
as the stem and the graft tissues produce substantial photosynthates required for
the growth of the bud in the young grafting. Brown budding is done when both the
stock seedling and bud wood have developed brown barks; the stock has accumu-
Plantation crops 9 5

In practice, the first step in budding is the collection of a twig containing at least one bud from a high-yielding clone. A piece consisting of the bark strip, the bud and a thin shaving of the wood is sliced out from the twig. The second step is to make a cut on the stock seedling. While the panel of the bark is removed to expose the stock cambial surface, the flap of the bark is left attached to hold the graft after budding. The third step is the insertion of the bark strip containing the bud (scion) into the cut on the stock seedling. The flap of bark on the stock is tied back in position over the bud after the insertion. After about 21 days the cambial layers of both the scion and stock unite. The stock shoot is pinched off leaving a sloping surface. This is important as it breaks all forms of apical dominance and allows the young bud to grow into a new shoot. The severed surface is painted; the budded plant is staked, and unwanted offshoots from the stock are continuously removed.

Transplanting Bud-grafted seedlings are transplanted when 2 or 3 whorls of leaves have been produced on the budshoot. By this time, the shoot has developed some level of apical dominance that can suppress further offshoots from the stock. Transplanting is done as from mid-June to July in Nigeria at a spacing of 6.5 m between rows and 2.5 m within the row. Holes measuring 45 cm x 45 cm x 45 cm are dug and the dug-up soil is exposed for 2 weeks before backfilling. Spacing has important effects on girth increment, thickness and quality of the removed bark. Closer spacings suppress branching and reduce the incidence of wind damage.

Land preparation The establishment area is cleared of undergrowth; the trees are felled and burnt when dry. The planting lines are neatly cleared and planting holes are dug.

Weed control Weeding is more important when the trees are young. Sodium arsenite sprayed along the rows is very effective for weed control in rubber plantations. Cover crops such as Pueraria phaseoloides, Calopogonium mucunoides and Centrosema pubescens control weeds and add nitrogen through fixation. In addition to the maintenance of the established ground cover, the rubber trees are ring-weeded. This involves clean weeding on area 100 cm in diameter around each tree for purposes of reducing competition for moisture, preventing twining of creeping cover crops, and reducing hazards of fire damage.

Fertilization Nitrogen is very essential during the establishment stage of rubber. Both urea and ammonium sulphate can adequately serve as nitrogen sources. Phosphate fertilizers are applied mostly at the early growth stage and reduced as soon as tapping commences. Potassium and magnesium are important in soils where the elements are deficient. Calcium nutrition is not encouraged because it has a yield-depressing effect. On the average, rubber requires 160 kg N, 13 kg P and 55 kg K per hectare.
Planlation crops

Tapping

Tapping is defined as controlled wounding whereby thin shavings of the bark are removed at regular intervals from the lower surface of the groove made into the bark at a depth of about 1 mm from the cambium. This exercise opens up the latex vessels blocked by plugs of coagulated latex and so permits the free flow of latex from the vessels.

The first step in tapping is "OPENING" often defined as the process of preparing the mature rubber tree for tapping. The tree is mature when 70% of the plantation satisfy the "opening" criteria as described below:

(a) For the seedling trees, 70% of the plant population has reached a diameter of 11-25 cm at a height of 135 cm above ground level.
(b) For bud-grafted trees, 70% of the population has reached a diameter of 16-20 cm at a height of 150 cm above ground level.

Once these criteria are met, the tapper makes a tapping cut with a special tapping knife (lobong knife) (Fig. 8.1). Because the latex vessels are spirally inclined in one direction, the slope of cut is from high left to low right. The slope is 30° from the horizontal. The shavings of the bark removed during tapping are only thick enough to open up all the latex vessels along the cut. Unnecessary thick shavings waste the bark reserve. The depth of tapping is another crucial matter in any tapping operation. Too deep a cut would damage the cambium that generates the bark while shallower cuts open up few latex vessels resulting in a low latex yield. This special demand has, over the years, made mechanization of the tapping process impossible and the skill of the tapper an important asset that the rubber farmer cannot compromise.

Tapping system/intensity

If the rubber tree is tapped with the hope of extracting all the latex in a very short period, the tree will be killed. Every farmer aims at maximum exploitation but not at the risk of losing the tree. This makes the knowledge of tapping intensity an important managerial component in the rubber industry.

Different tapping systems give different tapping intensities. The most widely used tapping system is the "half spiral alternate daily" (s/2, d/2). In this system, the tree is divided into two half circumference panels. In one cycle of tapping, only one-half is tapped every other day and as soon as this first half is exhausted, the tapper moves to the other side, thus allowing the first half some time to regenerate a fresh bark for future tapping. This system gives 100% tapping intensity. The first panel is normally exhausted in 5 years.

Full spiral, daily tapping (s, d) gives 400% tapping intensity and full spiral alternate daily tapping (s/2, d/2) gives 200% tapping intensity and so on.

Fitting the latex collection equipment

Having made the tapping panel, a metal spout is pressed carefully into the bark of the tree at a point 7.5 cm below the cut. The metal spout is not allowed to reach the wood so as not to damage the cambium whose primary function is the regeneration of the bark. The spout directs
the latex into the collection cup affixed, with a loose wire, to a point below the cut. As a matter of routine, a small amount of dilute solution of ammonia (anti-coagulant) is put into the cup before tapping starts. This solution prevents the latex from coagulating in the cup.

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**Time of tapping**

Because the turgor of the rubber trunk is reduced with a rise in the day temperature following water loss by transpiration, the latex yield falls rapidly from the morning hours towards midday. As a result, the tapper starts tapping very early in the morning (around 5 am) and ends around 9 am local time.

**Yield**

Latex yield depends on the variety, soil and prevailing weather conditions. On the average, yield is usually less than 1 tonne/ha of dry rubber. Improved clones with yield potentials of about 2-5 tonnes/ha of dry matter are available.

**Yield stimulation**

Stimulation as practised in the rubber industry is defined as the process of increasing latex yield with the application of growth regulating compounds or with any treatment that can cause an increase in the naturally occurring growth regulating compounds in the tree. Through this artificial means, latex yield can be increased, on the average, by 25 per cent. Most yield stimulating substances are hormones. The commonest growth regulating substances used for yield stimulation in rubber are 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). Both compounds are herbicides. Their applications are normally through a carrier or medium of transmission. The readily available “carrier” is palm oil. The hormone is thoroughly mixed into the carrier before application.

**Processing**

Processing of latex involves the removal of water, dirt and other foreign materials from the latex and the production of a standard marketable material that can be conveniently handled. Rubber is processed into any of the following:

(a) Concentrated latex
(b) Sheet rubber (ribbed smoked sheet)
Plantation crops

(c) Crepe rubber
(d) Crumb.

The choice of any of these depends on the quality of rubber expected, the storage and shipping facilities available. In Nigeria, most of the rubber produced is processed into crepe and crumb, and a very little amount into ribbed smoked sheet and concentrated latex.

Major pests

There are no major pests of rubber. In young plantations, termites, rats and squirrels may cause damage on the bark. Older trees are less vulnerable to the pests.

Major diseases

Root rot disease of rubber

Causal agents: (Fungi).

*Fomes lignosus* causes the white root rot.
*Fomes noxius* causes the brown root rot.
*Ganoderma pseudoferrugineum* causes the red root rot.
*Ustulina zonata* causes the dry root and stem rot.

Symptoms:

**White root rot** Characteristic wilting of the foliage of the tree as a whole. Rapid yellowing of the leaves and finally death of the plant. In some cases the tree may fall over while the foliage is still green.

**Brown root rot** Wilting, yellowing and death of the tree as in the case of the white root rot.

**Red root rot** Symptoms of attack are not very noticeable unless the roots are dug up and inspected. Infected roots are covered with a red mycelium with some soil adhering to it. The rotten portions of the root are brown and hard at first, later becoming lighter and spongy.

**Dry root rot** Presence of dry rotten wood, permeated by double irregular black lines. The rotten wood is whitish in colour, firm and dry in texture. A flat plate-like formation closely adhering to the bark of the tree.

Control Similar control measures are adopted for the white root rot, the brown root rot and the red root rot diseases. Exposure of the disease organism destroys it. Thus regular inspection by excavation of the lateral root and the collar of the tree will provide a cheap means of control through exposure. Infected lateral roots are cut off the tree and burnt. Collar protectant fungicide such as Formac 2 is effective in the control of the *F. lignosus*.

For the dry root rot, the boles of the trees are cleared occasionally of all scrap rubber that causes fermentation and consequently death of the underlying bark through which the fungus penetrates the tree.
**Plantation crops**

**Black stripe disease** This is also called the black thread disease. It affects the young cells near the cambium that are exposed by tapping.

*Causal agent:* *Phytophthora palmivora* (fungus).

**Symptoms:**
Vertical black lines appear on the tapping panel immediately above the cut. Affected region assumes a greyish colour. Finally, the bark separates, cracks and becomes covered with a whitish bloom of filaments of secondary invaders.

**Control:**
Less susceptible clones like PB 86, War 4, Tjir 1 are planted. Avoiding opening panels in the rainy season. Bi-weekly application of non-drying fungicidal panel dressing.

**Mouldy rot disease** This is another disease of the tapping panel caused by *Ceratocystis fimbriata*. The disease first appears as dark depressed spots on the tapping panel. When the spots coalesce they form a continuous sunken band parallel to the cut. The pathogenic organisms flourish when the rainfall and relative humidity are high. Hence the best control measure is to remove undergrowth and maintain the correct plant spacing during planting. This ensures free air circulation and prevents a build-up of humidity. Cessation of tapping when disease is active is also helpful in controlling its spread.

**Pink disease** This is a disease of the young branches. It is caused by *Corticium salmonicolon*. The first symptoms appear in the form of pink coloured encrustation on the bark. This quickly girdles the attacked branch. The bark dries up and cracks and the latex exudes from the wound. Infected portions are scraped off and sprayed with 5% solution of *Fylomac 90* or *Izal*.

**Bird’s eye leaf spot disease** This is a leaf disease caused by *Helminthosporium heveae*. It attacks plants in the nursery, bringing about general weakening and defoliation thereby delaying seedlings from reaching the correct transplanting or budding height. The control is by spraying weekly with *Dithane* at the rate of 2 kg in 100 litres of water.

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**Plantain and Banana**

Family: Musaceae

Botanical name: *Musa* spp.

**Botany** Plantains and bananas are large rhizomatous plants that survive vegetatively by means of suckers. They are giant herbs with juicy and non-woody aerial stem. The aerial stem consist of the pseudostem characterized with...
Plantation crops

overlapping leaf bases that are tightly rolled round each other. Whereas bananas, produce relatively sweet fruits that are eaten raw, the plantains produce starchier fruits that are usually eaten cooked. The main feature of the plant is the short basal underground stem called the corm. Numerous adventitious roots emerge from the corm, most of which grow horizontally at a depth of about 0.15 cm. Because of this shallow rooting the plant is never properly anchored and hence requires support during fruit bearing (peppering). The growing tip of the corm (meristem) continuously forms new leaves and later becomes the inflorescence. At the top of the inflorescence are the main flowers that are however non-functional. The fruits simply develop parthenocarpically from the ovaries of the female flowers. The inflorescence is harvested as a 'bunch'. Each 'bunch' consists of many 'hands' and each 'hand' is a cluster of 'fingers' (individual fruits). The fruit is botanically described as a berry.

The corm produces many branches referred to as suckers and the entire unit is collectively known as the mat or stool. Young suckers have narrow, lanceolate leaves called scales as different from the large foliage leaves. Suckers are of three types namely: pepper (a sucker emerging from the soil), sword sucker (a large sucker with lanceolate leaves and usually the best conventional planting material); and maiden sucker (a large sucker with foliage leaves).

Species

1. *Musa acuminata* This exists as a diploid, 2n = 22, with the genomic formula AA. The autotriploid (2n = 33) type with the formula AAA is named *Musa sapientum*. The 'Gros Michel' and the Cavendish pre AAA clones. They produce fruits that are edible and are usually eaten raw. They are generally called the bananas.

2. *M. balbisiana* is also diploid but with the genomic formula BB. The fruits are not edible. However, natural crosses between it and *M. acuminata* have resulted in the progenies AAB (the plantains) and ABB (the cooking bananas) that have edible fruits.

Propagation Plantains and bananas are only propagated asexually by means of suckers or bits. Suckers are planting sets that develop from buds on the short underground stem (corm) while the bits are large corms which have been dug up and divided into small pieces with at least one "eye" on each segment. Suckers are separated from their mother plants with a spade. The corm is carefully peeled and the pseudostem is cut a few centimetres away from the corm. The prepared suckers are planted not later than one week after preparation. The 'bits' are pieces of a chopped corm with good regeneration potentials.

Origin Asia.

Climatic and soil requirements Plantain cultivation is impossible if land becomes flooded from time to time. The crop requires a hot and humid environment. An annual rainfall of not less than 1,200mm that is evenly distributed.
throughout the year is ideal. Irrigated plantains are possible but the cost is usually prohibitive except when large scale production is targeted. An air temperature of about 30°C is suitable for a good crop of plantain.

**Plantain varieties** All plantains grown in Nigeria are triploids arising from the cross between *Musa balbisiana* and *M. acumunata*. There are three main types, namely, Popenich plantain, Horn plantain, and Falsehorn plantain.

**French plantain** — Male flowers persist throughout the life of the fruit; bears heavy bunches (11 -13 kg); large number of hands and fingers per bunch. It takes about 500 days from planting to maturity, the peak of harvest period is November to February.

**Horn plantain** — Male flowers degenerate and fall off during fruit growth and development; bear moderate sized bunches (6-9 kg). Small number of hands and fingers per bunch; individual fingers are long and horn-like; it takes about 400-500 days from planting to maturity.

**Falsehorn plantain** — Male flowers degenerate and fall off during fruit maturity; bunch size vary greatly (2-8 kg); with 16 to 22 fingers; it takes 300 to 450 days from planting to maturity.

**Banana varieties** Two main types, Gros Michel and Cavendish, are grown in Nigeria.

**Gros Michel** — Vigorous growing plant; male flowers degenerate and drop; fruits are slender and markedly curved.

**Cavendish** — Shorter than Gros Michel; bracts and male flowers persist; fruits are short and robust.

**Land preparation** The field is prepared with minimum disturbance to the soil (no tillage). The area is cleared of bushes and the thrash is allowed to dry before it is removed or burnt.

**Planting date** Plantain is planted in April or May in southern Nigeria. Delay is allowed as long as the young plant is not exposed to stress within 3 to 4 months after planting. Two months after planting, the plantation is inspected and all dead stands are replanted (supplying).

**Planting depth** The suckers are planted at a shallow depth. Planting holes are dug to measure 30 cm x 30 cm x 30 cm. Each sucker is placed in the hole and its corm is covered first with top soil and then with the bottom soil.

**Fertilization** Plantains and bananas require N, P, K, Mg and Zn for optimum growth and yield. Because N and K are easily leached, the elements are applied split during the growing season. In deficient soils, each stand needs 1 - 1.2 kg of ammonium sulphate of ammonia, 1.25 - 1.5 kg of muriate of potash and 300 g of single superphosphate. Micro-nutrient elements such as zinc are in some instances applied as foliar sprays. Organic matter is highly important and if household wastes are available, farmers are encouraged to deposit such wastes in the plantain field.
Mulching Mulching is essential especially during the critical active growth period when adequate moisture is needed to maintain leaf production rate of 4 to 5 per month. Mulching helps to keep the soil cool and conserve moisture for the shallow roots.

Weeding Until the canopy covers, weed control is important. Severe competition with weeds will lead to the early decline of the plantation and delayed harvest. Desuckering It is a good agronomic practice to allow the main ratoon crop to grow alone or with at most two 'followers'. Suckers which develop after the followers are removed with a specially designed gauge.

Propping Plantain is a shallow rooter and the heavy weight of the bunch tends to bend the plant. Both factors can cause tip-overs (the entire corm with roots come out of the ground); snap-off (corm breaks leaving a part in the ground); or doubling (pseudostem breaks). Strong winds can also cause doubling. For these reasons, bearing plantain and banana need support with strong bamboo stakes of about 1.5 to 2.5 m length. The process of providing such support is referred to as propping. The bamboo props are crossed to form a fork-like structure that is finally tied together and placed underneath the bunch.

Maturity The major indication of maturity is the yellowing of 1 or 2 finger tips of the first hand. Generally, bunches that are 3 to 4 months old are due for harvest.

Harvesting The bearing plant is cut and the bunch is harvested. Bunches are never allowed to drop forcefully on the ground when the main plant is cut. After the plant has been harvested, the mother plant is completely removed and the suckers are thinned. Although all suckers are potential mother plants, it is advisable to select only one (the ratoon) to continue the next cycle of production. The second harvest from the plantain mat is called the first ratoon crop and the third harvest is the second ratoon crop and so on.

Yield The yield differs with variety and the agronomic care given to the plant. Assuming that elite clones are used and the recommended care is maintained, the following yields may be expected:

- Falsehorn plantain - 20 tonnes/ha
- French plantain - 19 tonnes/ha
- Horn plantain - 16 tonnes/ha.

Storage A mature plantain bunch ripens in one week. For longer shelf life the fingers must be processed into chips.

Utilization The fruits are eaten as they are among the most nutritious of Nigerian fruits. The bananas are eaten raw while the plantains and cooking bananas are made into chips or fried ripe in oil.
Major pests

Nematodes
Nematodes have been reported to attack and damage roots of plantain. They weaken the plant and cause a reduction in yield. Infected plants may tip over when there is a strong wind. Nematodes are controlled by applying nematicide in a circle, 25 cm around the plant.

Stem borer (Cosmopolites sordidus)
The organism lays its eggs near the corncob of the main plant. The larvae attack the underground part of the plant. They feed and bore channels within the corncob. Consequently, the plant is weakened and may tip over.

Stem borers are controlled by leaving the land under fallow or by the use of systemic insecticides such as Paradane.

Major diseases

Black sigatoka
The black sigatoka disease is a leaf spot disease caused by the fungus Mycosphaerella fijiensis. All plantain cultivars, with the exception of the recently bred resistant genotypes, are susceptible to the disease. Leaves first show yellow spots, turn black and eventually become necrotic. Photosynthesis is impaired and small plantain bunches are produced.

The control is by foliar spray with any Benomyl fungicide or soil application of triadimefon or triadimenol.

COCOA

Family: Sterculiaceae
Botanical name: Theobroma cacao

Botany
The cocoa tree attains a height of about 4.5 to 8 m in diameter. It produces a central tap root system supplemented with branch roots that ramify the top 10 cm of the soil surface. The main stem of a young cocoa plant produces the first set of branches, 3 to 5 in number (Fan branch or jorquette), at about 90 to 120 cm above ground level. Further increase in height is by the formation of a side shoot (chupon) below the "fan" branches. At about 1 metre height the chupon forms a new main branch and another set of "fan" branches. This sequence of growth continues until 4 or more series of chupons and "fan" branches are produced. Usually, first and second layers are pruned and the main trunk and the "fan" branches of the lower storey increase in girth to form the main fruit bearing structures. Cocoa leaves are dark green, alternate, entire and oblong with strong midrib. The flowers are small, pinkish white and are borne on small pedicels in little clusters on the bark of the trunk and main branches at points where leaves formerly existed. The points are often referred to as cushions and the term...
carnivorous flowering is used to describe the production of flowers on the trunk and main branches of the tree. The fruit commonly referred to as a pod is botanically a berry. Each pod contains 20 to 40 seeds that are embedded in a mass of white, pinkish or brownish pulp. The pods are described with the colour, nature of the surface, the apical bottleneck, and the pod L/b ratio.

**Colour** When young, cocoa pods are green, light green or red in colour. In some instances, pods may have splashes of red on a green or white background. Green pods turn yellow while the red pods turn orange with ripening.

**Nature of pod surface** Pod surface may be smooth or warty; it may be expressed in deep ridges and furrows.

**Bottleneck** This is the constitution on the stalk end of the pod. It is either present or absent and where it is present it may be clearly visible or inconspicuous.

**Apex** The pod apex may be long and sharp or totally blunt.

**Pod L/b ratio** This is the ratio of the pod length and breadth. A pod with a high L/b ratio has a higher yield index.

**Origin** Cocoa is native to the New World. It is believed that the original home is the tropical forests east of the South American Andes near the source of the Amazon River.

**Climatic and soil requirements** Cocoa is a crop of the humid tropics. It performs best under conditions of little or no dry season. The actual rainfall ranges from 1,250 mm to 3,750 mm. The temperature range for cocoa is 21°C to 30°C. Above the latter, leaf development is greatly impaired. The soils of cocoa in West Africa are essentially the inland latosols. The oxisols are not usually fertile enough due to constant leaching. Suitable soils have adequate moisture retainer capacity; they are friable, permitting easy penetration of the lateral roots.

**Classification** Two races of cocoa, *Criollo* and *Forastero*, are recognized.

**Criollo** The criollo produces fruits that are either red or yellow in colour when ripe, range to warty and usually conspicuously ten-furrowed. The fruit has a distinct bottleneck and a conspicuous point. The fruit wall is thin and easy to cut. The seeds are plump with white or pale violet cotyledons. There are two types of criollo, namely, Central American criollo and South American criollo.

**Forastero** The forastero is classified into the Amazonian forastero and the Trinitario. The Amazonian forastero has green fruits that ripen into yellow at maturity. Fruits are furrowed, not warty, round-ended and generally oval-shaped. The fruit wall is thick and the seeds are flattened with dark purple colour. Trinitario is a hybrid of forastero and criollo. The fruit is red or purple when ripe.

**Varieties grown in Nigeria**

**Amelonado** The amelonado supplies about 90% of all processed cocoa beans in Nigeria. It was introduced into Nigeria in the 19th century. The variety has a
Plantation crops

**Plantation crops** mild flavour which is particularly suitable for the manufacture of chocolate.

F. Amazon The F₃ Amazon is a more vigorous tree with very high yield potentials. It starts bearing fruits 2 to 3 years earlier than Amelonado. It is, however, more susceptible to the black pod disease.

S. Varieties (Series 1 varieties) S₁ varieties are progenies from crosses between upper Amazon genotypes. They are as good as the F₃ Amazon.

S₂ Varieties These are progenies from upper Amazon selections crossed with Trinitario or Amelonado selections. They outyield the F₃ Amazon.

**Selection criteria**
1. number of pods/tree
2. number of beans/pod
3. bean weight
4. yield

**Planting method** In most cases, cocoa seeds are planted first in a nursery. This provides insurance against germination failures and all forms of damage to young seedlings.

**Nursery practice**
- The nursery site is usually located near an all-season source of water. The ground is cleared of all weeds and levelled. Beds, 1.8 m wide and 1.5 m long, are made. Shade of bamboo poles and palm fronds is raised over each bed.
- Nursery pots or polythene bags filled with well-sieved forest topsoil are arranged on the beds before seeds are sown.
- Cocoa beans are sown on their sides either in the morning or in the evening and watered thoroughly. Germination occurs within two to three weeks. The seeds are sown at any time of the year whenever ripe pods are available.

**Management of shade** Artificial shade is adjusted as required. Cocoa seedlings need gradual hardening off, hence the shade is reduced as the seedlings age. Sometimes this is automated as the palm fronds dry up with the onset of the dry season.

**Transplanting** Transplanting is done during the rainy season. The best time for transplanting is late May or early June. It is best when the seedlings are about 5 or 6 months old. The polythene bags are carefully removed before transplanting. The soil with the roots is then lowered into the planting hole and earth is packed firmly around it.

**Establishment** The establishment area or the field where the seedlings are to be transplanted must be ready before the seedlings are due for transplanting.

**Clear felling** This is rather unpopular among cocoa farmers. The undergrowth and small trees are cleared and the large trees are felled and cut into logs. Consequently, shade and weed problems and possible degradation of the exposed...
topsoil becomes apparent. The only process of restoring shade to such a plantation is through planting of temporary shade trees. In spite of these drawbacks, the method lends itself to possible future mechanization, more uniform growth, simplified shade control, and reduced incidence of damage by branches from forest trees.

Selective thinning

Some deep-rooted forest trees are left deliberately in the establishment area during land preparation to provide overhead shade. Such trees must be compatible with cocoa trees. Trees with dense foliage and liable to trip-over or break with the slightest storm are unsuitable. Those with well-spread canopy are desirable. Forest trees such as silk cotton or *Caesalpinia coriaria* are undesirable and are eliminated either by felling or poisoning. Selective thinning is the cheapest, easiest and the most successful method of establishment of companion trees.

Planting temporary shade

Where tree population distribution does not meet the shade requirement, it is necessary to plant quick growing nurse shade trees. Also where there is clear felling the practice of planting temporary shade trees cannot be compromised.

Ideally, it is better to plant temporary shade trees about one year before the cocoa seedlings are transplanted. The essence is to ensure that the shade plants would be able to furnish adequate overhead shade. Nurse shade trees include banana, plantain, tree cassava, pawpaw, pigeon pea and Glycine. Ideal shade plants establish easily; provide shade within the shortest possible time; compete minimally with the cocoa for water and nutrients; are not alternate hosts to pests and diseases; easy to remove when they are no longer needed and possess some economic value.

To ensure that the cocoa tree and nurse-shade plants are in straight lines, the establishment area is lined and pegged prior to planting. It is usual to work from the baseline along one side. A planting hole of 30 cm x 30 cm x 30 cm is considered satisfactory. Plant spacing depends on the variety. While a spacing of 3.4 m x 3.4 m is recommended for Amelonado, the F, Amazon is planted at a spacing of 3 m x 3 m. Recently, a high density planting of 1.5 m x 1.5 m has been proved to outyield the usual 3 m x 3 m spacing of the F, Amazon.

**Planting date** The seeds are sown when available. The best time for sowing is December or January. As the nursery takes 5 to 6 months the transplanting time will coincide with the rainy period. Transplanting starts as soon as the rains become steady. This ranges from April in the Ikom and Obubra areas to late May or early June in the western states of Nigeria.

**Weed control** At the juvenile stage, weed control is necessary. Once the plants are fully grown, the dense foliage helps to suppress weeds. The use of mulch and cover crops such as *Calopogonium* and *Pueraria* suppress weeds and reduce soil...
Plantage crops

Fertilization The heterogeneous nature of the soils and the variations in the varieties planted tend to create some problems in producing a useful fertilization programme for the production of cocoa. On fertile soils, fertilizers are very useful in long-term weed control.

Herbicides like simazine and diuron are very useful in long-term weed control. Generally, nitrogen, phosphorus, potassium, and magnesium have been recognized as important nutrients in cocoa production. Nitrogen fertilizers are indispensable when cocoa is grown without shade. Cocoa has been shown to respond to the application of 110 - 180 kg N/ha, 35 - 70 kg P2O5/ha and 100 - 120 kg K2O/ha.

Pruning Pruning is not mandatory in cocoa farms. The major reasons for pruning are to restrict growth of the plant to the first and second bunches and encourage the development of a spreading type of canopy. Pruning is usually done by experienced cocoa farmers.

Yield The yield is the weight of the properly dried beans obtained from a cocoa plantation in one hectare in a year. Yields in West Africa range from 250 to 1500 kg of dry beans per hectare. Higher yields can be realized with a sound fertilizer programme.

Processing

Breaking of pods After harvesting, the next stage is the breaking of the pods which is done without any damage to the beans inside. This is done by knocking the pod against a concrete object. The beans are extracted from the pods carefully.

Fermentation During fermentation, the mucilaginous fruit pulp is destroyed to free the beans; the heat generated (42-48°C) kills the embryo, prevents further germination and initiates the development of the chocolate flavour.

The wet beans are fermented with any of these three methods: the sweet box method, heap fermentation, and bag fermentation.

Breaking of pods/Use of sweet boxes The sweet boxes have shallow depths that do not exceed 90 cm. They may be of any length and breadth but are generally 120 cm x 90 cm. The boxes are perforated at the bottom to encourage free drainage. Three such boxes are required, one placed on top of the other. They are kept on a concrete platform. The beans are first placed in the box at the top and covered with banana leaves and are weighted down by blocks to consolidate them and facilitate drainage. After 48 hours, the beans are turned into the middle box. Fermentation starts after about 95 hours. Finally, the beans are turned into the bottom box then where they are removed on the seventh day to a drying slab. Turning and mixing are common features of this method, the reason is to ensure even fermentation.
2. **Heap fermentation.** This is commonly practised by local farmers in Nigeria. The beans are heaped in an enclosure roughly 1.2 m x 1.2 m or 60 cm x 60 cm with a height of 30 - 45 cm. The floor is first lined with pieces of sticks to allow drainage. Banana leaves are placed on the sticks and are used to envelop the beans. The heap is weighted down with bags to facilitate drainage. After three turnings, the beans are removed and drying starts on the seventh day.

3. **Tray fermentation.** The tray has a dimension of 1.2 m x 90 cm x 10 cm. It has a slatted split-cane bottom and is usually partitioned into two equal sections. A perforated wooden platform of equal dimension with the tray is first placed on the floor and a tray filled with the wet cocoa beans is placed on the platform. A second tray is similarly filled and placed on the first one. Other trays are so placed, one on top of the other, until the required number has been filled. The entire set-up is covered from top to bottom with a sack. No turning or mixing is done and the beans become fully fermented in 2-3 days. Drying commences on the third day.

7. **Testing for dryness.** The moisture content for dry cocoa beans is 6.8%. The simplest and the more practical method of testing for dryness is to take a handful of beans and press them together. If the beans crackle, the sample is dry. Another check is to cut through the bean with a sharp knife and if the cotyledons separate easily, the bean is dry. Cocoa beans also show the chocolate colour when they are sufficiently dry.

**Sorting** Dried beans are sorted to remove dirt, loose particles of seed coat, and broken beans. The good beans are bagged and later graded.

**Utilization** The main constituents of the cocoa beans are starch, sugars, cocoa fibre, essential oils, and cocoa butter. The fat-free fibre contains about 3% theobromine which can be converted into caffeine. Cocoa butter is a high grade vegetable fat. Chocolate is made by mixing cocoa mass (roasted and ground cocoa kernel), sugar, and cocoa butter. Other products include the various cocoa drinks such as Ovaltine, Bearnsita, Milo, etc.

**Major pests**

Capsids are the most serious pests of cocoa in West Africa. They kill young plants and cause considerable yield loss in mature trees. There are three species of the capsids, namely:

- (a) Brown capsid
- (b) Black capsid
- (c) Cocoa mosquito

The brown capsid, *Sohbergella singularis*, is very common and it attacks cocoa in all parts of Nigeria. The black capsid *Distantiella theobromae* attacks cola, cocoa and citrus. It feeds on fresh green shoots, pods and chupon. The cocoa mosquito, *Holopala bergeri*, feeds on the pods. Capsids cause twig die-back indirectly. The hole created by the insect...
Major diseases

**Black pod disease**

*Causal agent**: *Phytophthora palmivora* (fungus)

**Symptoms**: Brown spots on the pods. These spots merge as an advanced stage of infection and the whole pod turns black and rot. Infected young pods turn yellow and die prematurely.

**Transmission**: By splashing rain water which spreads the conidia (spores) of the fungus. Insect vectors and squirrels that feed on cocoa pods are also agents of spread.

**Control**: By spraying with fungicides (Perelox, Bordeaux mixture). Use of insecticides to check the insect vectors; planting of healthy seeds and reduction of excessive shade to encourage better air circulation.

**Swollen shoot disease**

*Causal agent**: Virus

**Symptoms**: Swellings of young shoot particularly the rapidly growing shoot. On young leaves, it occurs as a network of red vein bands which soon develop into vein clearing or chlorosis. Defoliation and dieback become apparent with severe attack.

**Transmission**: The disease may be seed-borne or it may enter the plant through damage or injury (mechanical transmission) or through insect vectors (mealybugs and aphids) as they suck sap.

**Control**: The cheapest means of control is to start all plantations with healthy seeds. All cultural practices that control the insect vectors and ants effectively reduce the spread of the disease. The regular use of insecticide is one of such practices. Once a plant is infected, it is cut into burn as there are no effective chemical controls. Alternative hosts of the disease pathogens, silk cotton tree, Baltic (*Adansonia digynna*) and *Cola cordifolia* (wild kola), are removed during land preparation.

**Withy's broom**

*Causal agent*: *Marasmus pericicae*
Plantation crops

Symptoms: Broom-like branches with underdeveloped leaves. Infected pods become hard and woody.

Transmission: By rain splash.

Control: Use of fungicides and resistant clones (upper Amazon).

Causal agent: *Manihot spp.*

Symptoms: Young pods are attacked and, in severe cases, the pods rot and become water-soaked.

Control: Spray with sulfur-containing fungicides like Zineb.

Cherelle wilt

"Cherelle" is a young pod that is about 5-20 cm long. Whenever the cherelle fails, wilts and becomes shrivelled on the tree without a causal pathogenic agent, the term *cherelle wilt* is used. The wilt has some physiological implications as a fruit-thinning mechanism.

**COFFEE**

Family: Rubiaceae

Botanical name: *Coffee spp.*

Species of economic value:
- *Coffea arabica*
- *C. robusta (canephora)*
- *C. liberica*
- *C. excelsa*

Botany

Coffee is generally an evergreen perennial crop with simple opposite leaves. The different species differ in height and branching habit. *C. arabica* is a small tree with dimorphic branches, thin, dark green and waxy leaves. The plant can attain heights of about 5 m if it is not pruned. *C. robusta* grows up to 15 m in height. It has large and thick leaves that are rounded at the base. Generally, mature coffee fruit contains two seeds commonly referred to as the beans.

Origin

*C. arabica* is native to the high wet forests of Ethiopia. It is a tetraploid (2n = 44). About 75% of the world coffee is *C. arabica*. *C. robusta* originated in the rain forest of equatorial Africa; *C. liberica* is indigenous to Liberia and *C. excelsa* is native to West Africa.

Climatic and soil requirements

Coffee is native to the tropics. But its better performance when grown with shade trees is an indication that the crop requires air temperature less than what obtains in the tropics. Under very high temperatures, there is the tendency for coffee to show very rapid growth, early production of berries, over-bearing of young wood, early exhaustion and, consequently, die

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**COFFEE**

Family: Rubiaceae

Botanical name: *Coffee spp.*

Species of economic value:
- *Coffea arabica*
- *C. robusta (canephora)*
- *C. liberica*
- *C. excelsa*
back. High temperatures in the soil cause death of the feeder roots and stunting of the plant.

Coffee is best suited to areas with clearcut wet and dry seasons. The rainfall requirements are in the range of 1,000 - 2,500 mm per annum with the optimal at 1,750 mm. With respect to soil requirements coffee thrives well on a wide range of soils. An ideal soil is rich, deep, friable and with a good supply of organic matter and clay. In Nigeria, C. robusta is grown in the high rainfall areas around the cocoa belt and C. arabica is grown in the Mandalla plateau and Obudu highland.

**Cultivation** Coffee is usually raised from seeds in a nursery and later transplanted into the field. Vegetative propagation by budding, grafting, and stem cuttings is also a common practice.

**Nursery practice** Seeds for planting are selected from middle-aged and vigorously growing plants that are disease-free. These seeds may be pre-germinated first before they are planted into the nursery. Seedlings are raised either on seed beds (ground nursery) or in polybags. Seed beds measuring 1.8 m x 3.6 m are made near a good source of water. The seeds are planted at a distance of 15 cm apart and at a depth of 2.5 cm. Shade is provided with palm fronds and the seedbeds are watered regularly for one month. The palm fronds are gradually removed during hardening-off of the seedlings.

With a polybags nursery, the 3:2:1 soil mix of topsoil, organic manure and river sand, respectively, is put into the polybags and watered. Polybags of about 20 cm x 25 cm lay-flat are used. Seeds are planted in the bags and shade is provided. The seedlings are ready for transplanting when they are about 45 cm in height.

**Land preparation** The establishment area is cleared at the end of the rainy season. The thrash is allowed to dry before it is removed or burnt. The field is lined out and based on the spacing the planting points are pegged.

C. arabica requires a spacing of 2.4 m x 2.4 m; C. robusta requires 3 m x 3 m and C. liberica requires 3.6 m x 3.6 m. Planting holes, 60 cm x 60 cm x 60 cm, are made at the pegged positions.

**Field planting** Transplanting is best done at the time when the seedlings have the greatest chances of survival. Usually, this coincides with the period of early rains in the forest belts. During transplanting, the seedling is placed erect in the center of the hole which is first backfilled with topsoil and finally with the dug-up soil. The soil is then firmed around the base of the seedling.

**Field Maintenance**

- **Weed control** Weed problems are minimal if:
  - (a) the ground is well prepared and thoroughly cleaned before transplanting;
  - (b) the correct spacing is used; and
  - (c) adequate shade plants are established.

Weed control methods include slashing with a cutlass and the use of herbicides such as Dalapon and 2-4-D.
Plantation crops

Pruning: Pruning in coffee is done with the following objectives:

(a) to force the tree to produce a maximum amount of new wood (coffee bearing wood)
(b) to control the shape of the coffee bush
(c) to reduce the size of the crop to that which the tree can safely bring to maturity
(d) to maintain a height that is convenient for collection of the fruits.

There are three types of pruning: single stem pruning, multiple stem pruning; and the Agrobio pruning.

Simple stem pruning:
(a) When the tree attains 67.5 cm in height, the main stem is cut at 52.5 cm.
(b) Below the point of cut-back, only one axillary branch is allowed to develop. At 127.5 cm, the sucker is cut back to 112.5 cm.
(c) Below the second point of cut-back, another axillary branch is allowed to develop. At 180 cm in height, it is finally capped at 180 cm.

Multiple stem pruning:
(a) The main stem is capped either in the nursery or soon after transplanting to induce the emergence of two lateral orthotropic stems.
(b) The two stems are cut again and four stems are allowed to grow.
(c) At full bearing capacity, the stems will bend away from each other leaving an open space at the centre of the tree. Once the lower stems start showing signs of exhaustion, they are removed and new suckers are induced to grow from the top layer, by capping the top branches that are not bearing fruits.

Agrobio pruning:
(a) The tip of the main stem is dragged down and pegged to the ground.
(b) Shoots are allowed to grow from the axillary buds.
(c) Four or five of the shoots are allowed to form the main shoots.
(d) The pegged tip may be severed or allowed to grow upwards.

Mulching: This is a very important cultural practice for coffee production. Some investigations in Uganda have shown that grass mulch of about 20-30 cm depth gave berry yields three times higher than the unmulched fields.

Shade: The provision of shade helps to reduce air and soil temperatures, and ensures that the coffee yields larger berries over a wide range of time. Shade plants are planted out in rows adjacent to the row of the coffee plants. Shade plants include, among others, Leucaena leucocephala, Acacia decurrens, and Albizzia lebbek. These are leguminous trees with good nitrogen-fixing potentials. They shed their leaves which help to mulch the soil surface thereby reducing soil temperature. On decomposition the litter increases the soil nutrient status.

Fertilization: When shade is not provided, fertilizer use becomes inevitable. In Cameroon and parts of the Mambilla Highlands where coffee is grown in altitude,
Plantation crops

of about 900 m or more above sea level, the plants are hardly shaded and the fertilizer requirements are usually high. The recommended fertilizer rates are 200 kg of urea, 50 kg of triple superphosphate and 100 kg of manure per hectare per year. Coffee requires boron, zinc and manganese. These trace elements are normally applied as fertilizer sprays.

Maturity and harvest: Although the different species vary in their maturity time, coffee bushes begin to bear fruits when they are 3-5 years old and continue to produce for 30-45 years. Fruits are harvested by picking from the tree periodically or by shaking them off the branches.

Yield: Berry yields are, in most cases, below 1 ton/ha. In places like Hawaii, berry yield of up to 2 tonnes/ha has been obtained.

Processing: Two methods of processing, the dry and wet methods, are available for processing coffee berries.

- The dry method is simple but slow. The berries are spread out either in the sun or in hot air chambers. After drying, the fruits are either picked into containers or the seeds are separated from the dry skin or pulp by hand or mechanically by the use of hulling machines before they are stored.

- In the wet method, the berries are put into large tanks containing water. Malformed fruits and contaminants float to the top while fully developed mature fruits sink to the bottom. The floating components are removed and those at the bottom of the tank are subjected to pickling and fermentation. The outer coverings of the fruits are removed and any pulp remnant is destroyed by fermentation and repeated washing in running water. The beans are dried either directly with sunlight or in hot air chambers. The beans are finally hulled to remove the seed coat.

Utilization: The coffee powder is a non-alcoholic but stimulating beverage.

Major pests:

Coffee leaf miner (Leucoptera coffeella) This is a tiny white moth. The caterpillars eat the surface of the coffee leaves and tunnel their way between the upper and lower leaf surfaces. The infested portion of the leaf dies and turns brown.

When the larvae are fully grown they abandon the tunnel, pupate and form adult insects. The insect is controlled by regular sprays of diazinon. Natural enemies exist and have been used effectively in some countries as a means of control.

Mealybug (Pseudococcus spp.) The mealybugs feed by puncturing and sucking sap from the bark of the plant. Once they begin to feed, they become attached to the plant and develop a tough scaly covering. Mealybugs are spread by ants which feed on the sugary exudates (honey dew) from the mealybugs. Bundling of the trees to restrict movement of the ants or spraying with Nicotine sulphate to check the ants helps to reduce the spread of mealybugs.

Coffee berry borer (Hypophtherenus hampei) The beetle feeds on the
young green berries and lays her eggs in the ripe ones. The consequences are premature fruit loss and a drop in fruit quality. The control is to spray the tree with Diazinon during flowering and fruiting.

**Coffee bug** *(Antestiopsis orbitalis)* These insects suck the berries empty. When the plant is not producing fruits, the insect attacks and feeds on the terminal buds. The insect is controlled by spraying with malathion.

**Diseases**

### Coffee leaf rust

**Causal agent** *Hemileia vastatrix* *(fungus)*

**Symptoms** Small light yellow spots on the underside of the leaves. The spots later enlarge, covering a diameter of about 2.5 cm. Diseased leaves drop, leaving the twig with a few leaves. The affected tree is weakened and may become susceptible to twig dieback.

**Control** All affected trees are sprayed with copper-based fungicide such as Bordeaux mixture.

### Twig die-back

This disease has more or less been described as a physiological disorder. The flowering branches start dying from the tip backwards. It is common on young trees grown at lower elevations under a low rainfall regime. The disease is controlled by stripping the plant of all berries. This is particularly important for crops bearing fruits for the first time.

**Coffee berry disease**

This is caused by the fungus *Colletotrichum coffeanum*. The disease attacks and damages green berries. Brown spots are formed all over the berries and the beans become shrivelled. A good spray with copper-based fungicide at flowering and during fruiting provides an effective control measure.
<table>
<thead>
<tr>
<th>Plant character</th>
<th><em>Cola nitida</em></th>
<th><em>Cola acuminata</em></th>
<th><em>Cola verticillata</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of tree</td>
<td>15-20m</td>
<td>8-12m</td>
<td>12-17m</td>
</tr>
<tr>
<td>Branching habit</td>
<td>Does not branch</td>
<td>Many branches near the base</td>
<td>Few branches</td>
</tr>
<tr>
<td>Bark of tree</td>
<td>Smooth with fine longitudinal cracks</td>
<td>Rough, splitting in squares</td>
<td>Longitudinal cracks</td>
</tr>
<tr>
<td>Foliose</td>
<td>Very dense</td>
<td>Sparser, continued to the branch tips</td>
<td>Sparser, confined to the branch tips</td>
</tr>
<tr>
<td>Leaves</td>
<td>Copper colour when dry</td>
<td>Brown when dry</td>
<td>Brown when dry</td>
</tr>
<tr>
<td>Fruiting period</td>
<td>Nov-Jan</td>
<td>April-June</td>
<td>May-June</td>
</tr>
<tr>
<td>Seeds</td>
<td>2 cotyledons</td>
<td>3-5 cotyledons</td>
<td>3-4 cotyledons</td>
</tr>
<tr>
<td>Colour of seeds</td>
<td>White, pink, red</td>
<td>Pink or red</td>
<td>Pink or red</td>
</tr>
</tbody>
</table>

With respect to the floral biology, kola nut trees may produce male flowers that have rudimentary gynoecium, or hermaphrodite flowers with androecium that is non-functional. The latter are important for the production of pods and nuts. There are cases where a tree may produce only male flowers. Such trees are unproductive and are better removed from the plantation. However, other causes of infertility in kola exist and it is proper to make the necessary diagnosis before cutting down any tree.

**Origin** Kola is native to tropical West Africa. It is extensively grown in Nigeria, Sierra Leone, Liberia, Ivory Coast, and Ghana.

**Climatic and soil requirements** Kola is a lowland tropical crop that grows between latitudes 6°N and south of the equator. It grows best in regions with annual rainfall of about 1,250 - 1,750 mm and well marked dry and wet seasons. The suitable soils are well-drained fertile soils that are rich in humus.

**Propagation** Kola is propagated from seeds. Stem cuttings have been tried in research stations using rooting bins. The results of the latter have been encouraging but the practice is yet to be extended to rural farmers.

Seeds are kept in boxes for at least 3-5 months to break the dormancy before they are planted. Pre-germination boxes are filled with a mixture of sawdust and topsoil, watered and planted up with the stored seeds. The boxes are covered with polythene sheets and kept indoors or under shade. As
Plantation crops

soon as the seedlings begin to emerge, they are transferred into polythene bags or nursery beds at a spacing of 30 cm x 30 cm. The seedlings spend five to six months in the nursery before they are transplanted into the field. At the seedling stage, palm fronds are placed in a pyramidal fashion over the seedlings to provide adequate shade. As the seedlings become older, the number of palm fronds is gradually reduced until the plants adjust accordingly to the prevailing weather conditions.

Land Preparation

Elaborate land preparation is required because kola is highly susceptible to soil-borne diseases. The establishment area is cleared of all stumps and residues of old woods which may serve as alternate hosts of pathogenic organisms. However, while preparing land for *C. acuminata*, a sparse population of trees is left to serve as shade plants.

Land preparation is done with the early rains in April or May in southern Nigeria. The seedlings are transplanted with all the soil in the bag after the polythene bag has been carefully stripped off. The hole is back-filled with topsoil and finally with the excavates from the hole. The soil around the base of the seedling is firmcd and mulched. Temporary shade plants which may be any of the food crops (maize, cassava or pigeon pea) are planted.

Regeneration

Regeneration by coppicing is a very important practice in kola plantations. It is one of the cheapest ways of rebuilding very old plantations. The tree is cut at the base and then shoots that grow out of the copicering are allowed to develop. Only one healthy strong regrowth from each copice base is retained as the new plant.

Weeding

It is important to keep kola plantations weed-free. Very weedy and untidy surroundings encourage infestations by kola borers and weevils. Thus a weed-free zone around each plant is necessary. As the plant grows the zone is widened. Any of the conventional weeding methods (cultivating, herbicidal treatment, and the use of cover crops) can be adopted in kola plantations.

Fertilization

Kola is seldom fertilized under the traditional farming system. However, there are reports that the crop responds well to organic matter and fertilizer applications. In the early years of growth, fertilizers are applied to induce the growth of the seedlings. As the crop approaches the fruiting age, a yearly application of 1.6 kg per tree of NPK fertilizer is recommended.

Maturity and Harvesting

Maturity of the pods indicates that the pods begin to change and drop. Harvesting is done by cutting the stalk carrying the follicles with a sharp curved knife that is firmly attached to a long pole. Before harvest, the surroundings are cleared of undergrowth. This makes picking easy as the pods can be collected.

The field is fixed and planting holes, 60 cm x 60 cm, are made at a spacing of 7.5 m x 7.5 m.

Transplanting

Transplanting is done with the early rains in April or May in southern Nigeria. The seedlings are transplanted with all the soil in the bag after the polythene bag has been carefully stripped off. The hole is back-filled with topsoil and finally with the excavates from the hole. The soil around the base of the seedling is firmcd and mulched. Temporary shade plants which may be any of the food crops (maize, cassava or pigeon pea) are planted.

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Yield
On the average, each tree produces about 210 market size nuts or 600 kg of processed nuts per hectare.

Processing
Mature follicles are split open and the seeds are removed. These are soaked in water for 18-24 hours to loosen the testa and make its removal easy. The seeds are then washed thoroughly and packed into a basket. The seeds are cured by sweating. They are packed into a container which is tightly covered. Through this process, the seeds lose water and become sufficiently dry for storage. They are finally packed into a basket lined with the fresh leaves of Feccania varipetala. The leaves help to maintain the humidity required to keep the nuts fresh. As a matter of routine, the nuts are checked every two weeks and the leaves are replaced during the check.

Major pests
Cola stem borer (Phosphorus virescens) attacks young trees. The larvae bore into the plant causing gummosis and twig dieback. As the larvae lodge within the internal tissues of the plant, they are only killed with systemic insecticides. Under very severe infestation, the trees are coppiced and regrowths are inspected regularly.

Pod borer attacks the cola pod causing a considerable drop in yield and quality of the nuts. The tree is sprayed with Gamalin 20 during fruiting to keep off the insects.

Pod rot disease
This is caused by the fungus, Phomopsis colocasiae; it attacks the pods causing the infected parts to become hard, dry, and black in colour. The disease eventually spreads to and damages the nut. The disease is controlled by spraying with Bordeaux mixture.
Botany

The oil palm is a monoecious with a dense network of fibrous roots. The stem is a single trunk that terminates in a crown of fronds. The male and female types of inflorescence are borne separately at the leaf bases of the branches (monoecy). The palm bunch usually originates from the female inflorescence. The fruit is a drupe consisting of the exocarp, mesocarp (oil bearing layer) and the endocarp (shell).

Origin

E. guineensis is native to Africa.

Climatic and soil requirements

The oil palm is found growing wild in clusters in groves or cultivated in the tropics between latitudes 15°N and south of the equator. The ideal climatic features suitable for oil palm include an annual rainfall of 2,000 mm or more that is evenly distributed throughout the year, high daily temperature ranging from 24°C to 34°C, sunshine totaling about 1,900 hours per year. Low sex ratio is common in areas with a distinct dry season and with several months of reduced hours of sunshine. Oil palm requires soils that are loose enough to allow the roots to spread extensively. Such soils are characterized with good water and nutrient holding capacity. The soils which support most of the oil palm plantations possess these features. They have loose brownish top soils over a great depth of largely non-mottled, non-concretional, and non-gravelly porous subsoil with a substantial amount of coarse sand and about 25% clay. The nutrient content of these soils is relatively low, thus making the use of inorganic fertilizers necessary.

Varieties of oil palm

The varieties of the oil palm can be described on the basis of the fruit characteristics:

1. Fruit colour (pigmentation)
   - Nigrescens — fruits are black when unripe but turn red when ripe with part of the top half retaining the initial black colour.
   - Virescens — fruits are green when unripe but turn light reddish-orange when ripe with greenish tip.
   - Albescens — fruits are white when unripe but turn pale yellow when ripe.

2. Shell thickness
   - Dura — very thick shell, 2-8 mm; thick kernel/thin shell that lacks fibre ring around the kernel.
   - Tenera — thin shell, up to 3 mm; the kernel is surrounded by a fibre ring. It is a hybrid from a cross between Dura and Pusfera.
Planted crops

Pisiferavery little or no shell; the kernel is surrounded by a fibre ring.

3 Fruit formation
Regular — absence of additional carpels around the fruit.
Mantled — presence of additional carpels around the fruit.

Planting materials/Genetic improvement
Yields per hectare are limited by variability within the bred seedling progenies. Although part of this variability is due to environmental factors, genetic variation makes an important contribution, so that a marked improvement can be expected from planting uniform stands of clones derived from the best palms. Vegetative propagation by tissue culture has reached the stage where clones from a number of elite palms are being tested in field trials. A short trunk is a desirable secondary character. Efforts to exploit this feature within E. guineensis have met with only limited success. The low-yielding E. oleifera has much smaller annual height increment than E. guineensis and it is also resistant to the vascular wilt disease. To take advantage of these characters, crosses between the two species have been undertaken in recent years. The F1 hybrids are intermediate between the parents in the expression of height but show a range of resistance to the disease. In West Africa oil palms are presently raised from improved seeds obtainable from NIFOR (The Nigerian Institute for Oil Palm Research).

Germination
Oil palm seeds require a certain amount of heat before they will germinate. In Asian countries, it is sufficient to expose the seeds to the heat of the sun in open sand beds, but in Nigeria, it is necessary to apply artificial heating in the form of fermenting vegetable matter or a wood fire. After the heat treatment, the seeds are cooled to ambient temperatures while maintaining optimum humidity. In 21 days, the seeds will germinate.

Nursery
The palm seeds are supplied as pre-germinated nuts and as such are planted as soon as they are delivered. The young seedlings are raised in polythene bags (polybags) until they are ready for transplanting. The black polythene bags (400-500 gauge, 40 x 35 cm layflat) are filled with top soil and placed in a square formation at 45 x 75 cm spacing. The nursery is adequately watered and weeds are removed as soon as they are noticed.

Land preparation
Palm trees are established in virgin or secondary forests. The area is underbrushed, trees are felled, cut in 10 logs and removed. These allow easy access into the field and make subsequent operations easy. The field is lined and planting points are pegged. A triangular spacing of 9 x 9 x 9 m (Fig. 8.1) giving a plant population of about 142 palms/ha is the standard. Planting holes, 45 cm x 45 cm x 45 cm, are dug at the pegged points.

Transplanting
Transplanting is done with the early rains in March or April and is completed before the end of May to avoid subjecting the young seedlings to moisture stress when the rains cease. Seedlings raised in polybags are transplanted with all the soil in the base after the bolus has been carefully stripped off.
Sometimes, the seedlings may have naked roots either because they were raised in a ground nursery or deliberately removed from the nursery bags to reduce transportation costs. The roots of such seedlings are immersed in a clay slurry to protect them from drying out. The planting holes for the naked-root seedling are shaped like a cross with a slight elevation at the center. During transplanting, the roots are evenly distributed in the four arms of the cross-shaped hole. During transplanting, the roots are evenly distributed in the four arms of the cross-shaped hole. The hole is first filled with topsoil and finally with the bottom soil before firming the soil around the base of the seedling. Palm seedlings are never transplanted too deep. Very deep planting retards growth.

**Weeding**

The siam weed is the most obnoxious in palm plantations. It grows rapidly and colonizes the plantation during the rainy season and constitutes fire hazard in the dry season. In young plantations, it outgrows the seedlings, forming a thick cover around the palms. Narrow-leaf weeds are also common in palm plantations. Weeding the plantation prevents weeds from smothering the palms; allows easy inspection and harvesting of the palms, keeps palm trees and diseases problems low. Weed control is done either by cutlassing, spraying with herbicides, or by the use of cover crops. Cutlassing, at regular intervals, keeps creepers, climbers and vigorously growing weeds under control. The inter-rows are slashed with matchets and the thrash is left as mulch in the plantation. The use of herbicides is more economical in large estates. However, wrong usage, in terms of dosage and application procedure, may have devastating effects. A 2:1 mixture of Amiben 40 and Ameye Lin 2.0 kg/ha can control siam weed in the plantation. A vigorously growing cover crop is established as soon as the weeds are killed with herbicides. This helps to foreseen future invasion by weeds. Ring weeding is a popular practice in most West African countries. A weed-free zone is constantly maintained around the tree to reduce the competition for nutrients and water. It also makes collection of loose fruits from harvested palm bunches easy.

**Pollination**

Yields in young palms are often limited by inadequate pollination. Consequently, it is a normal practice to dust the female inflorescences every three to four days with pollen dusted with talc. In some cases, artificial pollination is continued throughout the life of the palm in order to get modest yields. Originally, it was believed that oil palm was predominantly wind pollinated, but recently it has been shown in West Africa that insects are mainly responsible. A weevil, indigenous to Cameroon, *Elaeidobius kamevunicus,* has been credited with the pollination of most palms in the sub-region. It is estimated that yield can be increased by 20-50% with the introduction of the weevil in areas where they do not exist.

**Fertilization**

For raising the seedlings in the nursery, 56 kg of a mixture of N, P, K and Mg fertilizer in the ratio of 1:1:1:2 using sulphate of ammonia, single superphosphate, murate of potash and magnesium sulphate is applied at the

Plantation crops

second and eighth month of nursery life. For the transplanted palms, deficiency
in any of the macro-nutrient elements seriously reduces the fruiting potentials of
the tree. For instance, potassium deficiency causes confluent orange spotting on
the leaves, a disease that reduces photosynthetic surfaces of the plant. A sound,
fertilizer programme for oil palm depends on the soil type, rainfall regime, soil
nutrient status, the level of production, and the age of the palm.

Balanced Fertilizer Schedule for regions with Mg deficiency

| Fertilizer | Year of planting | WAP | MAP | Months after planting | MAP | MAP | MAP | MAP | MAP | MAP | MAP | MAP | MAP | MAP | MAP | MAP | MAP |
|------------|-----------------|-----|-----|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ammonium sulphate | 25 | 25 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Potassium sulphate | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Magnesium sulphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Source: NIFOR Oil Palm Manual

Fertilizers are applied in a circle with a diameter of 2 m round the palm in order
to reduce leaching losses.

Maturity: The first bunches are expected 3-5 years after transplanting.

Average length of time for the different growth stages

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination</td>
<td>3-4 months</td>
</tr>
<tr>
<td>Pre-nursery</td>
<td>4-6 months</td>
</tr>
<tr>
<td>Nursery</td>
<td>4-6 months</td>
</tr>
<tr>
<td>Pollination to harvest</td>
<td>5-6 months</td>
</tr>
<tr>
<td>Field planting to first harvest</td>
<td>32-44 months</td>
</tr>
<tr>
<td>First harvest to peak production</td>
<td>3-4 years</td>
</tr>
</tbody>
</table>
The bunch is mature when the fruits become loose and begin to dislodge. The usual guide is to count the number of loose fruits at the base of the tree. Once there are up to 10 fruits on the ground, the bunch from which they have fallen is due for harvest.

**Harvesting** The traditional method of harvesting involves pruning the subtending leaf before cutting the bunch by the stalk with a sharp cutlass. In modern plantations, the short palms are harvested with a chisel mounted on a short wooden pole. The stalk of the bunch is cut without necessarily cutting the subtending leaf. With the tall palms, harvesting hooks mounted on tall poles are used.

Another important produce from the oil palm is the palm wine harvested by tapping.

**Yield** Bunch yield varies from one variety to another as it is influenced by the number of leaves, percentage floral abortion, sex ratio, percentage bunch failure, and average bunch weight. Of these, sex ratio and the average bunch weight are the most important yield-determining components. Both are polygenic and are independently inherited. But under plantation conditions, they strongly influence each other. For instance, a large number of bunches is associated with a relatively low average bunch weight.

**Average Yearly Yield Pattern in the Nigerian Oil palm Industry.**

<table>
<thead>
<tr>
<th>Year after planting</th>
<th>Avg Wt of bunch (g/bunch)</th>
<th>Palm oil yield (tonnes) (15% ER*)</th>
<th>Palm kernel yield (tonnes) (3% ER*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.81</td>
<td>0.27</td>
<td>0.05</td>
</tr>
<tr>
<td>7</td>
<td>3.26</td>
<td>0.47</td>
<td>0.10</td>
</tr>
<tr>
<td>11</td>
<td>4.37</td>
<td>0.66</td>
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Palm wine yield ranges from 3,500 to 4,200 litres depending on the variety and prevailing weather conditions.

**Processing** Processing of palm fruits commences soon after harvest. If it is delayed as is the case under the traditional setting, the free-fatty acid (FFA) content will increase and cause a drop in the oil quality. A high quality palm oil has an FFA...
Plantation crops

of about 3.5% or less. With the traditional method of processing the oil may contain up to 35% FFA.

Utilization

The palm oil is rich in carotene which is a precursor of vitamin A. Palm oil is used in homes as cooking oil. In the industries, it is used for the manufacture of margarine, soaps, lubricating oils and candles. The palm kernel oil is used as skin lotion or as a laxative. When mixed with kerosene, it is used as a wood polish. After extracting the oil, the residue (palm kernel cake) forms a good portion of livestock feed. Palm wine obtained by tapping the tree is a very popular alcoholic drink used in many social gatherings in Nigeria. The leaves, rachises and petioles of the oil palm are made into thatches for roofing buildings. Brooms for sweeping homes are made from the leaves and the central spear leaf has some religious relevance in most churches.

Major pests

Nursery pests

Nursery pests include snails, crickets, and mammals such as rodents.

The snail (Helix aspersa) is a typical browser, scraping and rasping away young seedlings particularly in a ground nursery. Picking snails by hand is time-consuming but quite effective in the control of the pest. Chemical control with methaldheyde mixed with bran is also very effective. The methaldheyde stimulates the production of slime that drastically affects the movement of the animal thus exposing it to adverse weather conditions and its natural enemies.

Mammals

Rats (Rattus rattus) and mice (Mus musculus) remove or damage germinated palm nuts. They can attack and eat young seedlings in the nursery. Wood traps, cage traps and steel traps can be used to kill rats and mice. Rat poisons or rodenticides such as Warfarin could be put in foods like cakes, crumbs of bread and nuts. These serve as baits and they are scattered all over the nursery site for the animals to eat.

Field pests

Oil palm leaf miner (Caelenomenodera claviga) attacks and creates deep pits on the leaflets. The larvae of the insect are controlled by pruning and keeping affected leaves together during the rains. The rapid decomposition of the leaves kills the insects. The adults are controlled by spraying with Ultracide 40EC at the rate of 1.5 litres/ha.

The stropo weevil (Rhyncophorus phoenicis) produces larvae that tunnel through the trunk and destroy the internal tissues of the host causing the plant to wilt. The application of a systemic insecticide such as Nuvacron controls the larvae that are lodged in the trunk.

The stinging green caterpillar (Latoia viridissima) is a moth. It feeds by scraping the underside of the leaflet from the tip backwards. Heavy infestations result in pronounced defoliation and considerable yield loss. Infected plants are
sprayed with either Basudin 60EC or Ultracide 40EC at the rates of 3-6 mMitre and 1.5-3 ml/litre of water, respectively.

Diseases

(A) Major nursery diseases

1. Anthracnose is a fungal disease that causes black or brown blotches on the leaf margins. The disease is controlled by spraying with fungicide such as Dithane M45 at the rate of 2 g/litre of water. Perenox or other copper-based fungicides are not used because they cause severe scorching on young palms. A cheaper method of control is to avoid overcrowding of the seedlings.

2. Freckle is a fungal disease of young palms caused by Cercospora elaeidis. It is characterized by single or groups of brown spots surrounded by yellow-orange haloes on the palm leaves. Affected palms are adversely retarded. The recommended control measure is to spray with Dithane M45 or Captan at the rate of 2 g/litre of water.

3. Blast is a root disease of young palms. It causes the decay and eventual collapse of the root system. There is usually a drop in the disease incidence when the nursery is established at the right time.

(B) Diseases of the mature palms

1. Ganoderma trunk rot is a disease of palms growing in the wild. It is caused by Ganoderma zonatum. Internally, the disease causes the stem tissue to rot and the palm is killed even before external symptoms become obvious. The removal of stems and stumps of dead palms during land preparation helps to keep the disease incidence low.

2. Vascular wilt disease is a soil-borne fungus disease that attacks both the palms in plantations and in the groves. There is a progressive decrease in the growth rate of infected palms. Leaves become smaller and their outer whorls desiccate as the disease spreads. Internally, the surroundings of the vascular tissues are discoloured and this eventually spreads to the central vascular cells. The causal organism is Phasmatium oxytosporium. The cheapest means of control is the removal of old stumps of palms before transplanting new ones in the same field.

3. Freckle is a disease of both seedlings and adult palms. It is caused by the fungus Cercospora elaeidis, and the symptoms of attack are similar to those already described under major nursery diseases. The spread of the disease is mainly by rain splash and leaf contact. A balanced mixture of N and K fertilizer and mild pruning of infected leaves will minimize the spread of the disease.

4. Dry basal rot is a soil-borne fungal disease caused by Ceratocystis paradoxa. The symptoms include rotting of immature fruit bunches and, in severe cases, the palm collapses and dies. Good cultural practices, such as planned use of fertilizers, fungicidal sprays and weed control have been reported as viable checks to basal rot disease.
Crown disease causes pronounced bending and twisting of the rachis thus making the few leaves tattered and miserable. However, the disease hardly attains a worrisome level since infected plants are able to recover naturally.

Plate 7 Oil palm tree

Fig. 8.6 Longitudinal section of oil palm fruit

TENERA

Fig. 8.7 Typical farm design with triangular plant arrangement

DURA

PISIFERA
Vegetable crops

Vegetables are succulent herbaceous crops that are harvested and eaten in a fresh state. Vegetable production is either for the fresh market or for processing. It is highly specialized, with unique practices for nearly every crop. Unlike the field crops, vegetable crops are intensively grown. The harvests are eaten either raw or cooked as part of a main dish or in sauté. The edible parts may be the root as in carrots, Irish potatoes and yams; fresh pods in a vegetable cowpea; immature fruit as in okra and fresh maize; ripe fruits as in tomato, tender leaves as in green (Amaranthus) and kenkuren (Corchorus), young shoot as in oha (Pterocarpus soyauxii); immature flower as in cauliflower; whole shoot as in elephant grass or in bulbs as in onions.

Vegetables

Family: Solanaceae
Botanical name: Lycopersicon lycopersicum

Plate 8

Botany

The tomato is a short-lived herbaceous annual with weak trailing much branched stems covered with hairs at the juvenile stage of development. When young, most varieties grow erect but as they age, they are unable to carry their weight and eventually slump. Tomatoes have well-developed taproots that branch profusely to form dense root systems. The leaves are hairy, variable in shape, and are unevenly incised with lobed margins. The inflorescence emerges from the leaf axil and carries 4-12 hermaphroditic flowers. These flowers are often shed one to two days after they have opened. They are cleistogamous. The mature ripe fruits are glabrous and shiny and are commonly red or yellow in colour. They contain numerous seeds that are reniform in shape and light brown in colour. The local varieties in Nigeria are thin-walled, heavily seeded, and sour in taste.

Origin

The origin of tomato is the high elevation of the Andes in South America. The cherry tomato, L. hirsutum var. cerasiforme, which grows wild in the Peru-Ecuador area is believed to be the progenitor of the tomato in Nigeria.
Vegetable crops

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cultivation today. Tomato was introduced into West Africa by expatriate mission-
aries and civil servants.

Climatic and soil requirements Tomato is a warm season crop that requires a temperature range of 65 to 85°F or optimum yield. At higher temperatures with high humidity foliage diseases are rampant. Dry winds reduce fruit set as flowers drop before fertilization. Excessive precipitation during the growing period does not favour the tomato. The crop is not sensitive to daylength as it can set fruit on photoperiods between seven and nineteen hours.

The tomato grows well in many kinds of soils ranging from the sandy to the heavy clayey soils. It, however, grows best in rich well-drained loamy soils. Slightly acidic soils having a pH range of 6 to 6.5 is recommended as being optimum for tomatoes.

Tomato species Five species of *Lycopersicon* are recognized and recourse is made to them in breeding for disease resistance and better adaptation. They are: *L. pimpinellifolium* *L. cheesmanii* *L. peruvianum* *L. hirtum* *L. glandulosum*.

Tomato varieties In relatively recent times a great many cultivars have been, selected or bred to suit different environments, with fruits suitable for different purposes. Breeding emphasis has been on the development of uniform fruit colour and size, earliness, multiple disease resistance, resistance to fruit cracking, high vitamin content and suitability for mechanical harvesting. It will be impossible to list all the commercial varieties of tomatoes in this book and as new brands are being produced every year, any such list would almost certainly be obsolete soon after it is published.

Planting method The tomato is propagated by seeds. These are either sown direct into the field or sown in a nursery and later transplanted. 

Nursery practice The tomato nursery is either in a plastic greenhouse with insect proof sides or in propagation frames or in seed boxes. Ground nursery is also practised particularly at the peasant level of production. The plastic greenhouse nursery is for large-scale vegetable production projects with high managerial input. The propagation farms are excellent structures for raising healthy, robust vegetable seedlings. The use of seed boxes is very popular. The materials used for the construction range from packing cases to hardwood. The size depends mainly on the amount of seedlings to be raised and in the ease of movement of the boxes. Drainage holes are provided at the bottom to prevent waterlogging during watering.

The best soil mixture is good quality sterilized sandy loam mixed with well-
rotted compost or farmyard manure and clean river sand in the ratio of 3:2:1.
The mixture is sieved with 1 cm screen and then used to fill the seed box to within 4 cm of the top and firmed down. The seeds are planted 5 cm apart. The spacing permits the removal of seedlings during transplanting with some balls of earth. After planting, the box is watered, covered with a board and placed in a shade where it remains undisturbed until germination. Germination starts on the third day after seeding and is important to apply just enough water to the seedlings to prevent damping off disease. Seedlings are ready 3 to 4 weeks after planting depending on the seed vigour. Tomato plants are hardened before transplanting. This is achieved by increasing the frequency and volume of water applied. Hardening enables very good seedling establishment to be achieved.

**Land preparation** When ploughing or hoeing, it is necessary to check the depth of ploughing. A depth of 18 to 25 cm is sufficient in moist soils. It is wrong to turn up too much of the subsoil to the surface. Seed beds of 120 cm wide and of any convenient length may be prepared. It is desirable that a soil-improving crop (legume) precedes the tomato plant. If this is the case and heavy manure is to be applied, it is important that the residues of the previous planting and the manures are completely worked into the soil in advance of transplanting.

**Transplanting** Transplanting is the process whereby seedlings are removed from the nursery and replanted at a location where growth to eventual maturity becomes beneficial to the grower. Tomato seedlings are ready for transplanting at about the six-leaf stages when they are 3 to 4 weeks old. Transplanting is better done in the evenings. A spacing of 45 cm within the row and 60 cm between the row is recommended. This spacing permits two rows on a bed of width 120 cm.

**Staking and growth control** Tomato plants, especially the tall varieties, are usually supported with stakes to hold them off the ground. Where stakes are not required as in the dwarf varieties, the beds are well mulched to prevent fruit contact with the soil. As a rule, vegetative shoots are manually removed and the shoot apex is decapitated when the plant attains a height of about 200 cm. The latter operation helps to control the number of flowering trusses produced and ensures the production of larger fruits.

**Irrigation** During seasons of limited rainfall, or for short periods during which evapotranspiration is higher than precipitation, irrigation becomes very important in maintaining growth at an optimum level and obtaining good yields. Light cultivations are necessary to remove weeds which compete with tomato plants for water, nutrients, and sunlight. Besides controlling weeds, cultivations help to loosen soil that may have become compacted around the plant. Weeding is done by hand or with a hoe or cultivator.

**Fertilization** Depending on the nutrient level of the establishment area, organic materials (if available) are applied liberally before transplanting. The tomato plant benefits from a top dressing with an NPK fertilizer mixture applied when the lower buds of the first truss have become visible. NPK, at the rate of 1 kg per 9
Vegetable crops

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m², is incorporated into the top 5 cm of the soil either in bands or in rings 20 to 25 cm away from the plant.

Maturity and harvest An early fruit set can be induced with phthalamic sprays at the time of flower initiation. Under natural conditions, the tomato plant, especially those of the dwarf varieties could bear ripe fruits in 3 months. Staked tomato takes up to 4 months. Mature fruits, ripe or near-ripe fruits, are picked manually.

Yield With good crop husbandry, yields of 20 to 30 tonnes/ha or more are possible.

Utilization About 94% of tomato fruit is water. Other constituents include soluble sugars, citric and malic acids, mineral salts and vitamins A, B and C. Tomato is used in making salads, tomato soups and sauces.

Major pests

Nematodes or eelworms Many kinds of nematodes can attack tomatoes under humid tropical conditions. Severe infestations lead to swellings on the roots and lesions created provide entry points for bacterial and viral diseases. Crop rotation with crops that do not belong to the tomato family provides the cheapest means of control. Systemic pesticides are effective but the costs are usually prohibitive.

Whiteflies (Bemisia tabaci) These are vectors of some viral pathogens that cause the tomato mosaic, leaf curl and the tomato spotted wilt. The regular spray with a contact insecticide checks the white flies.

Ladybird (Epilachna spp.) Damage on the tomato by the larvae which attack the shoot and fruit. They can be effectively controlled with malathion.

Tomato fruitworm (Heliothis zea) This is a green or brown caterpillar with stripes. The larvae feed on the fruits of tomato and cause considerable losses in quality and yield. The control measure is to spray the plant during flowering and at the early fruiting stage with Sevin 50% wettable powder.

Mole crickets (Scapteriscus vicinus) These are seedling pests. They attack and cut the stems of the seedlings. The damage is more severe on mulched tomato beds. Any insecticidal dust can keep the insect under control.

Major diseases

Fusarium wilt is caused by the Fusarium oxysporium. The disease causes the death of the plant. Two methods of control are roguing and crop rotation. Damping-off disease causes seedlings to decay. The causal organism is controlled with any copper based insecticide.

Blossom end rot causes the discolouration of the end of the tomato fruit. The fruit ends turn black and such fruits are generally unacceptable when they become ripe. Water stress is believed to be one of the major causes. Irrigating the tomato plots will reduce or prevent the end rot disease.
Vegetable crops

Bacterial wilt is caused by *Pseudomonas solanacearum*. The upper portions of the plant including the meristematic regions are caused to wilt and die. Roguing is the most effective method to check the spread of the disease.

Generally, cigarette smokers or individuals who handle tobacco leaves are possible carriers and can help to spread some virus diseases that affect both tobacco and tomato. It is therefore important for such individuals to wash their hands before transplanting tomato seedlings. Virus diseases include the leaf curl, streak, tomato mosaic, and the spotted wilt. Chemicals are ineffective for controlling these diseases. Roguing is therefore recommended.

**AFRICAN SPINACH (GREEN)**

**Family:** Amaranthaceae  
**Botanical name:** *Amaranthus* spp.

**Species** The species popularly cultivated is *Amaranthus hybridus* ssp. cruentus, a light green coloured genotype. A very dark green type *A. viridis* is only accepted as a substitute being of a strong flavoured type. The latter is more abundant during the dry season.

**Botany** *Amaranthus* is normally an annual with great variations in growth habit. It has alternately arranged ovate to lanceolate shaped leaves measuring 5 to 10 cm in *A. hybridus* and strictly ovate and 18 to 24 cm in *A. viridis*. Individual flowers are small and are borne in dense terminal or axillary spikes. The seeds are tiny, black-brown and shiny.

**Origin** *Amaranthus* is of West African origin. The common name in most cities in West Africa is 'green', a word which stands as a synonym for green vegetables.

**Climatic and soil requirements** *Amaranthus* is well adapted to a wide range of climatic and soil conditions. Adequate soil moisture improves cold and dryness flowering. Atmospheric stress is controlled in the dry season plantings by surface irrigation. Soil high in organic matter and mineral nutrients is required for growing African spinach.

**Planting method** *Amaranthus* is one of the first vegetables to be sown in the season as it is sown with the first rain in compound farms, or raised in nurseries and transplanted at three weeks old. Propagation is only by seeds.

**Nursery practice** Vegetable growers manage their nursery beds before the seeds are sown broadcast. The nursery is well-watered until transplanting, twenty-one days after germination. At this time the seedlings are about 15 cm high. Field establishment closer spacings are preferred when the crop is grown for the fresh leaves. Branching is suppressed and this encourages the development of...
larger and more succulent leaves with higher market value. On the average, an inter and intra-row spacing of 30 cm x 15 cm would suffice for a good crop of Amaranthus.

**Weeding** Weeds do not only compete with the crop for moisture and nutrients, they also make harvest difficult as they are easily mistaken for the crop. Most leaf-eating insect pests of Amaranthus are harboured by weeds. Amaranthus in weedy plots is usually more tattered than those raised in weed-free plots.

**Fertilization** Heavy compost alone gives healthier plants than those grown with sulphate of ammonia alone which sometimes disposes the plant to web blight or skin blight. Compost at 25 tonnes/ha with sulphate of ammonia at the rate of 60 kg/ha increases yield by 65 per cent over no manure and no fertilizer treatments. Nitrate nitrogen gives a much darker green leaf, least than the other forest of nitrogen.

**Maturity and harvest** The succulent shoot is due for harvest three to six weeks after sowing depending on the variety and the environmental conditions. Tender shoots and leaves are cut and bunched. The frequency of cutting depends on the rate of regrowth but is usually as often as possible to control flowering.

**Yield** The yield varies greatly depending on the level of husbandry and the prevailing weather conditions. When conditions are optimum, one can expect a yield of 4-6 tonnes/ha of fresh leaves.

**Utilization** Amaranth are very important for their dietary contribution. *A. hybridus* has 16 to 17% crude protein, 8-12% fibre and 64-66% carbohydrate while *A. viridis* contains 14.8% crude protein, 14% fibre, and 63% carbohydrate.

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**EGUSI MELON**

**Family:** Cucurbitaceae  
**Botanical name:** Cucumis carinthiaca

**Botany** Egusi is a trailing annual. The stems are angular in cross section and usually well branched. Individual branches may extend to 3 - 4.5m. The leaves are pinnately lobed and the lobes are toothed. Egusi is monoecious. The male flowers are produced before the females. The fruits are round or oval, 15-20cm in diameter. They are either green or streaked with white patches. The seeds are pale yellow, smooth, flattened, and they taper towards the point of attachment.

**Origin** Africa

**Climatic and soil requirements** Egusi is a warm-season crop. It is adapted to areas where high temperatures prevail for long periods during the year. The crop is best suited to a rather dry climate under irrigated farming. In humid climates, the crop is particularly prone to attack from fungus unless planned with the first
Vegetable crops

Rains of the year. Excessive humidity affects flowering and encourages foliar diseases. The crop performs better, in fertile, humus rich, and well drained sandy-loam but will grow on a number of soil types as long as they are well drained. It tolerates some degree of acidity.

**Land preparation** Tillage is important as it eases root penetration and better crop establishment. When the crop is planted in the traditional mixed cropping system, mounds or ridges are made before *egusi* seeds are planted.

**Planting method** *Egusi* is propagated from seeds which are sown direct, usually two or three per hole at a spacing of about 1-2m between stands. When it is intercropped with arable crops, no definite spacing is maintained rather the crop is staggered on the ridges or mounds. Planting depth is 3cm.

**Weeding** Two to three weedings are recommended. The first is the main weeding involving a clean removal of all weeds while the crop is at the early growth stage. The second weeding is mild as it may involve hand pulling before the crop starts initiating flowers. At this stage the plants have covered up and the foliage of the trailing branches helps to smother weeds.

**Fertilization** The crop is generally grown in rotation or in mixture with other crops. In a rotation, organic manure or a soil improving crop is used to maintain a good level of organic matter. In some instances, both sources of organic matter are used. When commercial fertilizer is the main supplier of nutrients, 15-15-15 NPK fertilizer is applied broadcast at the rate of 725kg/ha before sowing.

**Maturity and harvest** The fruits are mature at 4-5 months after planting. The discernable signs of maturity are the drying and withering of the leaves and the fruits become exposed. During harvest, the fruits are detached and collected in several heaps in the farm. There is usually no harm in delaying harvest for days or even weeks.

**Yield** One plant produces about 3-5 fruits giving a total fruit yield of about 30,000 to 50,000 fruits per hectare at 1m spacing.

**Processing** The fruits are bruised either by cutting one end with a sharp knife or by knocking them together and left in the farm for 2-3 weeks to ferment. Fermentation breaks down the mucilaginous mass and makes the removal of seeds easy. The seeds are washed with clean water and sun-dried before storage.

**Utilization** Shelled *egusi* seeds are ground either manually or with a blender and used in making soups. The seeds are rich in high quality oil.

**Cultivated species** There are four species of *Capsicum*: *C. annum*, *C. frutescens*,

**Family:** Solanaceae

**Botanical name:** Capsicum spp.
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**C. baccatum** and **C. pubescens**. Of these, only two, **C. annuum** (sweet or bell pepper) and **C. frutescens** (Hot or red pepper) are grown on a commercial scale in most countries of the world. Whereas **C. annuum** is grown as a short-term annual, the **C. frutescens** is a short-lived perennial often grown as an annual in tropical West Africa. The fruits of **C. frutescens** are highly pungent and some types could be really fiery. Fruits of **C. annuum** are usually mild and less pungent.

**Botany** Peppers vary in growth habit depending on the species. **C. annuum** can attain heights of up to 75cm. Its bisexual flowers are usually yellow and are borne solitarily on the leaf axils. The fruits vary in shape and size. When ripe, they turn red, orange or yellow. **C. frutescens** can reach heights of about 1.5m. It is usually much branched and at the third or fourth year, it may become woody. The flowers are yellow and are usually carried in clusters of two or more in leaf axils. The fruits are small erect and conical. When ripe they are either red or yellow.

**Origin** Tropical America

**Climatic and soil requirements** Both species of pepper are highly related in their climatic and soil requirements. They are warm season crops requiring day temperatures between 27 and 37°C and night temperatures of 20 to 28°C. Although they are tolerant to a wide range of rainfall, they grow best with rainfall of about 625 - 1,250mm. Excessive precipitation causes poor fruit set and premature fruit drop. The best soil for growing peppers is well drained and fertile sandy loam with ample supply of organic matter.

**Land preparation** The field is thoroughly cultivated. Seedbeds or ridges are made and manured before the seedlings are due for transplanting.

**Planting method** Centrally, pepper is propagated from seeds that are first sown in a nursery. The seeds germinate 6-10 days after planting and are transplanted into well manured bed or ridges when they are 10-15cm in height. On a bed, a square spacing of 75cm x 75cm is recommended. On ridges spaced 1m apart, the plants are spaced 75cm apart.

**Weeding** Weeding is very important when the pepper plant is newly transplant- ed. It can be done by hand cultivation or by using herbicides. If hoeing is done, some care should be taken in order to avoid bruises on the roots as they will provide entry points for soil-borne disease organisms.

**Fertilization** Organic manures are incorporated during land preparation and NPK fertilizer is applied liberally several days before transplanting. Top dressing with potassium and phosphorus is important in very poor soils.

**Maturity and harvest** Flowering commences 6-12 weeks after transplanting and fruits are ready for harvest as from 4 weeks after flower initiation. Fruits are picked manually when they are ready.

**Yield** The fresh and dry fruit yields of **C. frutescens** range from 1 to 1.2t/ha and 340-450kg/ha, respectively.
Utilization *C. frutescens* is used as condiment and for flavoring soups, stew and sauces. It also has some medicinal applications in local orthopedics in Nigeria.

Major pests

Nematodes are major pests of pepper. They penetrate and cause stunting of the root system. The upward movement of water and nutrients is greatly impeded and plant growth and development are retarded. Nematodes are controlled by chemical soil treatment with Carbofuran. Resistant varieties are planted if available. Culturally, crop rotation reduces the incidence of nematodes as most strains are starved out of existence by the long absence of the host plant. Birds pick ripe fruits if harvest is delayed. The control measures are as described in maize and rice production.

Diseases

Mosaic and leaf curl diseases are serious diseases of pepper in Nigeria. Infected plants produce small-sized leaves that are discoloured, crinkled and curled. There are no chemical treatments for these virus diseases. Infected plants are uprooted and burnt.

Fruit rot is caused by *Colletotrichum capsici*. Infected fruits turn brown and the affected areas appear water-soaked and soft. Infected plants are sprayed with copper-based fungicide at the early stage of fruiting.

**OKRA**

Family: Malvaceae  
Botanical name: *Abelmoschus esculentus*

**Botany**  
Okra is a herbaceous annual with an erect hairy stem that turns very fibrous with age. The leaves have long petioles. They are broad, hairy and cordate. The large showy flowers are produced singly in the leaf axils. The pods are light green to green in colour. They are hairy, furrowed and split along the sutures at full maturity and dryness under the slightest pressure. The matured seeds are roundish and are either grey or black in colour.

**Origin**  
Okra originated in tropical Africa. It is presently widely grown in most countries in the tropics.

**Climatic and soil requirements**  
Okra is well-adapted to a wide range of soil and rainfall conditions. The crop is generally sensitive to drought. In regions where rainfall is uncertain, the crop can be grown on alluvial soils with a good water retention capacity. Ideally, soils for okra must be well drained and fertile.
Vegetable crops

Land preparation The land is cultivated to a depth of 25cm using the conventional tillage implements. It is a good practice to broadcast organic materials before the final cultivation.

Planting method Okra is propagated by seeds sown directly into the field at a spacing of 60 x 45cm. The seeds are soaked for 24 hours before sowing. Through this process, living seeds are separated from the dead ones. Three to four seeds are planted per hole and later thinned one at the above mentioned spacing.

Weeding Okra is not a good competitor with weeds. It requires a weed-free plot from seedling to maturity. Weeding is usually done with hoes.

Fertilization The 15-15-15 compound fertilizer is applied before sowing and nitrogen is applied as sulphate of ammonia as the flower buds begin to appear. Liberal application of organic mulch during land preparation is important particularly in areas with very poor soils.

Maturity and harvest Fruit production occurs over a range of time and maturity also follows a similar pattern. Yield The yield varies with cultivar and the level of crop husbandry adopted. On the average okra yields about 450-1000kg/ha of fresh pods.

Utilization Immature pods are used for making soups in tropical Africa. These pods contain vitamins A, B and C and some vital minerals. A mucilage preparation from the immature pods is used medicinally as a plasma replacement. The fibrous stems are utilized in paper and textile industries. The mature seeds contain about 20-25% edible oil.

Major pests Okra is attacked mainly by beetles. *Podagrica uniformis*, *P. sjostedti* and *lagria villosa* feed on the stalk and leaves and create holes making the leaves tattered. Photosynthetic surfaces are reduced thus causing a decline in pod yield. *Erias hibiscaga* and *E. inulae* attack okra seeds and fruits. The fruit quality and market acceptability are consequently reduced. *Aphis gossypii* feed in large numbers on the okra plant. In addition to physical injury on the plant, the insect transmits the okra mosaic virus.

The insect pests of okra are controlled by spraying with parathion.

Diseases The okra mosaic virus causes distortion and mottling of the leaves and substantial yield depression. Infected plants are pulled out and destroyed (roguing). An additional check is crop rotation and the planting of disease-free seeds.
Weeds

A weed is a plant growing where it is not required or wanted. It constitutes problems to crop production. Any plant can therefore be a weed depending on man's desire.

Harmful effects of weeds

Weeds compete for the environmental factors with crops. Such factors include nutrient elements, water, light and space.

Weed seeds contaminate crop seeds, thus reducing the quality and market value of farmers' produce.

Some weeds secrete toxic substances through their roots in the rhizosphere. Some of these chemicals can affect the germination of crop seeds or inhibit the growth of any crop around them. The latter circumstance is often termed Allelopathy.

Some weeds are parasites to crops. Such weeds almost lack photosynthetic materials. A good example of a parasitic weed is Striga hermonthica (witch weed) that infects sorghum and millet in northern Nigeria.

Weeds constitute problems during land cultivation and crop harvesting. Clearing and other land preparatory processes are usually difficult in very weedy lands. Weeds harbour pests and pathogenic organisms of crops. For instance, the grasshopper (Zonocerus variegatus) feeds on any weed whenever the specific crop that it attacks is not in the field.

Some weeds are poisonous both to man and his livestock. A good example is Solanum nigrum.

Weeds can predispose harvested seeds in storage to deterioration. For instance, succulent weeds can easily release water on harvested produce, thus creating a favourable environment for microbial activities. Weeds, particularly the wetland or aquatic types, often block drainage and irrigation canals thus obstructing free flow of water. Weeds can also pollute our waters.

Beneficial effects of weeds

Although weeds cause a lot of damage, they also have some beneficial effects, namely

(a) Weeds protect the soil and regulate the soil fertility by recycling nutrients in the soil.

(b) Weeds can be medicinal (drug weeds).

(c) Weeds can maintain the ecological balance especially in an uncultivated land where they form part of the community and contribute to the richness of the
Qualities of real weeds

All plants that serve as successful weeds possess certain qualities that protect them from permanent extinction. These qualities include:

Profuse seed production. Ideal weeds produce a lot of seeds. The relevance of this is better appreciated if one considers the numerous environmental hazards that the seeds will go through before they finally germinate into new plants. The siam weed (Chromolaena odorata) can produce 125,000 to 2 million seeds per plant compared to a stand of maize that can at its best produce about 400-600 seeds.

Seed longevity. Most weed seeds remain viable in the soil for many years. Some weed seeds have been discovered to be viable after being buried in the soil for 30 years. Compare this to maize seeds that take only 5 days to germinate or in the maximum two weeks.

Light requirements. Some weed seeds require light for germination. If they are buried deep and cut off from satisfactory light level, they remain dormant until they are brought nearer to the surface during cultivation.

Efficient means of dispersal. Many seeds have inherent mechanisms that ensure long-distance dispersal of their seeds. Some structures like the hair pappi, as in Tridax procumbens, aid wind dispersal and sticky surfaces aid, as in Boerhavia spp., dispersal by attachment to animal bodies. Other weeds such as Tallinum triangulare are endowed with the explosive or shattering mechanisms that enable them to throw the seeds certain distances away from the parent plant.

Escape mechanism. Some weeds possess certain features that prevent them from being eaten by livestock. The siam weed, for instance, produces a pungent smell that is very disagreeable to livestock; Acanthospermum hispidum has two terminal straight spines on the fruit that tend to discourage animals from picking them.

Smothering ability. A good weed can smother other plants. The fast establishment potentials and the vigorous early growth endow the weed with such a competitive advantage.

Weed classification

Weeds can be classified based on the following:

1. Plant morphology into (a) narrow-leaf weeds (Cyperaceae, gramineae and commolinaceae) and (b) broad-leaf weeds (compositae, rubiaceae, etc.).
2. A life history into (a) Annual weeds (Tridax); (b) Biennials (Cirsium vulgare) and (c) perennials (Urena lobata, Cyperus spp., Imperata cylindrica).
3. Nutrient requirements into (a) low fertility weeds (Axnonopus spp.) and (b) high fertility weeds (Tallinum spp.).
4. Habitat into (a) dry-land weeds (Digirostra horizontalis) and (b) wet-land weeds (Eichornia spp., ie water hyacinth).
5. Mode of living into (a) parasitic weeds (Striga spp.) and (b) non-parasitic weeds (Ipomea spp.).
Methods of weed control

A. Physical method
- Hand pulling
- Machine tillage
- Fire
- Mulching
- Cutlassing
- Hoeing
- Mowing
- Flooding

B. Biological method
- Use of natural enemies
- Close spacing crops
- Allelopathy

C. Chemical method

Herbicides are used for weed control provided precautions are taken to avoid or reduce damage to the crops and the environment. Many herbicide manufacturers provide helpful booklets and information manuals. It is mandatory for herbicide users to always use them in accordance with recommended rates and stipulated precautions such as the use of face masks and protective clothing.

Types of herbicides: Herbicides are classified on the basis of the following:

1. Time of application
2. Mode of action
3. Group of weeds controlled

Time of application

(a) Pre-emergence herbicides:
These are applied before the crop seeds germinate. They can be applied at sowing or after sowing. Examples are Atrazine and Alachlor.

(b) Post-emergence herbicides:
These are applied after the crop has emerged. The weeds may or may not have emerged at the time of application. Bladex (Cyanazine) and Stam F-34 (propanil) are post-emergence herbicides.

(c) Pre-plant herbicide

Mode of action: Herbicides can act by inhibiting mitotic division in seeds thereby preventing germination. They can also cause abnormal cell proliferation causing the plant to produce cells without differentiation. In some cases, abnormal cell metabolites which interfere with the normal metabolic activities thus causing death of the plant are induced by herbicides. Photosynthesis can be inhibited or the plant can be burnt down or caused to lose water at an uncontrollable rate.

Based on the mode of action, herbicides are grouped into (a) contact and (b) systemic herbicides.
Contact herbicides  These kill weeds by burning them down or by causing the desiccation of the plant tissues. As the chemical can only kill weeds that are touched, a complete cover of the field during spraying is necessary. Examples of contact herbicides are: parquat, sulphuric acid and diquat.

Systemic herbicides  Once applied, systemic herbicides are absorbed through any of the plant parts that is touched and circulated to all the tissues. The herbicide brings about a slow but permanent death of the plant. Examples are 2,4-D (for narrow-leaf weeds), Dalapon (for broad-leaf weeds) and Glyphosate (for any kind of weed).

Group of weeds controlled (a) Narrow-leaf herbicides control weeds in the grass family. Examples are Dalapon and Atachlor. (b) Broad-leaf herbicides control broad-leaf weeds. Examples are 2,4-D, 2,4,5-T and Diquat.

Total herbicides have the power to kill all kinds of plants. Paraquat and glyphosate are examples of total herbicides.

Herbicide selectivity  Although crops and weeds are plants, they sometimes tend to react differently to herbicides. In some cases, only the weeds are killed and the crops are spared after a complete spray with a particular herbicide and yet in other instances, the contrary is observed. Such reactions are more or less physiological as the power to detoxify the herbicide is an inherent attribute of the individual plant species. Aherbicide such as simazine is toxic to plants but corn has an enzyme system that converts it to hydroxysimazine which is non-toxic. Weeds in the corn field lack the power to do the conversion and are therefore killed by the herbicide. Similarly, weed control in a soya bean field is best done with the herbicide, Amiben. In contrast the weed species, soya bean converts Amiben to N-glycosylamiben which is non-toxic. While the crop is spared the weeds are killed.

Weeds in the corn field absorb the chemical as it is, weeds absorb the substance and convert it to 2,4-D which is toxic to plants. The weeds are eventually killed while the legumes flourish.

Other forms of herbicide selectivity are physical in nature as the crops avoid the lethal substance in any of the following ways:

(a) Possession of narrow leaves that are erect as in onions. Such morphological features discourage the accumulation of the chemical on the leaves to a lethal dosage. As a result, damage is minimal and the crop eventually outgrows the little damage caused by the chemical. The adjoining weeds with broad leaves collect the chemical in large amounts on their leaves and are killed.

(b) Direct application  The nozzle of the spraying machine is directed on the weeds between the crop rows.

Common weeds in farms and gardens

Plate 9

Botanical name: Pennisetum polystachion
Common name: feathery pennisetum
Family: Poaceae  
Habitat: A common weed of arable crops and old fallows  
Seed dispersal: By wind  
Control: Hoe-weeding and by the use of herbicides  

Plate 10a  
Botanical name: Commclrina diffusa  
Common name: Spreading day flower  
Family: Commelinaeae  
Habitat: A common weed of arable crops  
Control: Very difficult weed to control because of ease of regrowth and establishment. Herbicides are more effective.

Plate 10b  
Botanical name: Commelina erecta  
Family: Commelinaceae  
Habitat: A common weed of arable crops  
Control: Very difficult weed to control because of ease of regrowth and establishment. Herbicides are more effective.

Plate 11  
Botanical name: Chloris pilosa  
Common name: Finger grass  
Family: Poaceae  
Habitat: Weed of field crops. Common on roadsides.  
Seed dispersal: By wind  
Control: Hoe-weeding; pulling with hand and by use of herbicides such as Atrazine
Plate 12
Botanical name: Kyllinga erecta or Cyperus erectus
Family: Cyperaceae
Habitat: A common weed of swamp rice, drainage, and irrigation canals.
Seed dispersal: By wind
Control: Hand pulling and use of herbicides

Plate 13
Botanical name: Digitaria horizontalis
Common name: Crabgrass
Family: Poaceae
Habitat: A weed of arable crops. Common in drainage and irrigation canals and in waste places.
Seed dispersal: By wind
Control: Hoe-weeding, hand pulling, and by the use of herbicides such as Atrazine

Plate 14
Botanical name: Mariscus alternifolius
Family: Cyperaceae
Habitat: A weed of arable crops and pasturial land
Seed dispersal: By wind
Control: Hoe-weeding, hand pulling, and by the use of herbicides

Plate 15
Botanical name: Pennisetum purpureum
Common name: Elephant grass
Family: Poaceae
Habitat: A common weed of field crops, old fallows, and roadides
Seed dispersal: By wind
Control: Hoe-weeding and by the use of herbicides
Plate 16
Botanical name: *Sporobolus pyramidalis*
Common name: Cat's tailgrass
Family: Poaceae
Habitat: A common weed of arable crops
Seed dispersal: By wind
Control: By hoe-weeding and the use of herbicides

Plate 17
Botanical name: *Panicum maximum*
Common name: Guinea grass
Family: Poaceae
Habitat: Common in short-term fallows and roadsides
Seed dispersal: By animals
Control: By hoe-weeding, hand pulling, and by the use of herbicides

Plate 18
Botanical name: *Axonopus compressus*
Common name: Carpet grass
Family: Poaceae
Habitat: Common weed of arable crops; a common lawn grass. Useful in football fields.
Seed dispersal: By wind
Control: Hoe-weeding; pulling with hand; use of herbicides such as Atrazine

Plate 19
Botanical name: *Eleusine indica*
Common name: Goosegrass
Family: Poaceae
Seed dispersal: By wind
Control: Hoe-weeding, pulling with hand, use of herbicides such as Atrazine
Plate 20
Botanical name: Amaranthus spinosus
Common name: Thorny pigweed
Family: Amaranthaceae
Habitat: A common weed of pasture crops
Control: Hoe-weeding and by the use of herbicides

Plate 21
Botanical name: Tridax procumbens
Common name: Tridax
Family: Asteraceae
Habitat: A common weed of cultivated crops and lawns
Seed dispersal: By wind
Control: By hoe-weeding and by the use of herbicides

Plate 22
Botanical name: Erigeron floribundus
Common name: Fleabane
Family: Asteraceae
Habitat: A common weed in cultivated fields
Control: Hoe-weeding, hand pulling, and by the use of herbicides

Plate 23
Botanical name: Urena lobata
Common name: Catdillo or hibiscusbur
Family: Malvaceae
Habitat: A common weed of short-term fallows and arable fields
Seed dispersal: By animals
Control: By hoe-weeding, hand pulling, and by the use of herbicides
Plate 24
Botanical name: Boerhavia erecta
Common name: Red spiderling
Family: Nyctaginaceae
Habitat: A common weed of arable fields and lawns.
Seed dispersal: By animals. The fruit has sticky hairs for attachment.
Control: By hoe-weeding and by the use of herbicides

Plate 25
Botanical name: Sida acuta
Common name: Broom weed
Family: Malvaceae
Habitat: A common weed of arable crops, pastures, and short-term fallows.
Control: By hoe-weeding and by the use of herbicides

Plate 26
Botanical name: Ipomoea involucrata
Common name: Morning glory weed
Family: Convolvulaceae
Habitat: A common weed of cultivated fields.
Control: By hoe-weeding and by the use of herbicides

Plate 27
Botanical name: Chromolaena odorata
Common name: Siam weed
Family: Compositae
Habitat: Widespread in cultivated fields and bush fallows
Seed dispersal: Wind
Control: Hoe-weeding and by the use of herbicides
Plate 28
Botanical name: Ageratum conyzoides
Common name: Goatweed
Family: Asteraceae
Habitat: A common weed of field crops
Seed dispersal: By wind and animals
Control: The weed has a short lifespan and it is controlled by hoe weeding

Plate 29
Botanical name: Richardia brasiliensis
Family: Rubiaceae
Habitat: A common weed of arable lands
Control: By hoe weeding and by the use of herbicides

Plate 30
Botanical name: Cassia occidentalis
Common name: Coffee Senna
Family: Cassaliaceae
Habitat: A common weed of arable lands and short-term fallows
Seed dispersal: By explosive mechanism
Control: By hoe weeding, hand pulling, and by the use of herbicides

Plate 31a
Botanical name: Emilia Sonchifolia
Common name: Paint brush
Family: Compositae
Habitat: Arable lands
Control: Hand pulling and use of herbicides
Plate 31b
Botanical name: *Melanthera scandens*
Family: Asteraceae
Habitat: Short-term fallows
Control: Hoe weeding and use of herbicides

Plate 32
Botanical name: *Euphorbia hirta*
Common name: Garden spurge or snake weed
Family: Euphorbiaceae
Habitat: A common weed of arable lands
Control: By hoe-weeding and by the use of herbicides

Plate 33
Botanical name: *Acanthospermum hispidum*
Common name: Bristly starbur
Family: Asteraceae
Habitat: A common weed of arable lands
Seeds dispersal: By animals
Control: By hoe-weeding and by the use of herbicides

Plate 34
Botanical name: *Talinum triangulare*
Common name: Waterleaf
Family: Portulacaceae
Habitat: A common weed of cultivated lands
Seed dispersal: By explosive mechanism
Control: By hoe-weeding
Aerobic: Requires oxygen to live.
Anaerobic: Has the ability to survive in the absence of oxygen.
Anion: A negatively charged atom.
Annuals: Crops that mature and are ready for harvest in one year.
Anthocyanin: Water-soluble compound that imparts red, purple, or blue
colour on the shoot and fruits of some plants.
Asexual reproduction: Any method of reproduction in which fertilization is absent.
Axil: Angle between the stem or branch and the leaf. Buds are usually located in the axil.
Bicellular: Originating from the axil.
Black sigatoka: Severe leaf spot disease of plantains and bananas.
Boll: Mature fruit of cotton.
Bran: Materials scraped from the outer layer of rice grains during milling.
Bud: The portion of the plant meristem that is capable of growing into leaves, branches, and flowers.
Budding: A type of grafting that utilizes only one bud and a small section of the bark.
Calyx: A collective term for sepals. It forms the outer envelope of the flower at the bud stage.
Capsule: A dry fruit consisting of two or more carpels and capable of splitting when mature.
Caryopsis: Dry indehiscent fruit with the ovary walls fused to the seed.
Cereal: Any member of the grass family grown principally for the seed.
Chlorosis: Yellowing of plant leaves.
Clone: A group of genetically identical plants produced vegetatively from a single mother plant.
Corm: A tuberous bulb-like root-stock. In plantains or bananas it produces suckers and roots.
Cultivar: A cultivated variety with distinct attributes that differentiate it from the other members of the species.
Cultivation: Breaking and turning the soil either manually or mechanically.
Curing: Drying, as in tobacco.
Damping off: Collapse of seedlings.
Diploid: The two members of all homologous pairs of chromosomes are contained in the nucleus.

Endocarp: The innermost layer of the pericarp as in a fruit.

Endosperm: The component in seeds of crops like maize for food storage.

Erosion: Washing away and loss of soil particles by wind, rain, or irrigation water.

Exocarp: The outer layer of the pericarp as in a fruit.

F.: First filial generation.

Fallow: Previously cultivated land that is allowed to lie idle, usually in order to replenish its fertility naturally.

Fertilization: Simultaneous application of water and fertilizer.

Fertilizer: Any organic or inorganic material added to the soil to supply plant food.

Flush: Produce new shoot.

Follicle: A pod made up of a single carpel that opens usually only along the inner suture to which the seeds are attached.

Forage: Plants used as food for animals.

Galls: Swellings on the roots of plants usually caused by nematodes.

Germination: A process whereby a seed is caused to start growth.

Glumes: The two lower empty chaffy bracts as in the spikelets of grasses.

Gynoecium: The female part of a flower (pistil).

Hardening-off: Toughening seedlings gradually in the nursery to prepare them for the field.

Hectare: A measure of the land area equal to 10,000 square metres.

Hermaphrodite: Having the pistil and the stamen in the same flower.

Horticulture: The branch of agriculture that deals with the growing of flowers, fruits, and vegetables.

Humus: Fraction of the soil organic matter remaining after many of the plant and animal remains have decomposed.

Hybrid: First generation of offspring resulting from hybridization between two parents that differ in some loci.

Inflorescence: A cluster of flowers on a floral axis or the arrangement of the flowers on a plant.
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**Internode**  The portion of a stem between two nodes.

**Kilogramme**  A measure of weight equal to 1,000 grammes.

**Latex**  Milky juice obtained when the plants in the family Euphorbiaceae are wounded.

**Leaves**  Long fibres obtained from the seeds of cotton during ginning.

**Lesions**  Wounds or dead patches on the leaves or stem.

**Meristem**  The region at the tip of a stem or branch that is capable of bringing about growth due to repeated mitotic division.

**Mesocarp**  The middle layer of the pericarp that is often fleshy.

**Mosaic**  Leaves have discoloured spots and patches.

**Mulch**  Any material (straw, saw-dust, gravel, or plastics) spread on the soil surface to reduce water loss.

**Necrosis**  Complete death of the plant.

**Nematode**  Small worm-like pest that lives in the soil from where it attacks plant roots.

**Node**  The point on the branch or stem on which a leaf or branch is borne.

**Nodulation**  Formation of nodules by certain soil micro-organisms (bacteria) on the roots of leguminous plants.

**Nursery**  A piece of land or a container with soil where young plants are reared for sale or for transplanting.

**Nymph**  An immature insect that looks like the adult except that the wings and the sex organs are not developed.

**Ornamentals**  A piece of land or a container with soil where young plants are reared for sale or for transplanting.

**Parasite**  Any organism that lives on and derives its support and food from another organism.

**Pasture**  Growing grasses that are meant for grazing.

**Pathogen**  Any disease-causing organism.

**Pest**  A crop pest is either a plant or an animal that attacks and causes a reduction in crop yield.

**pH**  The numerical indicator of acidity or alkalinity of a medium.

**Photoperiod**  Daylength.

**Post-emergence**  After germination and emergence.

**Propagule**  Any plant used for propagation or regenerating the plant.

**Protein**  A biological polymer composed of amino acids.

**Race**  Inflorescence in which the flowers are borne on pedicels along an individual axis.

**Ratoon**  Second and subsequent crop from the original plant.
Rhizome: A root-like stem that grows prostrate on or under the ground.

Salination: Accumulation of salts in a soil.

Scion: The part of a graft combination which will form the upper portion.

Silo: A structure for storing grains.

Spikelet: In grasses, a small inflorescence composed of one or more flowers within a common pair of glumes.

Stubbles: Short stalks of cereal plant left behind after harvest.

Subsoil: The part of the soil that lies below the plough layer.

Sucker: A shoot which arises on a plant from below the ground or from an axillary bud.

Supplying: When seedlings are so few within a given area and many planting points are empty, some new seedlings are transplanted into the empty points so as to maintain the correct spacing. The process of planting up the empty points with young seedlings is referred to as supplying.

Thinning: When seedlings are so many in a given area, some are removed so as to maintain the correct spacing and avoid unhealthy competition and poor crop stands. The process of removing the excess seedlings is referred to as thinning.

Tillering: Production of several shoots from one root.

Tissue culture: The culture of isolated plant cell or detached fragments of plant tissues on a nutrient medium under aseptic conditions.

Triploid: Having three basic sets of chromosomes (3x).

Undergrowth: Shrubs and low bushes growing among taller trees.

Volunteers: Plants originating from seeds left from previous crop.

Waterlogging: The soil is so saturated with water that crop performance is drastically affected.

Weathering: A process by which rocks are broken down by natural agents.

Wilting: Plants show signs of death as if they are water stressed.
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CROP PRODUCTION: TOOLS, TECHNIQUES AND PRACTICE is written to familiarize students and teachers of Agricultural Science with a wide range of features, potentialities, and limitations of actual crop production vis-à-vis recent scientific discoveries and innovations in agriculture. The book should prove invaluable in helping its users relate concepts taught in the classroom to actual practice.

The following topics have been adequately treated in the book: list of crops in Nigerian agriculture, farm machinery and implements, soil and plant nutrition, simple farm tools, irrigation and drainage, arable crops, plantation crops, vegetable crops, and weeds.

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