Agricultural Science

for Secondary Schools in Guyana

Book Two
BOOK II

Fitzroy Weever
Joy Johnson
L.M. Philip Nwei
Yvonne Mce Intosh
Nathalie Henery
Wendell Archer
Lennox Vicerie
Wilmer K. Bagot
Edward O' D Williams (Convenor)

PROJECT STAFF:
Co-ordinator: Fitzroy Marcus
Asst. Co-ordinator: Rita Lowell
Secretary: Lucy Williams
Specialist Editor: Hazel Moses

Design staff: Petaline Mc Donald
Beverley Edward
Michelle Burgess
Deonarine Geer
Tyrone Doris
Emerson Samuels
Rawle Franklin
# CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. PRINCIPLES AND PRACTICES OF CULTIVATION</strong></td>
<td>1</td>
</tr>
<tr>
<td>- Selection of crops</td>
<td></td>
</tr>
<tr>
<td>- Land preparation</td>
<td></td>
</tr>
<tr>
<td>- Propagation of crops</td>
<td></td>
</tr>
<tr>
<td>- Care and maintenance of crops</td>
<td></td>
</tr>
<tr>
<td>- Harvesting and marketing</td>
<td></td>
</tr>
<tr>
<td><strong>2. CULTIVATION OF CROPS</strong></td>
<td>43</td>
</tr>
<tr>
<td>- Cabbage</td>
<td></td>
</tr>
<tr>
<td>- Sweet potato</td>
<td></td>
</tr>
<tr>
<td>- Citrus</td>
<td></td>
</tr>
<tr>
<td>- Coconuts</td>
<td></td>
</tr>
<tr>
<td><strong>3. MANURES</strong></td>
<td>81</td>
</tr>
<tr>
<td>- Organic manures</td>
<td></td>
</tr>
<tr>
<td>- Inorganic manures</td>
<td></td>
</tr>
<tr>
<td><strong>4. INTRODUCTION TO RECORD KEEPING</strong></td>
<td>96</td>
</tr>
<tr>
<td>- Importance of record keeping</td>
<td></td>
</tr>
<tr>
<td>- Simple records</td>
<td></td>
</tr>
<tr>
<td>- Examples of simple records</td>
<td></td>
</tr>
<tr>
<td><strong>5. SWINE</strong></td>
<td>100</td>
</tr>
<tr>
<td>- Introduction to swine</td>
<td></td>
</tr>
<tr>
<td>- Management of pigs</td>
<td></td>
</tr>
</tbody>
</table>
6. FISH CULTURE
   - Fishes
   - Rearing of fish
   - Fishing
   - Marketing

7. FARM MACHINERY AND EQUIPMENTS
   - The tractor
   - Tractor attachments
ACKNOWLEDGEMENT

The writing team is grateful to the following persons and Organisations for the assistance given in the production of "Agricultural Science For Secondary Schools In Guyana BK II"

Inter American Institute for Cooperation in Agriculture - Guyana.

Fitzroy Marcus – Project Co-ordinator, for his guidance and patience.

Rita Lowell – Assistant Co-ordinator, for serving as facilitator to the team.

Petaline MacDonald and Beverley Edwards – Design Typists attached to the Secondary Schools Text Book Project.

Lucy Williams – Project Secretary, for providing valuable secretarial services.

David Symes – Consultant, for providing the team with the necessary skills to proceed in preparing the series.

Emerson Samuels, Rawle Franklin, Tyrone Doris and Deonarine Geer who prepared the illustrations.
FOREWORD

It is with considerable pleasure that one welcomes this second set of books of the Secondary Text-book Project. We congratulate all those responsible for the project.

Guyanese children and the society as a whole will be the beneficiaries of the fruit of much labour put in by planners, administrators, writers, editors, consultants, and, most important of all, project co-ordinator, Mr. Fitzroy Marcus. We thank them.

We are also very mindful of the financial assistance and advice which the project has received from the UNDP. It is in this kind of co-operation and collaboration that education will be made possible for this world's children.

Dale A. Bisnauth
Minister of Education &
Cultural Development
Preface

This Project underscores the importance of making textbooks available so that the quality of education is improved. This joint effort by UNDP/UNESCO and the Guyana Government to provide low cost texts and to encourage the development of textbook writing skills, represents a significant milestone in the development of a publishing capability within the Ministry of Education.

The tasks involved in this exercise were many and difficult but commitment of the small project staff and the writing team contributed to successful production.

The writing team included experienced teachers, teacher educators and university lecturers. This was a deliberate attempt to use experiences from across the education sector while catering for the needs of our learners.
1. PRINCIPLES AND PRACTICES OF CULTIVATION.

In this chapter efforts have been made to outline the sequential steps in crop production. Such steps are selection of crops, land preparation, propagation of crops, care and maintenance and harvesting and marketing.

Selection of crops

Selection of crops suitable to a region or an area depends on factors such as climate, soil type, labour and capital, transportation and marketing facilities, and socio-economic conditions.

Climate

Climate is the most important limiting factor in the production of crops. Climate is the average of rainfall and temperature found in a particular place for a long time usually a year or more, In the Caribbean, rainfall is of tremendous significance. The amount and distribution of rainfall throughout the year is very important. One area may get over 70-80 percent of total rainfall for the year in 3 months and for the rest of the year it is dry. In such a situation the farmer must select the types of crops that will mature within the short period when there is moisture. Long-duration crops, like sugar-cane, cannot be grown there unless it is supplemented by irrigation water during dry spells. If irrigation cannot be provided, drought tolerant crops like cotton can be grown in those areas.

Temperature is not a critical factor in the Caribbean islands, as it is in the tropics and sub-tropics. In mountainous areas, there is lowering of temperature as one moves upwards from sea-level. At upper elevations where conditions are much cooler than the coastal plains, as in Guyana, cool weather crops like potatoes, lettuce, carrot, cabbage and some varieties of pulses can be selected to be grown. In the coastal areas where temperature is higher than in the hilly areas, warm weather crops like corn, cotton, sorghum, rice, sugar-cane and peanuts could be selected to be grown: Temperature and rainfall also influence the quality of the fruit. Under low rainfall and high temperatures, fruits like pine apples, mangoes and citrus fruits are much sweeter.
Soil type

While climate largely determines the crop growing regions, soil characteristic is an important factor in selecting specific crops, because soil requirements vary somewhat for different kinds of crops. The selection of the right type of soil best suited to the crop or crops is important. Crops like rice and sugar-cane require a clayey type of soil which could retain moisture for plant growth, while crops like peanut, cassava and potatoes prefer a loose, friable type of soil for easy penetration of pegs as in peanuts, and for better development and easy harvesting of tubers and peanut pods at the time of maturity. Most crops prefer a pH range of 4.5 to 6. Sugar-cane can tolerate very acid soils if drainage is good. Crops like coconut and beet can tolerate and grow successfully on sandy alkaline soils.

Labour and capital

Based on the availability of labour and capital, the farmer may choose to grow crops which need either intensive or extensive care. Cash crops like potatoes, pepper, onions and tomatoes need more inputs like finer land preparation, fertilizers, pesticides, irrigation water and more labour to care the plants. These are referred to as crops which need intensive care. On the other hand crops like cotton, cassava, mango and citrus do not need as much care and inputs as the crops mentioned under intensive care. The farmer may select his crops depending on the availability of land, labour and capital resources.

Transport and marketing facilities

Another factor that needs consideration in selecting crops is a market for the produce. If there is no market in the vicinity and transportation to outlet centres is difficult and expensive, it will not be wise to select crops that are easily perishable. Instead, it is better to choose crops that are high-priced and can withstand storage well and offset the high transportation cost.

Socio-economic factors

Socio-economic factors like consumer preference, market demand for produce, financial resources available for capital and recurrent expenditure are also factors which determine the selection of crops to be grown in an area.
Land preparation

Having selected the crop best suited to his situation, the farmer needs to attend to other areas of crop production, e.g. land preparation. This is a very important step in crop production. Because plants absorb nutrients in solution from the soil, they must be grown on fertile soils if they are to produce maximum yield. Fertile soils have physical and chemical properties which allow root systems to develop fully. They also permit roots to carry out their functions properly. Very often, lands which are used to grow crops do not have all the properties plants need. Farmers then, need to prepare these lands so that there is a favourable environment for planting and growing crops. The process of land preparation includes the following activities:

- land clearing
- laying out
- ploughing
- harrowing
- mulching
- constructing beds and drains, or ridges and furrows
- mixing in limestone
- mixing in manures
- applying pesticides

Depending on the existing soil conditions, only some of these activities may be necessary in order to provide favourable soil environment for crop production.

LAND CLEARING

Land clearing is done to remove unwanted vegetation and objects from the field. Existing plants need to be removed for the following reasons:

- They would compete with crop plants for soil nutrients, soil moisture, direct sunlight and root space.
- They are hosts for some pests e.g. insect pests and fungi.
- Some plants have pimplies and thorns which cause injury to farmers and livestock.
- Some plants cause irritation to farmers e.g. cow itch (*Mucuna pruriens*) cause serious skin irritations.
- Some plants are poisonous.
- Some plants interfere with the free flow of air among crop plants.

Objects such as large rocks, branches and scrap metal occupy much and hinder other activities necessary for land preparation.

The method used for land clearing depends on the area of land, the crop to be
grown, the type of vegetation on it, the slope of the land as well as tools and equipment available to the farmer. These factors also affect the amount of clearing that is done on a particular field. Generally, clearing may be done manually or mechanically.

**MANUAL LAND CLEARING**

On forested lands, full clearing is not usually done. The cutlass and hook-stick are used to slash shrubs and other undergrowth just above ground level. The axe and wedge are used to chop trees at a convenient height above ground level.

Tree stumps are removed especially when ploughing has to be done. Dried debris is usually burnt, but this is not recommended since burning destroys valuable organic matter as well as the soil structure. In addition, bare soil particles which are left on sloping land would be exposed to erosion. Debris should be heaped up and allowed to rot. This will increase the soil organic matter content which is needed for maintaining good soil structure.

On smaller fields which might have been cultivated before, the main land clearing tools are the cutlass and hookstick, or the hoe. Clearing is done at ground level. The pitch fork and rake are then used to heap up debris for rotting or for the compost.

**MECHANICAL LAND CLEARING**

The bulldozer is popularly used for land clearing. It performs well on savannahs and lightly forested areas. It is capable of removing most of the vegetation. Motorized chain-saws can be used to fell large trees. In large land clearing operations, there are heavy machines called “the tree dozer and stumper”, which can fell and remove stumps of large trees. The fore-mounted rake on the tree dozer is useful in heaping up debris to be rotted. Bulldozers are used for this purpose too, but unfortunately they scrape off much of the valuable topsoil which is vital to healthy crop growth and development.

On fields where the vegetation is mainly herbaceous, the tractor and harrow can be used to chop up the plants before ploughing is done.

**LAYING OUT**

Laying out makes it possible for farmers to design fields so that other farm activities can be done orderly and with much ease. Fields which are well designed can be managed efficiently. The laying-out process involves:

- finding out the slope of the field
• fixing the boundary lines around the field
• setting up a baseline from which other measurements would be taken
• dividing the field into blocks of regular shapes (rectangular or square) – pathways should separate each block
• measuring off areas for drainage and irrigation channels (on sloping land channels should flow across the slope)
• measuring off areas for dams
• dividing blocks into plots
• dividing plots into beds, drains or ridges and furrows.

There are advantages of laying out fields. Some of these are: to have good drainage and irrigation systems, to give plants enough space for growth so as to make maximum use of land, to have easy access to and from plants and to determine the yield per hectare.

PLoughing

Crop farmers plough fields so as to break up surface soil and to turn the topsoil to a desirable depth. In this way the sub soil is exposed to sunlight and other atmospheric conditions. Soil particles in the subsoil layer are more compact than those in the topsoil layer therefore when the sub-soil is exposed to atmospheric conditions it will weather and become friable. Loosing up the soil particles allows free movement of water, air, and plant roots among soil particles. Surface water can now move over soil clods to the spaces between them and into field drains, thereby reducing water logged soil conditions.

Aerated soils also encourage the activities of soil micro-organisms which speed up the rotting of soil organic matter to humus. Also, oxygen is available for the respiration of root hairs. Since plants need friable soil throughout the root zone, ploughing must be deep enough on the heavy clayey soils to allow proper root growth.

The control of crop pests such as weeds and soil insects also results after ploughing. Weeds are buried with the topsoil while soil organisms in the sub-soil are exposed to direct sunlight and are killed. This causes an increase in the soil organic matter content which later decomposes to form humus. Humus helps to maintain small, friable soil clods, release plant nutrients to the soil and keep soil particles moistened.

Ploughing on sloping lands should be done across the slopes. Ploughing along
slopes encourages gully formation and serious erosion problems.

When ploughing is done manually on heavy soils, large digging forks are commonly used. The hoe is popularly used on light soils (sands). Mechanically, ploughing is done by the tractor with a plough attached.

HARROWING

Harrowing or chipping is done after ploughing to break up large soil clods into smaller ones. In this way a soil structure of suitable tilth can be prepared for planting. Tiny seeds need to be sown on seed beds with a fine soil tilth so that seeds can be in close contact with soil particles from which they obtain moisture for germination. Soils with small friable soil clods can keep more water around the soil particles since there is an abundance of small pore spaces. These soils are also better aerated and allow tiny roots and root-hairs of seedlings to grow freely.

![Diagram](image.png)

**Fig 1.1** (a) Root development in friable soil conditions  
(b) Root development in untilled and compact soils conditions

After the field has been ploughed, large furrow slices can be broken up by the tractor and harrow. Harrowing is essential on clayey soils. On sandy soils it may not be necessary since the rotovator can produce the soil tilth required. On smaller scales of operation, chipping is commonly done with the cutlass on clayey soils. On sandy soils, large furrow slices can be shattered with the back of the hoe while ploughing. The rake is sometimes used for chipping and levelling.

For wet-lands soil preparation as is necessary for rice planting, harrowing is done on flooded clay fields with the tractor and harrow. Soil clods are destroyed and puddled soil conditions result.

Farmers need to be cautious of the disadvantages of producing a fine soil tilth.
Some disadvantages are:

- compaction of the lower layers of soil particles
- blocking of soil pores thus causing surface crusting during wet conditions
- loss of soil moisture when fresh soil is repeatedly turned over and exposed to air in dry conditions. Successful harrowing can be obtained in suitable weather conditions and on soils with high levels of humus.

**CONSTRUCTING BEDS AND DRAINS, OR RIDGES AND FURROWS.**

![Diagram of root development with shallow and deep drains](image)

Fig 1.2  (a) The effect of a shallow drain on root development  
(b) The effect of a deep drain on root development

The formation of beds and drains, or ridges and furrows allows the removal of excess soil from the root zone of plants. When excess soil water moves from the soil to the field drains and out into drainage canals, the water table of the soil is lowered. Plant roots can then grow deeper into the soil. Deeper root penetration helps roots to reach more nutrients in solution during dry weather conditions, and anchors plants firmly in the soil as well. Some plant roots rot when they are in continuous contact with too much soil water.

Well balanced soil particles have an abundance of small pore spaces with a good balance air and water.
Fig. 1.3 Cambered beds

When planting is to be done on low lying lands, the farmer needs to construct raised beds on which to grow crops. Beds raised to about 20 cm above ground level not only facilitate free draining of excess water, but also provide more room for root development. Beds are usually about 120 cm wide with drains 30 cm wide around each bed. Top soil removed during drain construction is used to heighten beds. Beds with curved tops which slope gently towards the two long sides are called cambered beds.

Fig. 1.4 Ridges and ridge formation

Ridges are built higher and steeper than beds. There is a line along the centre of the ridge where the two steeply sloping sides meet. Ridges also allow free water movement but there is more room for root development. Excess soil water collects in the furrows and flows out of the field to the main drainage system. Deep drains and furrows lower the water table so that more soil is drained.

Drains and furrows can also be used as irrigation channels to lead water into
the field during dry weather conditions. Farmers must ensure that drainage outlets are closed when they are irrigating fields.

Tools and equipment used for the construction of drains are: the garden fork, shovel, spade, garden line and pegs. On a larger scale the hynac drain digger is used. Tools and equipment used for furrow construction are: the hoe, garden line and pegs. On the larger scale, the tractor and ridger are used.

INCORPORATING LIME STONE

Many crop plants cannot tolerate high levels of soil acidity. This soil condition causes some nutrients to become insoluble and remain in the soil therefore none can be dissolved in the soil water which root hairs absorb. Plants grow poorly and produce little or nothing on such soils. The level of soil acidity can be found out by sending a good soil sample from the field to the soil laboratory. From the results, the amount of limestone needed to correct the acidity can be determined.

Limestone helps to make the soil less acidic. It facilitates desirable chemical reactions in the soil, improves clod formation and supplies calcium, one of the essential plant nutrients. Applications of limestone should be made at least 10 days before organic manures are added to the soil because limestone destroys the nitrogen contained in these manures. There is need to mix limestone with the top soil particles.

MIXING IN MANURES

All substances added to the soil to increase the supply of plant nutrients are called manures. They may be either organic or inorganic. Organic manures include animal dung and urine mixture, compost, and green manure. Inorganic manures are concentrated substances which are also called fertilisers e.g. urea, triple super phosphate and muriate of potash. A laboratory test should be done on a soil sample of the field to find out the quantity of each type of nutrient present. By comparing those figures with the amount of nutrients the crop needs, the quantity of manure to be applied to the soil can be calculated. Nitrogen, phosphorous and potassium are nutrients which root hairs absorb plentifully from the soil. They should be replaced before the next crop is planted. The manures listed earlier are popular ones used on crop farms.

Organic manures are usually broadcast over the field and mixed into the top soil. On a large scale, the tractor and disc-harrow or the tine harrow could be used. Inorganic manures can also be broadcast over the soil in the final stages of land preparation.
APPLICATION OF PESTICIDES

Pesticides are applied to the soil to control crop pests which live there. Crop pests include nematodes which block transport vessels in plant roots, soil fungi which cause damping-off and root rot, and soil insects which destroy roots as they feed. Nematicides, soil fungicides and insecticides are chemical substances used to control these pests. Nematodes and insect pests can be controlled with applications of Furadan 5G or Vydate L to the soil. Soil fungi can be controlled with applications of Rizolex 50 W.P or Banrot to the soil. Diazinon 60 E.C or Diazinon 40 W.P are also recommended for the control of soil insects. Care should be taken to follow the manufacturer’s instructions for use of these pesticides.

On nematode infected soil, nematodes can be controlled by fumigating the soil with a nematicide e.g., Nemagon. Nemagon is a liquid fumigant. When it is injected into the soil it becomes a lethal gas which kills the nematode.

Propagation of crops

Propagation of plants is the growing of new plants by using different plant materials. There are two basic types of plant propagation:

- **sexual** reproduction
- **asexual** reproduction

Sexual reproduction

Sexual reproduction is the process whereby seeds are used to produce new plants. A seed is a mature ovule. It is really a young plant in the resting or dormant stage. It is the means by which a plant reproduces itself at a later time when conditions are favourable.
Fig 1.5 (a) Monocotyledons - corn seed  (b) Dicotyledons - bean seed

PARTS OF A SEED.

The main parts of a seed are:

• the **testa** which gives protection to the cotyledon and embryo in the early stages of growth

• the **cotyledons** which are seed leaves in which food materials are stored for the embryo

• the **embryo** which is made up of the young shoot or plumule and the **young root** or radicle

• the **plumule** or embryonic shoot which consists of a short embryonic stem extending above the attachment of the cotyledons

• the **radicle** which is an extension from below the cotyledons and which develops into a root

• the **endosperm** which is an additional storage of food in some seeds.
Fig. 1.6 (a) Maize cotyledon and endosperm
(b) Coconut embryo and endosperm

SELECTION OF SEEDS

Healthy plants are grown from good quality seeds that were produced by plants with vigorous growth and high yields.

Seeds should be harvested when they are mature. They should be free from excessive moisture and stored in a dry place. Large seeds should be selected since they store a large amount of food which is essential for early nourishment of the young plant. These seeds should not be wrinkled nor warped. They must be free of any insect damage or any form of infestation. The embryo must be free from damage before germination can take place.
Seeds should not be stored for a prolonged period. Old seeds usually lose their capacity to germinate.

REQUIREMENTS OF GERMINATION

Most seeds, especially crop seeds, begin to grow soon after they are planted in a moist, warm soil. Each kind of seed has its own requirement and preference for moisture, temperature, air and light.

- **Moisture** is the first requirement for germination. Some seeds require more moisture than others, for example, spinach and cabbage require very little moisture while rice has to be completely submerged. Seeds with water proof seed coats must be scratched so that water is allowed to seep in.

- **Temperature** is another requirement. Some seeds such as corn and beans germinate in warm temperatures. Others such as wheat, germinate in cold temperatures.

- **Air** contains oxygen which seeds need for germination. Seeds that are sown too deep, especially in heavy clay soils, do not germinate because they lack oxygen. The smaller the seed, the more shallow it should be sown.

- **Light** is necessary for the germination of some seeds. For this reason, some seeds will germinate only when brought to the surface after having been buried for months or years. On the exposure to sunlight they soon start to grow.

Before seeds are planted, the farmer must carry out a viability test to ensure the germination of eighty percent (80%) of his seed lot. This avoids waste of seeds and time. The following experiment illustrates how this can be done.

**Viability Test:** A sample of a hundred seeds is placed in a moist blotting paper on a flat tray. As the seeds germinate they are counted and taken out. This is done at intervals until what seeds remain fail to germinate. If the germination count is less than 75-80% then those seeds should not be planted.

There are basically two types of seeds; **dicotyledonous** seeds and **monocotyledonous** seeds. Seeds germinate in two different ways. **These are epigeal germination and hypogeal germination.**
Fig. 1.7 Epigeal germination

In some plants during the process of germination the germinated seed leaves are lifted above the ground. This is called **epigeal** germination. In other plants, for example corn, the seed leaves are left below the ground level. This is called **hypogeal** germination.
Fig 1.8 Hypogeal germination

Seeds are planted either in a nursery or directly on a garden bed. Some seeds that are very small and have delicate seedlings are planted in a seed box or seed bed in a nursery.
THE NURSERY

A nursery is a place where seeds are sown until they germinate and develop into mature seedlings.

A typical nursery should be protected against strong winds by wind breaks such as hedges or trees. A tall hedge around the nursery protects the seedlings from strong dry winds and straying animals. The roof should be covered with clear plastic or fibre glass sheets instead of metal, to protect the plants from excess sun and heat.

SEED - BOXES

Seeds can be sown in wooden seed-boxes, the dimensions of which are normally 35cm $\times$ 25cm $\times$ 7cm. The bottom of the box has slits for drainage. Plastic boxes should have holes instead of slits. Seed boxes should be thoroughly cleaned.

PREPARATION OF SEED - BOX FOR SOWING

A thin layer of straw is placed at the bottom of the box in order to cover the slits and prevent the soil from passing through.

Three centimetres of potted soil is placed in the seed-box. Finely sifted soil is placed on the soil in the box. The soil is pressed down gently to a depth of 1-1.5 cm from the top.

Fig. 1.9 Preparation of seed-box with different layers
Fig.1.10 Layers of soil in a seed box

SOWING SEEDS

Seeds are sown in rows or broadcast thinly over the entire surface. This is done by a gentle shaking movement of the packet or spread by the thumb and forefinger.

The seeds are covered with a thin layer of sifted soil. The seed box is covered with appropriate material and watered regularly.

SEED GERMINATION

Some seeds such as eggplant, pepper and celery take about six to eight days to germinate. Other seeds such as lettuce and pakchoi take three to four days.

When seventy five percent of the seeds have germinated, the covering should be removed, and seedlings exposed to light.

Pricking out (or thinning out)

At the two or three leaf stage, the underdeveloped seedlings are pricked out and replanted. This transfer helps because it gives the seedlings more light. The seedlings have more root room to develop stronger roots. Diseases which may attack the seedlings in the seed boxes are controlled.

A leaf is held between the thumb and index finger. The soil is stirred around the plant which is gently lifted out with a hand spade or shallow spoon. The seedling is then replanted into a new box.

POST GERMINATION CARE

In wet seasons seedlings should be watered when necessary. Whereas in dry seasons they should be watered twice a day.

The soil should be stirred up at intervals to encourage aeration, infiltration and prevent crusting.
Weeds should be hand picked since weeds compete with plants for food nutrients and sunlight. Pests and diseases are controlled by the application of appropriate chemicals.

HARDENING OFF

Hardening off is done to prepare seedlings for field conditions. Seedlings are watered less frequently and are exposed to the sun and rain. After this process seedlings are transplanted to the field at specific spacing.

Asexual reproduction

The production of new plants by any other way than the planting of seeds is called asexual or vegetative reproduction. There are two types of vegetative propagation. These are natural vegetative reproduction and artificial vegetative reproduction. There are two types of vegetative propagation. These are natural vegetative reproduction and artificial vegetative reproduction.

NATURAL VEGETATIVE REPRODUCTION

This occurs when vegetative parts of plants produce new plants without the aid of man. These may be in two categories—above ground and underground. Some examples of vegetative reproduction above ground are fallen sugar-cane stem, fallen leaf buds from the Bryophyllums spp.(leaf of life), fallen bulbs from the king yam and through adventitious bud development on exposed roots of plants as in the breadfruit plant. Examples of below ground vegetative reproductive organs are stem tubers such as white potato, root tubers such as sweet potatoes, rhizomes like ginger, bulbs such as onions and corms like eddoes.

(a) coco corm
(b) yam tuber
old corm
present corm
next year's corm
flesh of tuber
new shoot

Fig.1.11
Fig. 1.11  Some underground stems

Fig 1.12  Stem cuttings

**ARTIFICIAL VEGETATIVE REPRODUCTION**

Examples of artificial vegetative reproduction are budding, grafting, layering, air layering and cuttings, including tissue culture. This type of reproduction must be carried out by man.

**Budding:**  Citrus are propagated by means of budding. The bud of a plant with desired characteristics is placed into a closely related plant which will benefit from
the desired qualities of the bud.

(a) unprepared root stock

(b) root stock prepared for budding

Fig 1.13 Preparation of root stock.

1 Selected stem to be used as budwood

2 Prepared budwood

3 Budwood wrapped in a damp muslin cloth

Fig 1.14 Preparation of budwood.

Propagating citrus plants by means of budding

1 cutting the bud

2 bud ready for budding

Fig.1.15
3 Root stock with inverted cut
4 Bud inserted in root stock
5 Bud wrapped with budding tape

6 Unwrap budding tape.
   Head of root stock broken back

Growth of inserted bud

Fig 1.15 Budding operation.

Fig 1.16 Successful budding operation.

The plant which is used as the root stock must be hardy. The bud is called the scion. Budding consists of three steps:

- preparation of the bud wood.
• preparation of the root stock
• budding operation.

The bud wood is taken from the stem before the last flush. After the leaves are clearly cut off the bud wood is stored in a damp cloth.

An inverted T cut is made on the root stock at a height of 38-45 cm above the ground. A bud is removed from the bud wood and placed in the root stock by lifting the bark and pushing the bud upwards. Budding tape is used to wrap the union. After ten to fourteen days the wrap is removed. If the bud is green then it will grow.

A rectangular patch is removed from the root stock and a similar patch is also removed from the budwood. The bud is placed directly on the patch of the root stock and fastened with sellotape.

**Grafting**: In grafting, the whole shoot is used. Types of grafting are:

• grafting by approach
• cleft or terminal grafting
• vaneer grafting.

![Diagram](image)

1 Mango stone  
2 Damp moss  
3 Root stock with crown removed

**Fig 1.17 (a) Approach grafting**
Cleft grafting: The seeds of the root stock are planted. The plants are left to grow. When they are four months old they are cut to 25cm from the ground and a vertical cut of 7.5 cm is made through the centre of the root stock.

A scion of 4cm is prepared with a corresponding wedge shape. The scion is forced into the vertical cut. The two cambial layers of the same size should be joined and then strapped.

Vaneer grafting: The stock at most times is larger than the scion. The top of the stock is taken off after the grafting operation has been successfully completed.
A thin long section is removed from the stock and a corresponding cut is made on the scion. This is about 5cm long. At first a thin section of the bark is removed, but as the knife goes towards the root, the cut moves deeper into the stem until the end of it is about one third of the diameter. A transverse cut at an obtuse angle is made on the stock to accommodate the scion.

**Grafting by approach**: The cambium layers of the root stock and the selected scion are brought together after incisions of about 7.5cm on both scion and root stock are made. This takes about eight weeks for a successful union to occur.

**Layering and air layering**: Layering is the development of roots on a stem which is still attached to the parent tree.

**Simple layering**: A soft stem is gently pulled to the ground and covered with two inches depth of soil. The soil is kept moist. Roots develop after a period of three to four weeks.

---

**Fig 1.19 Simple layering**

Cut stem from the main branch a week after the new plant is taken out, put in
a pot or in a field.

## Care and maintenance of crops

Sowing seeds or transplanting seedlings into the field is only part of a series of operations to achieve harvest. Following the establishment of seedlings, a number of maintenance operations are necessary. These vary from crop to crop and the specific operations will be dealt with under individual crops, but the practices common to many crops are as follows:

- irrigation
- weed control
- mulching
- fertilizer application
- pest and disease control

### Irrigation

Rainfall in the Caribbean is not evenly distributed throughout the year. Even areas which receive a high total of annual rainfall have dry seasons when water shortage may occur and cause crop failure. After the plants have been established in the field, if there is insufficient rainfall or if rain is not forthcoming it is necessary to apply supplemental water to avoid adverse effects on the normal growth and development of the plant reduction in the yield of crops. This artificial application of water to the soil to ensure an adequate supply of moisture to meet the crops needs is termed **irrigation**. Irrigation is essential for the profitable production of most crops. A rainfall of 140-180cm per year is considered good for crop growth. Irrigation is necessary wherever the annual rainfall is less and in areas where there is a shortage even for a short while during the growing period of the crop.

The amount and frequency of irrigation depend on the soil type, the kind of crop, stage of growth of the plant, the effective rainfall, the rate of evaporation from the soil surface and on transpiration from plants. Fine clayey soils hold moisture longer than sandy soils and can be irrigated at longer intervals. Deep soils hold large quantities of water than shallow soils. Organic matter incorporated in light soils increases the water holding ability of such soils. In general, vegetable crops grown for their foliage require uniform moisture throughout their development, while those grown for fruits and seeds require large amounts during fruit set and development.
Environmental factors like high temperature, wind speed and low humidity, increase the water needs of plants with the resulting increase in the need for frequent irrigation. The amount of rainfall and its distribution during the growing season largely control the frequency of irrigation.

After a rainfall irrigation, when excess water has been drained off by gravitational force, the soil will have maximum quantity of water available for the plant, to meet its needs. At this stage soil is referred to as being at field capacity. The continued removal of water by plant roots and evaporation from soil surface leads to a stage where the remaining water in the soil will be held firmly by the soil particles and will not be easily absorbed by plant roots. When this happens the plant begins to wilt. This means that the moisture reserves of the soil available for plant growth are exhausted. This stage is referred to as the permanent wilting point (pwp). The volume of water held between actual field capacity and permanent wilting point is referred to as readily available moisture. The difference between actual available moisture and maximum available moisture in the soil would indicate the amount of water to be applied. Available soil moisture can be determined by the instrument termed tension meter. Generally, irrigation should begin when 60 percent of the maximum water is removed from clayey or medium textured soil or when 40 percent is removed from sandy soils.

**Sources of irrigation water**

Water may be obtained from surface water sources such as rivers, streams, lakes, reservoirs, or from ground water sources such as springs, shallow wells or deep bore holes. It may also be obtained by collecting rain water directly from roofs. A farmer may use one or more sources in obtaining water for irrigation.

**Methods of irrigation**

The method to be used in an area will depend upon the topography of the area, the characteristic of the soil, the type of crops to be grown and the size of the area to be irrigated.

Sprinkling water by means of a hose from pipe lines, or using watering cans on a small vegetable garden to supply the water needs of the crop during a brief dry spell, is one from of irrigation.

**CHANNEL (FURROW) IRRIGATION.**

In channel irrigation canals are built to convey the water from lakes, rivers and wells to furrows or basins, through gravitation. In furrows only part of the surface area is
wetted, in level basins the whole area is flooded. Basins may vary in size from large paddy fields for rice which are continuously flooded during the growing period of the crop, to very small basins for a few plants or a single tree which are flooded for a short period.

Fig 1.20 Setting out plastic syphon spiles for irrigation

Furrow irrigation is adapted to soils of clayey or medium texture, where intake is medium or low and where the surface soil is deep and uniform and the subsoil does not impede drainage. The topography of the land must be gently sloping and uniform for good water distribution.

Large quantities of water should be available, but the area to be irrigated at any one time should be restricted to the number of furrows the irrigator can observe closely enough to adjust flow rates satisfactorily.

SPRINKLER IRRIGATION

Sprinkler is more suitable where land is too steep, topography uneven or soils very permeable. In overhead sprinkle irrigation water is pumped into distribution pipes from canals or reservoirs and water is applied through fixed or revolving nozzles spread at regular intervals. The portable aluminium pipes (light weight) are moved at intervals so that water is distributed evenly over the cropped area. Fringe area may not get enough water with sprinkler irrigation, and 40 percent overlap is needed for equal moisture penetration near the periphery of each circle. The rate of application
should not be greater than 75 percent of the soils capacity to absorb it. In this method the distribution of water is better than surface irrigation, and there is less wastage of water through seepage. The initial capital cost and maintenance costs are very high and reliable workmen for moving the pipes and refitting them are necessary. Sprinklers are less efficient at wind speeds above 4 miles per hour, as the distribution of water from the sprinklers is liable to be uneven.

**DRIP (TRICKLE) IRRIGATION**

This method is very useful where water is in short supply. Water is supplied through PVC pipe lines to each row of plants and a small nozzle allows water to drip out and maintain a moist zone around the plant roots. By this method the plant root zone is never dry and never water logged. As water is not spread over the whole surface of the field, weeds are not encouraged between plant roots and losses from evaporation and seepage are reduced to a minimum. Drip irrigation has recently become popular in Australia, Israel and USA.

**Weed control**

As crops grow, other plants make their appearances in the field. Any plant growing in a place where it is not wanted is termed a weed. By this definition a maize plant on a cassava field is a weed. If these plants are not controlled at the early stage (two leaf stage) of growth they crowd out a cultivated crop and have many adverse effects on the crop plants as well as on the quality of the produce. In the tropics, high temperature and sunshine favour rapid and luxuriant weed growth when moisture conditions are favourable. Most weed grow faster than crop plants even under conditions that are not favourable for crop growth. In the early stages of crop growth weed competition is particularly harmful and it should be eradicated while the crop is young.

**Harmful effects of weeds**

- Weeds compete with crop plants for soil moisture, light, nutrients and space.
- Weeds harbour insect pests and disease organisms of crop plants.
- Weeds increase the cost of cultivation.
- Weeds make it difficult for crop products when it is contaminated with weed seeds.
- Weeds increase cost of maintaining irrigation and drainage channels.
- Some weeds poison man and livestocks e.g. Datura.
METHODS OF WEED CONTROL

Hand pulling: If the area cropped is small or when there are few weeds in the field it is advisable to hand pull them. When crops are growing very close to each other and use of implement is difficult, hand pulling is advocated. This practice is most suited for annual and biennial weeds before they have come into flower. In perennials since their stems are deep into the soil repeated pulling will be necessary.

Inter-tillage: After the crop has germinated a range of implements ranging from cutlasses to short handle hoes, tine harrows, cultivators and rotavators are used between rows of plants to control weeds. Cultivation aims at either disturbing the root system of the weeds or burying them between rows of crops. The best time to cultivate is before the weeds have become established, since they are more easily killed when they are small. Cultivation should be done as often as necessary to prevent weeds from injuring the crop. In wetter areas more weeding is required before the crop grows and covers the soil, and suppresses weeds by shading. Over and above a certain number of weedings it becomes uneconomic as the resulting extra yield will not justify the extra expense incurred.

Flooding: Flood-tolerant plants like paddy could thrive well under flooded conditions. Flooding provides an anaerobic condition. All cyperus varieties and some grasses are killed in paddy fields that are flooded continuously and the weeds are completely submerged.

Smothering weeds can be controlled by using straw paddy husk as mulches. Mulching controls weeds by cutting out light from the surface of the soil. This prevents germination and growth of weeds. Many weeds are incapable of penetrating the thick layer (about 6 inches) of mulch even if they were to germinate they would therefore die.

Fertilizers and manures: The proper and timely application of fertilizers and manures could encourage crops to grow faster and suppress associated weeds.

CHEMICAL WEED CONTROL

It is possible to control weeds using chemicals without seriously affecting the crop in which the weeds are growing. These chemicals are termed weedicides or herbicides. They can be applied on the weeds or soil either in the form of spray or granules. Herbicides complement cultural methods of weed control rather than replace them. They could control weeds speedily and at the right time better than mechanical control methods. They are often best applied when the weeds are young, since weeds are more susceptible at this stage and less chemicals are required.

Contact non-selective weedicides: Some chemicals destroy all plants to which they
are applied by scorching the area of the foliage with which they come in contact. These are termed as **contact non-selective herbicides**. Their effectiveness depends on how thoroughly the foliage of the weeds is wetted by the herbicide. Since non-selective contact weedicides kill any foliage they come in contact with, whether crop or weed, they are generally used to control weeds before planting a crop. They can also be used with care on some hardy crops to control weeds between rows of plants. In sugar-cane or pineapple plantations non-selective contact weedicide like *paraquat* (Grammoxone) can be used to control weeds, provided care is taken by accurately directing the spray on weeds and shielding the young foliage of the crop from the spray.

**Selective contact weedicides**: They are selective in action. They destroy the weeds and leave the crops unharmed. Selective contact weedicides like **3,4 DPA (Stam F 34 or Surco pur)** are used in rice fields to control broad loaf weeds without damaging the rice plant. The chemical is used after the weeds have germinated and are at a two leaf stage.

**Systemic (translocated) weedicides**: These are hormone type and selective. They are capable of checking or destroying weeds without seriously harming the crop between which the seeds are growing. These types of herbicides are translocated within the plant system to points of active cell division, i.e. root and shoot tips and cause disturbance in the normal process of growth and eventual death of susceptible plants. Unlike contact herbicide, complete coverage of the weeds by the spray solution is not necessary. Selective translocated weedicides are particularly of value for destruction of deep rooted perennial weeds. They do not show scorching effect immediately after the weeds are sprayed. Examples of selective translocated herbicides are **2,4-D MCPA** which are commonly used in rice fields.

Some herbicides are applied to the soil at or before planting or after the plants are established. They prevent the emergence of weeds for some time. These are referred to as **soil sterilants**. The length of sterilization depends on the nature of the weed, the chemical used, its rate of application, the soil type and rainfall. Commonly used soil sterilants in fields are:

<table>
<thead>
<tr>
<th>Crops</th>
<th>Herbicides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar-cane</td>
<td>Atrazine, Alachlor</td>
</tr>
<tr>
<td>Maize</td>
<td>Gesaprim</td>
</tr>
<tr>
<td>Onions</td>
<td>Dacthal, Ramrod</td>
</tr>
<tr>
<td>Pepper</td>
<td>Lasso</td>
</tr>
<tr>
<td>Groundnut</td>
<td>Linuron, Planvin</td>
</tr>
</tbody>
</table>
Herbicides are strong chemicals which can be dangerous to plants if applied above the recommended dosage. If applied below the recommended dosage it will not have the desired effect on the weeds.

Fig 1.21 Early peppers showing mulches and trickle irrigation

**Mulching**

Mulching is the practice of having a layer of straw, leaves, compost, farm yard manure, pulverized corn cobs, peanut hulls, cotton seed hulls, wood shavings, sawdust, plant refuse, spreading paper or polythene sheets over the soil surface. Even a loose layer of soil produced by cultivation forms a mulch. Mulching is done before or after a crop is established. If paper or polythene sheets are spread over the entire field, holes have to be made at the recommended spacing at planting or seedlings points. If plant refuse such as straw, leaves, etc. are used, it should be spread to about 6 inches thickness over the soil between rows and around plants avoiding the base of the plant.

**PURPOSES OF MULCHING**

- Conserves soil moisture directly by preventing evaporation and indirectly by destroying weeds.
- Helps regulate the temperature in and around the plant near soil surface. Soil temperature under straw mulch may average several degrees lower than those of the unmulched soil.
• Helps to suppress weeds around the plants.
• Adds organic matter to the soil on decomposition.
• Improves the quality of produce, for example clean strawberry fruits are obtained from a mulched field.
• Serves as a barrier to the dislodging of finer particles from soil aggregate.
• Provides protection of the soil from erosion.
• Increases water infiltration.

High cost of paper mulch and difficulty to obtain enough plant refuse especially for complete coverage of the soil restrict the use of mulches on crops of high value which are known to respond well. Polythene sheet mulches are used in pineapple and coffee production in countries like Hawaii and Kenya.

**Fertilizer application**

The quality of crop produce depends primarily on a continuous supply of available nutrients and moisture in the soil. High fertility in the soil is required for rapid early growth, and most seed and fruit producing plants cease growing at the time of fruit set and the subsequent yields are dependent upon the amount of plant growth before fruiting.

Fertilizers are frequently applied to the soil during land preparation and at which time, they are rapidly mixed with the soil. Silt and clay loams can usually be fertilized sufficiently with phosphorous and potassium before planting to supply the nutrient needs during growth of the crop. These soils are free from leaching. Sandy soils which are susceptible to leaching and are poor in nutrient holding ability may require frequent light application of fertilizers during the growth of the crop.

The major nutrients required by plants are nitrogen, phosphorous and potassium. They are needed in adequate quantities for healthy plant growth. They function in the following ways:

**NITROGEN**
• helps to build up vegetative parts of the plant, producing large green leaves
• is necessary for filling out seeds.

**PHOSPHOROUS**
• is necessary for cellular metabolism
• assists in fruit set and fruit and seed development,
• stimulates root production.

**POTASSIUM**

• helps in the formation and translocation of carbohydrates
• helps in the formation of large rigid stems
• helps in disease resistance.

Information from soil and plant tissue tests will reveal the nutrient needs of a plant. Appearance, vigour and production of plants also determine plant food needs. This information can be used for making the necessary application of readily available nitrogen, phosphorous and potassium fertilizers to the soil.

Commercial fertilizers such as ammonium sulphate and muriate of potash when added to the soil, increase the amount of nutrients available to plants. They are necessary to furnish the limiting elements in the soil.

Most annuals and biennials are fertilized prior to seeding or at transplanting. They may also be side dressed during the growing period. Band or hill placement locates the fertilizers closer to the plants. This can be done in widely rowed planting. In close planting it is best to broadcast the fertilizer.

**Pest and disease control**

Crop plants are attacked by pests and diseases in all stages of growth. Pests and diseases also attack all parts of the plants, namely the roots, stems, leaves and even the seeds. As a result of their attack they frequently limit the development of our crop plants causing reduction in yield, and lowering the quality of the produce. These losses are very substantial mostly in tropical and sub-tropical countries where temperatures and humidity in those areas facilitate rapid and constant multiplication of organisms.

For most diseases, prevention is better than cure. Field hygiene helps to prevent infection and the spread of diseases. On the other hand, it is advocated to use control measures such as chemical spraying after the first sign of insect attack is observed or more precisely when the attack is at the initial stage of causing economic damage to the crop. The recent trend is not to fully rely on chemical control but to use all other control measures such as physical and mechanical, biological and cultural with minimum use of chemicals.
Harvesting and marketing

Marketing of vegetables

Harvesting and marketing must be considered as important as any of the steps mentioned before in the principles and practices in the production of the crop. These practices will determine:

• the yield of the crop
• the quality of the produce and the storage capacity
• how much food will be available to the community for consumption
• the price and income that farmers will realize from the sale of his produce.

Harvesting

The term harvesting means reaping, gathering and storage of crop produce. Harvesting should be timely i.e it should be done to obtain maximum yield. When a crop is harvested too early or too late, this results in pre-harvest and post-harvest losses,

Steps should be taken to prevent these losses since they affect income of the farmer. In order to avoid loss, harvesting must coincide as far as possible with the following:

• dry weather
• market demand
• maturity and quality
• water/moisture content.

Dry weather permits rapid maturity, easy harvesting and low levels of spoilage of crops. In wet conditions, harvesting of some crops results in losses due to fungus and difficulties in transportation.

If planting of some crops were to be timed so that harvesting will take place during the time when the demand for the produce is high, farmers will enjoy a better price for the produce.

Good quality and matured fruits and vegetables are demanded over those of poorer quality.
MATERIALS HARVESTED FROM DIFFERENT CROPS.

The harvested portion of cultivated plants differ. The following table shows some crops and the materials harvested.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Materials Harvested.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cereals</strong></td>
<td></td>
</tr>
<tr>
<td>Rice, wheat, sorghum</td>
<td>matured grains</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
</tr>
<tr>
<td>Soya-bean, cow pea, bora</td>
<td>pods (dry or green)</td>
</tr>
<tr>
<td><strong>Root Crops</strong></td>
<td></td>
</tr>
<tr>
<td>Cassava, sweet-potatoes, yams, carrots</td>
<td>tuberous roots.</td>
</tr>
<tr>
<td><strong>Stem crops</strong></td>
<td></td>
</tr>
<tr>
<td>Sugar cane</td>
<td>stem cutting</td>
</tr>
<tr>
<td>Irish potato</td>
<td>stem tuber</td>
</tr>
<tr>
<td>Ginger</td>
<td>stem (rthizome)</td>
</tr>
<tr>
<td>Eddo</td>
<td>stem tuber (corn)</td>
</tr>
<tr>
<td><strong>Leafy vegetables</strong></td>
<td></td>
</tr>
<tr>
<td>Cabbage, celery, calaloo</td>
<td>leaves</td>
</tr>
<tr>
<td><strong>Fruit vegetables</strong></td>
<td></td>
</tr>
<tr>
<td>Ochro, cucumber,</td>
<td>green fruits</td>
</tr>
<tr>
<td>Boulanger</td>
<td></td>
</tr>
<tr>
<td><strong>Fruits</strong></td>
<td></td>
</tr>
<tr>
<td>Mango, pineapple</td>
<td>yellow fruits</td>
</tr>
<tr>
<td>Papaw</td>
<td></td>
</tr>
</tbody>
</table>

35
Fig 1.22  Materials harvested from different crops.

METHODS USED IN HARVESTING.

They are basically two methods of harvesting:

- manual
- mechanical

Manual harvesting: Manual Harvesting is done by hand. Sickles are used to harvest crops such as rice and millet. Scythes are used to harvest barley and grass.
Digging forks, hoes and cutlasses are used to harvest potatoes, ground nuts, yams and cassava. Sharp edged knives are used to harvest pine apples, ochroes, tomatoes, cabbage and boulanger.

Fig 1.23  Harvesting by hand

Mechanical harvesting: Mechanically operated harvesters are common in large scale production of crops. Some of these machines like the combine, do many operations at the same time e.g. cutting, threshing, winnowing, and loading. Mechanically operated machines are used to harvest such crops as rice, sugar cane, cotton and white potatoes.

Fig 1.24  Harvesting rice with a combine
Marketing

The production of a crop is not complete until the produce reaches the final consumer in the market.

Marketing is a complex and sometimes expensive activity and involves several essential services in order to ensure that the produce reaches consumers both locally and internationally as well as in the form desired.

![Marketing crop produce](image)

Fig 1.25  Marketing crop produce

**ESSENTIAL MARKETING SERVICES**

Marketing is defined as transferring goods from the producer or farmer to the consumer in the right place, form and time. In doing so, there are several specialized functions that are essential in a modern agricultural economy.

These services include:
- assembling
- information and intelligence
- processing
- purchasing
- grading
- transportation
• storage
• pricing
• negotiations

Agricultural products are collected at the farm gate and transported to marketing centres or storage bonds.

Processing, grading and storage may be done depending on the nature of the product. Some products are purchased after they are processed. Packaging is done to present the produce in an attractive manner to the consumer. Packaging also makes handling and transport easier and also promotes sales when the package is labelled.

Storage takes place in silos, and ware houses. Storage guarantees that the product lasts for a longer time and that it is available for consumption as production declines. One of the essential marketing services is the pricing mechanism. Price is influenced by such factors as

• demand and supply of the product
• perishability of the product
• storage facilities.

Price of most agricultural products fluctuate seasonally with production. Perishable products tend to carry a low price when the supply is greater than that demanded by consumers.

Adequate storage causes prices to be somewhat stable in time of glut. There are several outlets through which crop produce finds itself from the farmer to the consumer. The produce is either retailed or wholesaled.

Retail markets - Small quantities of crop produce are usually sold to many consumers in our municipal and rural markets in the country.

Wholesale markets - There are some agencies and organisations that buy large quantities of farmers produce. These agencies form a link between farmers and small consumer. These agencies include

• Guyana Marketing Corporation
• Guyana Rice Export Board formerly Guyana Rice Board
• Guyana Sugar Corporation.
Exercises

1. Describe briefly how climate and soil types influence the selection of crops in a particular area.

2. Look at Fig 1.8. You are asked to select a container of soil in which to grow some bean seeds.
   (a) Which container would you choose?
   (b) List some physical properties of the soil in each container which will affect plant growth.

<table>
<thead>
<tr>
<th>Container A</th>
<th>Container B</th>
<th>Container C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Size of soil clods</td>
<td>- Very large clods</td>
<td>- Compact soil particles</td>
</tr>
<tr>
<td>(b) Pore spaces</td>
<td></td>
<td>Many and small they contain a balance of air and water.</td>
</tr>
<tr>
<td>(c)</td>
<td></td>
<td>Root hairs get enough moisture and oxygen.</td>
</tr>
<tr>
<td>(d) Movement of water</td>
<td>Water passes freely over soil clods.</td>
<td></td>
</tr>
<tr>
<td>(e) Availability</td>
<td></td>
<td>Moisture around soil particles dissolve nutrients.</td>
</tr>
<tr>
<td>(f) Ability to hold water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. How would you prepare the soil in container B to grow the bean seeds?

4. List your activities.

5. Discuss with your teacher and classmates the reasons for each activity you have listed.

6. Draw a nursery and state the importance of each feature.

7. Why is it necessary to sterilise soil in the boxes?

8. State step by step how you would plant some pepper and tomato seeds. Start with
the selection of planting material.

9. Carry out a post-germination programme. Include pricking out-of seedling, hardening off of these and the transplanting into field.

10. Make a collection of plant parts that can be used for vegetative propagation. Label each specimen.

11. Discuss the advantages and disadvantages of

   (i) furrow irrigation
   (ii) sprinkler irrigation.

12. What are the harmful effects of weeds to crop? List 4 methods you would employ to control the weeds in your garden?

13. (i) Why is mulching not widely practised in Guyana?

   (ii) List five (5) advantages of mulching,

14. What steps can a farmer take to maintain soil fertility in his garden?

15. List the effects of deficiency of nitrogen, phosphorous and potassium on crop plants.

16. Complete the following table below.

   The first is done for you.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Materials</th>
<th>Harvested.</th>
<th>Method used.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>grain</td>
<td></td>
<td>manual/mechanical.</td>
</tr>
<tr>
<td>Corn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackeye</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar cane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassava</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pakchoi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundnut</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eschallot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ochro.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

41
17. (i) Give the names of two local and two original marketing agencies.
(ii) What produce/product is marketed by each agency?

18. Identify the services that are essential in the marketing of agricultural produce. Give one reason why each service is considered essential.
2. CULTIVATION OF CROPS

In this chapter four selected crops, namely, cabbage, sweet potato, citrus and coconut will be discussed.

Cabbage

Botanical name- *Brassica oleracea* var. *capitata*

Family - *Cruciferae*

Origin and distribution

The present day cabbage is believed to have originated from the wild cabbage found growing along the chalky coast of England and along the western and southern coasts of Europe. It is now grown throughout the world.

Structure of the plant

The plant is a biennial, and has a very short stem surmounted by a mass of thick overlapping leaves forming a compact head, which may be pointed or round, green or red, smooth or crinkled. Flowers have 4 petals, 4 sepals, 4 stems (2 long), 2 fused carpels forming fruits which split from bottom.

Economic importance

Cabbage may be eaten raw or cooked. They may be pickled e.g Sauerkraut (sour cabbage); a favourite food in Germany and Russia. Large ‘drumhead’ long aged cultivars are grown for feeding livestock in developed countries.

Soil and climate

Cabbage a hardy cool-season crop, is at its best during a cool, moist period. It will however, stand wide variations in temperature. Fertile, moist, well drained soil with a pH of 6.5 is ideal. The soil should contain a liberal supply of organic matter.
Varieties

In selecting varieties, one must consider such factors as market demand, disease resistance, season of the year to be planted and resistance to premature flowering.

Varieties recommended to be grown in Guyana are **O.S. Cross, K.K. Cross, K.Y. Cross, Premium Flat Dutch and Copenhagen Market**. Other varieties recommended to be grown in the Caribbean are **Early Jersey, Charleston Wake, Early Round Dutch** and **Red Acre**.

Nursery

Cabbage seeds are sown in a nursery bed and transplanted into the field. Nurseries should be sited on high land which does not flood easily, and should be slightly shaded and protected from heavy winds. The seed bed should be a rich fertile sandy loam. The site should be hoed or ploughed and allowed to weather for a few weeks. After weathering, chip or harrow to break up clods and loosen the soil. Beds can then be made 70 cm wide with drains 30 cm in between beds. Apply well rotted pen manure, mix it thoroughly and use a levelling board to obtain a level surface. Eight ounces of superphosphate should be incorporated per square yard, well mixed and the beds watered thoroughly. An insecticide (chlor dane or aldrin) should also be applied at the rate of one tablespoon per gallon of water. The seed bed must be thoroughly watered after the cabbage seeds are sown. An area of 150 square feet of nursery bed is adequate to plant an acre of cabbage in the field. For this you will need about six to eight ounces of seeds.

The seeds should be broadcast or sown in drills about two to three inches apart and covered with half-inch of fine silted soil. Plants grown in drills are more vigorous and much easier to lift and transplant. The bed should be watered immediately after sowing and covered with palm leaves, straw or damp jute bags to conserve moisture and hasten germination. Seeds germinate only when there is sufficient moisture. The bed should be thoroughly watered daily with a watering can fitted with a fine nozzle (rose) until the seeds germinate.

CARE OF SEEDLINGS

Soon after the seedlings germinate (i.e. 7-10 days after sowing) part of the cover may be removed leaving minimum shade. Gradual exposure to sunlight hardens the plant. The amount of sunlight may be increased daily so that the seedlings will be strong enough to remain in the sun and rain without shading.

Daily watering is still necessary since a shortage of water retards growth. Excess water, however, causes ‘damping off’ a fungal disease which causes the
seedlings to wilt and collapse at ground level.

**Land preparation and transplanting**

The field for a cabbage crop should be ploughed in the season and allowed to aerate for a few weeks. Cabbage does best in a neutral soil. If the soil is acidic, apply about two tons lime per acre on heavy soils and about one ton on light soils at ploughing time. Since cabbage needs a soil of high fertility, incorporate about 10 to 20 tons of well rotted pen manure or compost per acre at harrowing along with 170 kg (350 lb) of triple phosphate or 3-4 cwt of 5-10-10 NPK mixture. It must be well mixed into the soil and the land levelled. In wet season, in low lying areas, raised beds are prepared 90 cm (3 ft) wide and of a convenient length, with 30 cm (1 foot) drains between beds, 15 cm -20 cm deep to remove excess water from the beds.

Before uprooting the seedlings, the nursery bed should be thoroughly watered to facilitate lifting of the seedlings without much damage to the roots. Only healthy seedlings with six to eight leaves should be selected and removed carefully with a ball of soil attached to the roots. The seedlings are transplanted in the field when they are 3-4 weeks old or when the seedlings are 10 cm -12.5 cm high at the spacing of 60 cm between rows and 45 cm within rows. Transplanting is best done in the cool of the evening and preferable during rainy weather so that the plants get the best chance to establish themselves.

**Irrigation**

Cabbage must have an adequate supply of moisture throughout the growing season, but excess water in the soil or too much fluctuation is undesirable, since it tends to produce loose and small heads. In the dry periods, therefore, care should be taken to see that the soil is not allowed to dry completely. A typical sign of water scarcity is the leaves become dark green and feel leathery. When there is adequate moisture the leaves are brittle and of a lighter green. Uneven moisture after the heads are formed may cause splitting. Water may be supplied by either the furrow or the sprinkler system.

**Weed control**

Cabbage plants must be kept free from weeds from the start. Weeds can be hand picked when they are young or weeded using cutlasses, without causing damage to the shallow roots of the cabbage plants.
Fertilizer application

A top (side) dressing of 275 lb of ammonium sulphate per acre could be applied between 4 and 6 weeks after transplanting.

Insect pest of cabbage

Cricket (Acheta spp.): It is a major pest of cabbage. The adult insect is dark brown or black in colour with a body length of 2-3 cm. The cricket lives under clods in the soil or in grasses around the cultivated plants. At night it attacks the plants eating parts of leaves during seedling and transplanting stages. As a result, seedlings may have to be replaced.

![Cricket illustration]

Fig. 2.1

Control: Soak beds with aldrin solution before transplanting. Mix 2 table spoonful of aldrin 4-% E.C in a gallon of water and apply the mixture with watering can or spray can. If the damage continues spray the solution around the seedlings or lightly dust the soil surface with 5% aldrin dust at 20 lb per acre.

Cutworm (Agrotis spp.): The adult is a moth with brownish grey body, grey forewings with dark brownish-black markings, the hind wings are almost white basically, but with a dark terminal fringe. The larvae live in the soil during the day and at night they climb the seedlings and denude them of leaves. Stems below ground may be completely hollowed out. The attacked plants first wilt and then die. A few greenish black excreta pellets may be seen below the seedlings. These worms feed for about 3-4 weeks and then pupate in the soil.

Control: Deep ploughing will bring larvae and pupae to soil surface for exposure to predators and the sun. Dusting soil with 5% aldrin dust at the rate of 20 lb per acre.

Cabbage leaf miner (Liriomyza brassicae): The adults are minute flies. The larvae live between the upper and lower surfaces of the leaves. The leaves show grey, colourless, winding lines with a maximum width of 1.2 cm (1/2 in). It is popularly
called ‘chinese writing’. The damaged leaves are rendered unattractive and unsaleable. Sometimes young plants, when severely infested, may die.

**Control**: Spray plants with malathion or dimethoate.

**Diamond-back moth** (*Plutella xylostella*): The adult is a small grey moth. There are three pale triangular yellowish marks along the hind margin of each forewing, and when the wings are closed these marks form a diamond pattern which gives the moth its common name. The hind wings are grey and narrow, with long fringe of hairs. Larve are greyish green in colour with black heads when hatched, when mature the head turns to a light yellow and the body, a light green. The body of the larva is widest in the middle. The larvae feed on the underside of the leaf and make holes. Sometimes they feed on the lower epidermis of the leaves and only the transparent upper epidermis is left.

**Control**: Larvae could be controlled by spraying ambush, carbaryl or malathion at recommended rates.

**Diseases**

**Club root** (*Plasmodiophora brassicae*): The causal organism is a fungus. It is prevalent in acid soils. It attacks the roots causing characteristic swellings. The malformed roots are club-like in appearance near the stem of the plant.

**Control**: Keep the soil alkaline (pH 7.2). This can be done by applying slaked lime at the time of land preparation. Practice crop rotation.

**Black rot** (*Xanthomonas campestris*): It appears at any stage of plant growth. The disease is first indicated by yellowing of the leaves and blackening of the veins. Later the plants show dwarfing and one sided heads. If the disease attacks the plants early no heads will be formed.

**Control**: Use clean seeds, as the disease causing organism is carried over by seeds. Practice crop rotation. Field sanitation is important.

**Root Knot** (*Meloidogyne* spp): The disease is caused by a parasitic eelworm (nematode) which attacks the roots of plants producing irregularly shaped galls. As infection increases the plants become stunted and eventually die.

**Control**: Soil should be treated with nematicide e.g. nemagon or soil fumigants such as vapam, methyl bromide or shell DD prior to planting. Rotation with crops with small grains, corn or soyabean should be practiced.
Harvesting

Cabbage should be harvested when the heads are mature into a firm white head. It takes 2-4 months depending on the variety. Harvesting should be done in the early morning or late evening to prevent excessive water loss. Cabbage is harvested with about 2-3 green wrapper leaves attached to the head, as there is a preference for cabbage which is green and fresh. Care should be taken not to bruise the head as this makes it unattractive. When the crop cannot be sold within 48 hours refrigeration is necessary.

Sweet potato

Botanical name - *(Ipomoea batatas)*

Family - *Convolvulaceae*

![Diagram of Sweet Potato](https://example.com/sweet-potato-diagram.png)

Fig. 2.2

Origin and distribution

The sweet potato is believed to be native of Central and South America. It is now grown extensively in the tropics and sub-tropics from about 40° N to 32° S and from sea-level to about 2000 m. The best growth is where the average is 24° C or over.
Economic importance

The edible tubers are eaten boiled, baked or fried in oil or curried. They may also be candied with syrup or used as a puree. The tubers are sliced into pieces and dehydrated to produce flour. The flour is used in the preparation of biscuits, cakes and puddings. The tubers are rich in starch, and the yellow fleshed and pink fleshed varieties contain appreciable quantities of vitamin A and minerals like calcium. The tubers are processed for starch, glucose, syrup and alcohol. Sweet potatoes are also fed to livestock. The tender tips and leaves are used as pot-herb in Africa, Indonesia and the Philippines. The leaves and vines are widely used as fodder for livestock.

Soil and climate

Sweet potato could grow on a wide range of soils but a well drained sandy loam with clayey sub-soil is best. On very rich soils the crop produces too much vine at the expense of tubers. On heavy clay soils the roots are likely to be rough and irregular in shape. Very light deep soils tend to produce long slender roots. The crop is particularly adapted to newly cleared land such as those found in our riverin areas. Desired pH is between pH 5.2 - pH 6.7. Sweet potato needs a warm climate. It grows best at an average temperature of 24°C (75°F) or more with a well distributed annual rainfall of 75 cm - 125 cm (30" - 50") and an abundance of sunshine. In high rainfall areas they are often planted at the end of the rainy season, because they are relatively drought resistant.

Varieties

Several varieties are grown in the Caribbean. Some of the varieties have tubers with white skin and white flesh, while others have a pink skin and a white flesh. The flesh of tubers of some varieties is dry and powdery and of others , moist and soft when cooked. Varieties recommended to be grown in Guyana are S-128, CHS-6, T-67, ‘Black Rack’ and White Lady.

Planting material

When selecting planting material make sure they are from high yielding varieties. Generally in Guyana, apical pieces or mid portions of vines (slips) from one crop are used immediately after harvest for planting the next crop. It is not advisable to continue successive planting with cutting from the previous crop for many seasons as there is steady deterioration in tuber size and yield. After every 3-4 seasons it is best to plant a nursery with medium sized tubers to obtain fresh slips.
For raising slips from tubers, medium sized tubers (2 cm- 4 cm wide) are planted in a well prepared and manure nursery plot at a spacing in 45 cm between rows and 30 cm within rows, and planted at a depth of 5 cm-7.5 cm in moist soil. To produce planting material for one acre, about 350 sq. ft nursery area is required. Before planting the tubers should be dipped in a solution of thiram (42.5 g dissolved in 4.5 litres of water) or any other recommended chemical against surface contamination by disease organisms. When the tubers sprout, frequent irrigation will activate the growth of the sprouts. An application of 100-200 lb of ammonium sulphate per acre will induce growth. Cuttings from new vegetative growth are taken at approximately 6 weeks after planting, and transplanted in the field.

**Land preparation and planting**

In deep soil there is a tendency for the roots to grow longer and slender, therefore deep ploughing is not advocated. Plough or fork the soil to 15 cm-20 cm deep. After ploughing, the soil should be harrowed and raised beds or ridges and furrows are prepared. Beds should be 90 cm long, 30 cm wide and 20-30 cm deep drains in between beds. On the beds two rows should be planted 60 cm apart i.e 15 cm from the edge of each side of the bed.

In rows, the distance between slips should be 25 cm-30 cm. In ridge planting, ridges are usually spaced 60 cm-90 cm apart (centre to centre) and slips planted 25 cm-30 cm apart on the ridges. Planting is done during the rainy season. Stem cutting about 25 cm-30 cm long with 5-6 nodes are used for planting $\frac{1}{3} - \frac{1}{2}$ of the slip in the soil. In India the central portion of the cutting is buried in the soil leaving a node exposed at either end.

**Weed control**

The crop is most susceptible to weed competition during the first 4-5 weeks. A single weeding should be done at this stage or earlier, either manually, mechanically or using herbicides. Weeding should be done preferably with herbicides like ameben or promotryne. These pre-emergence herbicides should be sprayed before stem cuttings are planted in the field. This will control weeds for about 3 weeks after planting, in the mean time the luxuriant growth of the vine soon covers the ground and suppresses the weed growth.

**Irrigation**

Sweet potato is considered to be a moderately drought tolerant crop, but if rainfall is not sufficient, the crop should be irrigated. Water may be supplied by either surface
or overhead irrigation. Moisture is essential for sprouting and development of vines and especially during tuber formation. The period of highest water requirement by the plant is when it has an extensive feeder root system and leaf area.

Immediately after planting, slips must be watered and in dry weather irrigation must be continued on alternative days for the first fortnight and later at 10-12 days interval. Irrigation increases yield and improves the grade and quality of marketable tubers. However, very high soil moisture at the full growth phase causes the plants to become excessively leafy at the expense of the tuber production.

**Fertilizer application**

Farmyard manure or compost causes a profuse growth of vines and development of large roots, but satisfactory high yields are obtained with the use of commercial fertilizers. It seems best therefore to apply manure to other crops and to depend on fertilizer to furnish the elements that are needed for sweet potato crop. Application of moderate amounts of nitrogen influences the shape of the tubers. Phosphorous is required in relatively small quantity, but potash is required in relatively large quantity by the crop. The exact quantity of fertilizer required can only be known after a soil test. The following amounts may be applied per acre at land preparation until the soil is analysed.

- Ammonium sulphate - 150 lb
- Triple super phosphate - 200 lb
- Potassium sulphate - 150 lb

Four weeks after planting another 150 lb of ammonium sulphate should be applied as side dressing. The sweet potato vines take root at various places if left undisturbed. It is necessary to turn back the vines from time to time to prevent rooting at the nodes and to encourage even crops with few medium sized tubers.

**Insect pests**

*Sweet potato weevil* (*Cylas formicarius*): It is a most destructive insect pest of sweet potato. The adult is an ant-like weevil about 7-8 mm long with a slender snout. It has glossy blue black thickened forewings (elytra), reddish brown legs and thorax and black head. It is found in tunnels and leaves. It lays eggs in holes in the vines or tubers. Hatching takes place within a week. The white legless larva (grub) tunnel through the vines and tubers where it feeds and lives for about 2-3 weeks. The tunnels are tortuous and filled with fungi and bacteria causing extensive rotting of the tubers. When badly infested the tubers are unfit even for stock feed. From 25-75%
of the crop is often destroyed. Plant vigour, yield and storage life are reduced.

Fig 2.3

**Control:** Sweet potatoes should be planted only in fields which had no *Cylas* infestation within the last 12 months and preferably more than 1 km away from any infested land. Only sweet potato weevil-free planting material should be used for planting. Resistant varieties should be chosen if available.

Earthing up the plants reduces damage as the adult weevil cannot burrow downwards more than 1 cm. After harvest the field should be cleared of trash, which should be burned. Do not grow more than 2-3 crops of sweet potato, sequentially, on the same field, as infestation by weevil increases.

If in the harvested crop, 5% tubers are infested by weevil, do not grow another sweet potato crop but grow some other crop. The slips to be planted should be tied into bundles of 20 each. These bundles should be dipped in 2% triazophos emulsion (10 fl. oz of 40% E.C in a gal. of water) for one minute. The slips should be kept in shade for one day before planting.

**Leaf eating caterpillar (*Spodotera spp.*)** : Numerous larvae skeletonise the leaves, entire vines may be defoliated.

**Control:** Spray with carbaryl or trichlorphon as recommended.

**Stem borer (*Megastes grandolis*):** The adult insect is a moth. It is found in Brazil and Trinidad. The larvae bore into the stem and on the tuber. The frass produced by the tunnelling is usually pushed out through the first entry hole. When it has fed in the tuber for 5-7 weeks the full grown larvae spins a cocoon not far from the hole above ground through which the adult will emerge.

The attacked plants are stunted and may shed their leaves. Frass can be seen on the soil around the crown of the plant. Cuttings may die due to larvae feeding inside them. Harvested tubers, when cut open, are found to be riddled with clean tunnels.

**Control:** Spray with carbaryl or malathion as recommended. Treat the slips before planting as for the control of sweet potato weevil.
Harvesting

The time for harvest is when 75% of the leaves turn yellow and begin to drop or when the tubers are broken, if the exudate of the sweet potato dries out quickly and forms a white crust; otherwise it becomes dark or greenish in colour. The time to harvest varies from 3-5 months according to the variety planted. In the dry season the field is irrigated 2-3 days before harvest to facilitate easy lifting of the tubers. The tubers are lifted using a digging fork or similar implement with care as bruised tubers do not store well. For long storage tubers must be cured at 30°-32° C at 85-90% relative humidity for 4-7 days. After curing they can be stored at 13°-15° C with relative humidity of 85-90%.

YIELD

With good management a yield of 20,000 lb of tubers and 10,000 to 15,000 lb of vines can be obtained per acre.

Citrus

Family: *Rutaceae*

Genus: *Citrus*

Origin and distribution

The cultivated species are believed to be native of tropical and sub-tropical regions of South-East Asia. From there it spread to Mediterranean areas. It was introduced to the Caribbean by the Spanish, Dutch, French and English in the 16th and 17th century. Citrus is cultivated throughout the sub-tropics and tropics. But much of the commercial production is now in sub-tropical regions with a Mediterranean climate. Most important producers of oranges are Brazil, USA, Mexico, Italy, Spain, India and China. Japan supplies about half the world production of mandarin. Mexico produces mainly lime, China produces principally shaddocks.

Economic importance

Citrus fruits may be eaten fresh as are the sweet orange, tangerine and grapefruit or their segments may be canned. Juice is extracted and consumed, or it may be concentrated four or more times. Juice of lemon and lime is diluted into lemonades
and other soft drinks. Segments of shaddock are used in fruit salads because the pulp falls apart easily. After extraction of juice, citrus pulp and molasses are used as cattle feed. Essential oils are made from the peel of fruits, leaves and flowers of some citrus species. The most expensive essential oils are derived from flowers of sour orange (neroli) and from the fruits of birgamot sour orange. Sour fruit is used in making marmalade (type of jam). Citron peel is candied.

**Soil and climate**

Citrus is cultivated from sea level up to 1000 m. The optimal temperature for growth of citrus is between 25° C and 30° C. Above or below temperature of 38° C and at the minimum temperature of 13° C. An average annual rainfall of about 1,250 to 1,500 mm (50 to 60 in) is required if citrus trees are to be grown without irrigation. Even distribution of rainfall throughout the year is most important. A dry period of two months is sufficient for flower induction. When this period is followed by irrigation, the trees would flower within 20 to 28 days.

Citrus grows well on a wide variety of soils, from coarse sand to heavy clays. Good drainage is essential for better growth and high yields. Best soil for citrus is a medium-textured, reasonably deep fertile soil, free from injurious salts, and the best pH range from 6 to 7. High elevations with slightly sloping lands are preferred.

**Species and varieties**

Colour and shape of the leaf blade, petiole wing, size, weight and shape of the fruit are important for diagnosis of the species and varieties. Some of the species of citrus are:

<table>
<thead>
<tr>
<th>English name</th>
<th>Botanical name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet orange</td>
<td><em>Citrus sinensis</em></td>
</tr>
<tr>
<td>Sour/ seville orange</td>
<td><em>Citrus aurantium</em></td>
</tr>
<tr>
<td>Mandarin (Tangerine)</td>
<td><em>Citrus reticulata</em></td>
</tr>
<tr>
<td>Grapefruit (pomelo)</td>
<td><em>Citrus paradisi</em></td>
</tr>
<tr>
<td>Lime</td>
<td><em>Citrus aurantifolia</em></td>
</tr>
<tr>
<td>Shaddock (pummelo)</td>
<td><em>Citrus grandis</em></td>
</tr>
<tr>
<td>Lemon</td>
<td><em>Citrus limon</em></td>
</tr>
</tbody>
</table>
Sweet oranges

Fig. 2.4

The plant is less hardy than sour orange. It is rather shallow rooted. It grows to a height of 6 to 8 m. Leaves are dark green in colour, narrow, ovate, smooth, sometimes serrated and rounded at the base with narrowly winged petiole. Fruit peel is 0.5 cm thick, tightly adherent, ripening to an orange colour, but often remains green in the tropics. The plant is resistant to scab and tristeza, but susceptible to gummosis.

Varieties

There are several types of sweet oranges grown in the Caribbean. The varieties include Valencia (most popular), Parson Brown, Hamlin, Navel and Pineapple. Parson Brown and Hamlin are early maturing varieties. Pineapple and Washington Navel are mid season varieties, whereas, Valencia and Ruby are late maturing varieties.

Grapefruit

Fig. 2.5
It is a spreading tree and grows to a height of 10 to 15 m. Leaves are pale green when young, petiole rather broadly winged. The petiole wing touches or partly overlaps the leaf blades. Lamina ovate, flowers axillary, single or in clusters. Fruits are large, 8 to 10 cm in diameter, greenish or pale yellow when ripe. The skin is often quite thick and the pulp is pale yellow-green. A few varieties have attractive pink pulp in contrast to the normal pale yellow colour.

Varieties

Varieties of grapefruits grown in the Caribbean are Marsh or Marsh seedless (most important commercial variety in the region), Thompson or Thompson Pink, 'Ruby Red and Duncan.

Tangerine

Fig. 2.6

This plant is well adapted to cool, hilly areas. The tree is relatively small with slightly drooping branches. Leaves are small and narrow, ovate, elliptic or lanceolate, dark shiny green above, yellowish green below. Flowers axillary, small 1.5 to 2.5 cm in diameter. Fruit depressed-globose, 5-8 cm a diameter. Peel is thin, loose, easily separated from segment, green, yellow or orange-red when ripe. Seeds small. It is better to use mandarin for yellowish-green fruit and tangerine for those with deep orange rind. One variety of tangerine is Portugal.
Lime

Fig.2.7

A small such branched tree, grows up to 5 m in height, branches have short sharp spines. Leaves small and ovate. Petiole narrowly winged. Flowers small, white. Fruit small, ovate or globose often with apical papillae. Peel is thin, adherent, greenish yellow when ripe, pulp greenish and very acidic. The tree is highly susceptible to diseases like anthracnose and tristeza but resistant to scab.

Varieties

Varieties of lime grown commercially in the Caribbean are the West Indian (Mexican or Key Lime) and the Tahiti (or Persian Lime).

Sour orange

Fig.2.8
Plant is hardier than sweet orange. The tree grows to 10 m high, thorns slender, leaves medium sized, petiole 2-3 cm long, rather broadly winged. Lamina is ovate. Flowers axillary, white, very fragrant. Fruits rounded with an uneven skin. Peel of fruit is thick, rough, strongly aromatic, pulp very sour and bitter with numerous seeds. It is extensively used as a root stock for sweet orange, grapefruit and lime.

**Propagation**

In the past citrus has been propagated from seeds, cuttings or inarching. Most of the varieties do not reproduce plants similar to the mother plants from seeds. In addition, seedling trees tend to be thorny and slow to come into bearing. Therefore it is now mostly propagated, more conveniently by budding. In budding, a bud from a desirable tree is inserted on to another desired seedling of the related species referred to as rootstock.

**Selection of rootstock**

The type of rootstock chosen depends on many factors. It should have

- good seed production potential
- high degree of polyembryony
- good union with the scion and more or less the same growth rate
- ability to grow on different types of soil
- tolerance to viral and fungal diseases and nematode attack
- good nursery performance
- tolerance to drought.

No single rootstock is satisfactory in all respects. In the Caribbean **sour orange**, **rough lemon** and **hog shaddock** are commonly used as rootstocks as they are adapted to a wide range of environmental problems in citrus.

**Seeds and seed collection**

The source of seed for establishing rootstock is one of the most important factors in developing healthy and disease free citrus trees. The seeds of citrus contain one or more embryos (polyembryony). From one seed, two, three or more plants may
emerge. One of the embryo is sexually formed as a result of the union of the egg and ovum. They will not have the same characters as the maternal parents. That is why they are not used as rootstock. All the other embryos are formed from the tissue of the nucleus or from the integument tissue of the ovule. They are therefore called **nucellar** embryos. These embryos have the same characters as the mother plant. They are also more vigorous and rapidly growing than the embryo formed sexually and may completely suppress it during growth.

In citrus, rootstocks are obtained from nucellar seedlings. Fruits to extract seeds to raise seedlings for rootstock, are selected from healthy, vigorous growing, disease resistant citrus trees typical for the rootstock. Fruits selected must be of good size, fully mature and ripe. The fruits should be picked directly from the trees which are 10 years old or older.

The fruits are cut around the ‘equator’ of the fruit, not deeply, to avoid damage to the seeds. The halves of the fruit are then twisted and separated. The halves are squeezed to free the seeds, and the seeds are washed to remove the pulp. Seeds are best sown fresh as they lose viability on drying out. However, if needed, they may be stored for a short period of time (10 to 15 days) in moist ground charcoal in a cool place (7-10°C).

**Sowing seeds**

Initially seeds are sown on seed beds or in seed boxes. Seed beds are located preferably on virgin soils or soils that have not been used for citrus before. The soil is ploughed and harrowed to a depth of 10 cm, and levelled. In low lying areas beds are prepared with drains in between. The size of each is 1 metre wide, 10 metres long and 0.25 m high and the beds are laid 0.40 m apart.

One seed per hill is sown at a depth of 1.5 cm and at a spacing of 15 to 30 cm between rows and 5 cm within rows. Seeds are watered immediately. Seeds germinate in 3 to 4 weeks after sowing. Moderate watering is required every 2 to 3 days and hand weeding and removal of weak or diseased seedlings are also necessary as the plants grow.

To allow for good growth, seedlings should be transplanted to nursery beds when they are about 6 to 8 cm high or as soon as the seedlings have put out 4 to 5 leaves (i.e. 2 to 4 months after sowing). A well drained loamy soil is needed for adequate drainage in the wet season. Size of the bed is 1.8 m wide and of convenient length with 0.7 m path in between beds. All plants with crooked or otherwise defective roots are discarded and healthy vigorous plants planted in the nursery. The seedlings are transplanted at a spacing of 100 cm between rows and 30 cm within rows on nursery beds. They may be budded after a further 6 months when the stem has reached a
diameter of 1 to 2.5 cm at the budding height.

The entire nursery operations from planting to budding and subsequent training of plants could be carried out in plastic bags. This is the practice used in Trinidad, elsewhere in the Caribbean it is grown in seed beds and transferred to nursery rows.

**BUDWOOD**

Twigs to obtain scion should be taken from carefully selected desirable mother trees of known history. The trees must be free from virus and other disease and should possess good quality and high yielding ability. Budwood should also be taken from well mature branches of the current years growth after the stem has turned brown and rounded (not angular) with well developed dormant buds in the axil of leaves.

Budwood is normally collected on the morning of the day of budding and used immediately. In case budwood has to be stored for transportation, cut off leaves, and cut the budwood into 15 - 20 cm pieces and pack in moist cotton wool, damp saw dust or sphagnum moss and wrap in moist sacking, firmly tied and store in a cool place (10 to 13°C). In this manner budwood can remain fresh for up to seven days. Budwood is always taken from outside branches. Here the spines are small and tend to disappear.

**BUDDING**

![inverted T cut](image)

Fig.2.10

To be suitable for budding the seedlings should have a straight stem for a distance of at least 20 to 30 cm above ground level. Lateral shoots growing from below the budding point should be removed 2 weeks before building. The rootstock is budded with scion from selected sweet orange, grapefruit or tangerine depending on the variety to be grown.
The T or inverted T method can be used for budding. The inverted T method is commonly used. Using a sharp, clean budding knife a vertical cut about 25 to 40 mm long is made in the bark of the seedling at a height of 20 to 30 cm above ground level. A horizontal cut is then made at the bottom of the vertical incision, this should be about 12 mm wide. The two cuts therefore form the inverted T. Using the tail of the budding knife lift the bark upwards and outwards at the junction of the horizontal and vertical cuts.

In cutting the bud from the budwood, it is held with the basal and away from the bud. Using a sharp knife, a bud is sliced from the budwood with a shield shaped portion of the bark 18 to 24 mm long surrounding the centrally placed bud. This bud shield is carefully inserted into the incision which has been made on the stock seedling. The inserted bud is tied with raffia or budding tape. In tying the bud, the tying material is first wrapped around the horizontal cut proceeding upwards, taking care that the bud is not moved out of place and also to avoid the penetration of water through the edges, but the eye of the bud is left free. In order to prevent rain and sunlight damaging the bud, a leaf is often tied over the bud to shade it.

Two to three weeks after budding the plant is inspected and if the bud is still green, union has probably taken place. The tape is now partially unwrapped and the bud is forced into growth. This is done by lopping the rootstock at about 15 cm above the bud union by cutting half way through it and bending it over. This promotes shoot formation. The initial training of the budding consists in allowing only one shoot to develop from the bud, cutting off any other that may appear. All shoots arising from the rootstock are also to be eliminated. The new shoot is tied to the “stub” previously left in the rootstock over the bud union.

After the new bud has opened fully, the top of the rootstock is cut off close to the point of bud union. The cut is painted to prevent entry of disease organisms. Stakes are used to support growing shoot until they harden and the danger of being blown off has passed.

**Selection of orchard site**

In selecting sites to plant citrus one may look into the following:

- adequate drainage
- adequate irrigation
- deep soil with no impervious layers below to allow for good root development
- soil should be highly fertile and free from iron salts. Land level or slightly slopy
• plants should be protected from strong winds either naturally (aspect) or by establishing wind breaks
• availability of labour
• accessibility to market.

Land preparation and planting

The field for planting citrus must be cleared of all trees and bush growth, weeded and drains constructed to provide adequate drainage. Plants suffering from wet feet will never grow well and may suffer from foot rot and other diseases. The field is lined out and stakes are placed to locate the planting holes. All measurements should be made from the base line along the edge of the farm. The planting systems can be square, rectangular or triangular. On steep slopes plants should be lined out along the contour.

Normally holes of about 60 cm deep and 60 cm wide each way are dug. Top soil, dug from preparing holes, is kept apart and surface soil surrounding the area is mixed with farmyard manure, compost or poultry manure and the hole is filled. A mound of about 45 cm high from the ground level is formed and allowed to settle down for 6 weeks. The mound helps to avoid foot rot disease in clayey poorly drained soils and helps to prevent the damage caused by fiddler beetle larvae.

Citrus may be transplanted in the field either with bare root or with a ball of earth or from plastic bags. Using bare root, the transplants are easier to handle and transport, but they require careful handling and should never be allowed to dry out as they are very susceptible to sun and wind injury. They should be planted immediately after digging. Planting with bare roots permits inspection of disease and nematode damage. On the other hand, planting from plastic bags permits transportation over long distances and the transplants may be left out of the ground for a number of days. This practice is useful in drier areas, but transplants are heavier and more expensive to transport. Plastic bags are first removed before planting, taking great care not to disturb the soil around the root. Best time for planting is the beginning of the rainy season (May/June or January in Guyana).

Spacing

The planting distance will depend on the nature and fertility of the soil, topography, and the type of rootstock and scion. On an average soil, or on flat lands in the Caribbean the spacing recommended are as follows:

Grapefruit  7.5 x 7.5 m  ( 175 trees / Ha)
Orange and lemon  6.0 x 6.0 m  (275 trees / Ha)
Lime and tangerine  4.5 x 4.5 m  (495 trees / Ha)

**Irrigation**

Water should be applied immediately after planting and irrigation should be provided if dry days follow. The soil should be kept moist but not wet. Once the trees are in bloom or young fruits are forming on the trees, a regular supply of water must be assured. Frequent and light watering is preferred to widely-spaced and heavy watering.

**Weed control**

Early and regular weeding is necessary for citrus. Ring weeding at 2 metres radius around the base of the plant is needed. This will also help to deter ants which can be destructive to the trees. Weeding can be done with cutlass or by machine mowing. Legumes like Centrosema could be sown between plants to reduce weed growth, check erosion and add organic matter to the soil. Weedicides like **Diuron** or **Dalapon** can be used to control weeds.

**Fertilizer application**

Trees that are fertilized properly grow much faster, maintain their growth rate better and come into bearing earlier than the trees which do not receive proper fertilizer treatment. Smaller amounts of fertilizer applied at frequent intervals are better for young trees than the same total amount applied at intervals of several months. Fertilizer should be spread evenly on the ground in a circle about 30 cm away from the trunk in the very early stages. As the tree grows, the distance of the circle from the base of the trees must be increased.

Specific fertilizer needs of individual farms can be assessed through a combination of leaf tissue analysis and soil testing. For young citrus trees, a fertilizer mixture with high nitrogen and low potash is good. A general fertilizer recommendation for young trees is given below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Application per year</th>
<th>Total fertilizers applied per year/ tree (kg/Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First year</td>
<td>4</td>
<td>1/2 kg of 10-5-5 NPK mixture</td>
</tr>
<tr>
<td>Second year</td>
<td>3</td>
<td>1 kg of 10-5-5</td>
</tr>
<tr>
<td>Third year</td>
<td>3</td>
<td>1.5 kg of 10-5-5</td>
</tr>
</tbody>
</table>

63
Fourth year 3 2 kg of 10-5-5 “
Fifth year 2 3 kg of 10-5-5 “

After the fifth year, trees start bearing. At this stage fertilizers high in nitrogen and potash but low in phosphate are recommended e.g. 16-8-16 mixture.

Sixth year 2 2.5 kg of 16-8-16 NPK mixture
Seventh year 2 3.0 kg of 16-8-16 “
Eight year 2 3.5 kg of 16-8-16 “
Ninth year 2 4.0 kg of 16-8-16 “
Tenth year and onward 2 4.5 kg of 16-8-16 “

It is recommended that half of the annual dosage be applied soon after blossom fall and during the rainy season, and the remainder applied about midway through the growing season.

Pruning and training

All diseased, dead and badly shaped inward growing branches and suckers produced from the rootstock should be removed in the early years of growth. Cut surfaces should be painted with bituminous paint to prevent fungal infection through them. Heavy pruning should be avoided as it delays production. Only declining trees are severely pruned back in order to rejuvenate them.

The young shoot from the new bud should not be allowed to branch before it reaches a height of 90 cm. It is prevented from branching by rubbing off all new buds below this height. A main trunk with four or five primary branches distributed equally around the axis, and at vertical intervals of about 30 cm, starting about 90 cm above ground level, is desired.

Insect pests of citrus

*Citrus mealybug (pseudococcus citri)*: Mealybugs are found on leaves, twigs and at the base of the fruits. They cause serious injuries to leaves, young buds and fruits of citrus. Attacked leaves wilt and turn yellow as if affected by drought. Roots are often stunted. Heavy infestation may kill young trees.

Mealybugs secrete a sweet sticky substance called honeydew on which sooty moulds grow. These moulds later form a black coating on the leaves, fruits and
branches. This interferes with the photosynthesis of leaves and green parts of the plant. Mealybugs are spread by red ants, which carry them from one feeding place to another.

**Control**: Controlling the spread of mealybugs involves limiting the activity of ants, using chemicals like aldrin, dieldrin or diazinon. Spray chemicals like malathion or light mineral oils to destroy mealybugs.

**Aphids (plant lice)**: Citrus plants are attacked by black citrus aphid (*Toxoptera aurantii*). The adults are shiny black in colour and from 1.2 to 1.8 mm in body length. The young ones are brown in colour. As in mealybugs, the aphids are spread from one plant to another by attendant ants. They feed by sucking the sap from succulent growing shoots, leaves and flowers of citrus, especially in the nursery stage. As a result young leaves get distorted. Clusters of black aphids could be seen on flush growth on the under surface of young leaves. Aphids also transmit virus diseases like tristeza.

**Control**: Spray at the sign of damage, using dimethoate, demeton-S-methyl or malathion in water as recommended. The attendant ants can be controlled by spraying dieldrin on tree trunks and on ant hills.

**Mites**: Mites destroy the epidermal cells of leaves and fruits and cause russetting of fruits, also leaf and fruit fall. The skin of injured fruit is thicker than usual. Mites cannot be seen with the naked eye as they are very small, about 0.1 mm long. They live in colonies on the under-surface of the leaves especially along the veins and midribs, during the dry season. Within three or four weeks of favourable weather (i.e. high temperature and humidity) a massive infestation takes place.

**Control**: Spray a solution of lime-sulphur, Roger 40 or chlorobenzilate as recommended.

**Leaf cutting ants** (*Atta spp.*): The adults cut pieces of living leaf tissue and drag them to their nests. Severe attack results in total defoliation. They could defoliate a tree in a single night.

**Control**: Their nests must be found and destroyed. Aldrin or chlordane is either blown down as dust or poured down as solution in water at the entrance to the nest. Poisonous baits like mirex pellets could be used successfully in dry weather. In wet weather the bait disintegrates.

**Citrus moth**: Widespread damage is brought about by fruit piercing moths. The adult moth bores holes on fruits, forming an entrance for fungi which cause the fruits to rot and fall.
Control: Harvest the fruits as soon as they become ripe. Spraying with insecticide like malathion gives a partial control.

Mediterranean Fruitfly (Medfly) - *Ceratitis capitata* - The eggs are laid in groups by the female fruitfly into the pulp of the fruit just under the skin. On hatching, the maggots bore through the pulp into the fruit often accompanied by fungi and bacteria which rot the fruit. Severely attacked fruits fall prematurely.

Control: Collection and destruction of all infested fruits. Using baits containing suitable insecticides so that entering flies are killed. Different countries enforce quarantine legislation to restrict importation of fruits likely to contain the larvae.

**Diseases of citrus**

Gummosis (Foot rot): Causal agent is a fungus of *Phytophthora* species particularly phytophthora *cirtrophthora* and *P. parasitica*. Foot rot begins as a discolouration on the trunk and branches of susceptible varieties. The spots become larger and exude gum which causes a brown rot to appear on the trunk, branches and roots of infected trees. The lesions occur at the union on budded trees and at the crown on the seedling trees. The bark is killed to the cambium layer and spreads until the trunk may be girdled and the tree dies. Leaves turn yellow and eventually die. It also causes brown rot of fruits. Water logging and high humidity favour infection. The attack is severe on sweet orange, grapefruits and lemon used as rootstock.

Control: Badly infected branches and adjoining healthy looking parts should be severely pruned, and the cut surfaces painted with a fungicide paste such as Bordeaux paste. For best control use resistant rootstocks such as sour orange, poncirus and bud at about 50 cm from ground level.

Tristeza: This is a virus disease, transmitted by the black citrus aphid (*Toxoptera citricidus*) and by using disease budwood. The virus is sap transmissible. It causes partial suppression of new growth, and yellowing of the leaves, followed by leaf fall and die-back. Roots then gradually die, followed by the death of the tree.

Control: Use resistant rootstocks such as sweet orange, Cleopatra mandarin and rough lemon. Sour orange is susceptible to tristeza attack.

Scab: Causal agent is a fungus belonging to the species *Elsinoe* and *Sphaceloma*. It attacks twigs, leaves and fruits, producing rounded corky brown spots. The whole fruit may be covered with a superficial scale-like growth and young leaves may become twisted. In severe infections, the bark of the tree may develop blisters and finally rupture. High temperature and high humidity accelerate the severity of injury. Sour orange, lemon and some grape fruits are particularly susceptible. Sweet orange
and lime have marked resistance.

**Control**: Spray copper fungicide immediately after the fall of flowers and when the young fruits have set. Copper fungicides include capitan, kocide or perenox. Dissolve 8-10 g of perenox in 40 to 45 litres of water and spray the mixture.

**Melanose**: The disease is caused by the fungus *Diaporthe* (*Phomopsis*) *citri*. It produces brown raised pustules on young twigs, leaves and fruits, more particularly on mature trees. This gives a sandpapery feel to leaves and fruits. It is very serious in Florida.

**Control**: Use of fungicide e.g captain, Bordeaux mixture.

**Anthracnose**: Anthracnose in citrus is caused by fungal species of *Gloeosporium* and *Colletotrichum*. The former fungus causes the tips of twigs of 'Mexican' limes to die in the West Indies, where it is a serious disease and is difficult to control. The other fungus attacks branches, leaves and fruits which have become weakened or injured.

**Control**: Spraying copper or lime-sulphur, pruning and field sanitation are recommended.

**YIELD**

Budded plants begin commercial production by year 4. Yields increase gradually and reach the optimum production in year 10. The magnitude of the yield varies with the levels of management and with climate and soil conditions existing in the territories.

Under good management in the West Indies, by year 10 the average yields are:

- Sweet orange - 100 to 160 kg per tree.
- Grapefruit - 150 to 250 kg per tree.
- Lime - 72 kg per tree.
Coconut

Botanical name *(Cocos nucifera)*

Family - *Palmae*

![Diagram of coconut anatomy](image)

**Origin and distribution**

Some authorities argue that coconut originated in the West Coast of Central America, but most likely its centre of origin seemed to be in or around Malaya or Indonesia. It is now grown between the tropics of Cancer and Capricorn at low elevations. It cannot thrive at high altitudes with cold climate. Major coconut growing areas are the Philippines, Indonesia, India, Sri Lanka, Pacific Islands, Malaysia and Mozambique. A fair amount of coconuts is grown in Brazil, Venezuela, Guyana, Jamaica, Trinidad and Tobago and Bahamas. In most countries coconuts are a small holders crop. In the Philippines over 80% of the total coconut acreage is in small holdings, averaging 5 acres in size, while in India average holdings are less than 1 acre. In some countries coconuts are planted in large plantations. In Jamaica they are planted together with bananas. In Seychelles they are planted with cinnamon and vanilla.

**Economic importance**

Uses of coconut palm and its produce are numerous. The dried kernels (endosperm) of mature coconut fruit (copra) are used to extract edible oils. Copra contains 60-68% oil. With improved crushing techniques, the average oil extraction rate for copra is 64%. The oil can be used for illumination in festival time e.g Deepavali lightings. The residue from the crushed copra after oil is extracted is called copra meal (poonac), and is used as livestock feed. Milk produced from freshly grated
kernel of mature fruit is widely used in curries and making sweets. The coconut apple or haustorium of germinating nut is edible. The hard shell that covers the kernel is used for fuel. Half shells are used for bowls, cups and as ladles. They are also used for making buttons, combs, bangles, ash trays etc. The separated fibres of the husk of coconut is used for filling mattresses, making floor-mats, brooms, brushes and ropes. Coconut water of young coconuts is relished by many throughout the tropics as a refreshing beverage. The jelly-like endosperm of young coconuts may be eaten. In countries like South India and Sri Lanka the developing unopened inflorescences of coconut palm are tapped to get sweet toddy. The juices that ooze from tapped and shaved inflorescences are collected in receptacles coated inside with hydrated lime to prevent sweet toddy getting fermented. This juice can be consumed raw as a beverage or boiled and processed to make palm sugar or jaggery. If lime is not added and it is left for some time in the receptacle, it ferments to form an alcoholic beverage which contains about 6% alcohol. The beverage is termed ‘toddy’. The fermented toddy can be further distilled to produce a strong alcoholic drink termed arrack in South India and Sri Lanka.

Coconut leaves are plaited and used for decoration at festivals. They can also be used for thatching, screening and for construction of temporary walls. The midrib of the leaflets are used as brooms. The trunks of the coconut palm are used as timbers for low cost housing and farm structures in many countries. It is also used for firewood. The roots are used by natives as components of dysentery and mouth washes.

**Soil and climate**

Coconut can be grown on a wide variety of soils provided they are adequately drained. It will tolerate a pH range of 5.0 to 8.0. Rainfall of 1250 to 2500 mm evenly distributed throughout the year is adequate for good growth. It does not grow satisfactorily with less than 1000 mm of rainfall per annum. Long dry seasons do not give economic production. The plant requires plenty of sunlight and does not do well in cloudy areas. It becomes stunted under heavy shade. Suitable average temperature is 27° - 32° C, below temperatures of 20° C abnormalities in nuts are seen.

**Varieties**

**Tall palms (variety typica):** Tall palms are most commonly planted for commercial production. They grow to a height of 20 - 30 m and start bearing after six or seven years after planting. They are normally cross pollinated. The nuts are medium to large in size and 4000 - 6000 nuts usually yield 1 ton of copra. The tall palms are hardy and
will thrive on different soil types and under different environmental conditions. Common forms are referred to by the name of the country in which they are grown e.g. Jamaica tall, Panamanian tall. In the Western Caribbean (Cuba, Haiti, Dominican Republic, Jamaica and Bahamas) the tall varieties were found to be susceptible to lethal yellowing disease especially the Jamaica tall. The Malayan dwarf variety was introduced to Jamaica to replace the Jamaica tall since it was moderately resistant to the disease. Recently a hybrid formed by crossing Malayan dwarf with Panama tall variety termed Malpan showed a high resistance to the disease. The copra of the tall variety is a better quality than that of the dwarf variety. The rate of conversion of fresh coconut meat to copra is also higher in the tall variety. Productive life of the plant is 50-60 years or more.

**Dwarf variety** (variety - nana): They are short and 8-10m high the most, when they are 20 years old. They start to bear about the third year when they are less than 1 metre high. Maximum production is reached at 20-25 years, but the nut size is so small and the yield of copra per hectare too is less than the tall variety. Often the male and female flowers open at the same time on the same palm and self-fertilization is common. Because of this the dwarf palm retains its character when introduced into new areas.

**Propagation**

The coconut palm is propagated by the fruit (seed nut). The ripe fruit should be selected from old mother trees of known performance. The mother plant must be high yielding, stout, with even and good growth, with closely spaced leaves on the crown. The bunch stalk must be short and capable of supporting the weight of a good number of fruit. For early germination the nuts can be soaked in water for one or two weeks before sowing.

**Nursery**

![Fig.2.11(a)]
Fig. 2.11(b) Planting seed-nuts in the nursery

Sowing seeds in the nursery facilitates the selection of healthy, vigorously growing seedlings which are transplanted into the field. A light sandy loam soil is best for a coconut nursery. In water logged areas, raised beds 25 cm above ground level should be erected. The beds should be long and narrow to facilitate watering and inspection. Adequate space between beds must be given for paths and drains. The nuts are best planted in shallow trenches (15 cm deep) at a spacing of 23-30 cm apart in rows and 23 cm between rows. The nuts should be planted horizontally and tilted slightly upwards. After planting, the trenches are filled with soil, leaving the upper edge of the nut (about 5 cm) exposed.

The nursery beds should be regularly watered if there is no rain. The seed beds are sometimes mulched (after sowing and before germination) with dried coconut leaves after removing the butts. Seeds may germinate after 12 weeks, but the majority takes 17-18 weeks. Any seed-nuts which have not sprouted after five months should be discarded. Fertility of the soil in the nursery is immaterial, because the seedlings can live for at least a year on the reserves of the food in the nut (kernel and coconut water). Termites and scale insects cause considerable damage to young plants in the nursery and can be controlled by the use of aldrin and malathion.

Selection of seedlings

The seedlings selected for transplanting must show early germination, vigour and rapidity of growth. They must be free from pests and diseases and should have straight wide stem, with three broad dark green leaves.
Leggy seedlings with weak stems and pale narrow leaves should be discarded. In general, 30-50% of the seedlings in the nursery are normally discarded. The aim is to transplant seedlings which will grow quickly, come into bearing at an early age and then give a heavy yield of nuts.

**Land preparation and transplanting**

Land must be cleared of large trees as coconut palms do not tolerate shade. On slopy land, soil and water conservation measures should be undertaken, and in low lying areas land should be well drained to avoid water logging. The field is then lined out and planting holes are dug at a spacing of 7.5 - 9 m between plants in square or quincunx method (i.e palms in each row alternating with those in the row on either side).

Fig. 2.12

Fig. 2.13
The spacing depends on the fertility of the soil and the variety of the palm. Wider spacing can be given in fertile soils and narrow spacing in poor soils. Optimum spacing for tall palms is 8-9 m. Spacing given to 'Malayan Dwarf' in Jamaica is 6.4m in triangular planting and Maypan is given 7.6 m. Over-crowding the plants reduce production of nuts. Planting holes of 60 \times 60 \times 60 \text{ cm} are usually recommended. Split coconut husks are sometimes placed at the base of the planting holes. The holes are then filled with a mixture of top soil, well rotted pen manure or compost and wood shavings. It is allowed to settle down before seedlings are planted.

The seedlings are usually transplanted in the field when seedlings are 6-9 months old. Seedlings should be lifted carefully with the nuts attached to them and placed in planting holes at the same orientation as they were in the nursery. Each is planted at a depth of 30 to 45 cm below ground. The soil should be filled round the nut, it should not cover the collar of the seedling nor get into the leaf axils. As the plant develops, the trunk is earthed until all the soil is flush with the ground level. Planting is usually done at the beginning of the rainy season.

**Post planting operations**

Young plants must be protected from damage by cattle, goats, wild animals and rodents by fencing individual trees in small holdings or by erecting 4-5 strands of barbed wire fencing in large plantations. In the absence of rainfall, irrigation must be given preferably daily during the first three years. However, an application of four gallons per seedling, at least twice a week is necessary. The young palms should be circle weeded to a radius of 2 m several times in the year and the weeds may be allowed to form a mulch over the cleared circle. The base of the palm may also be mulched with coconut husks or dropped palm fronds. Cover crops like legumes are sometimes grown to keep down weeds between plants. In large plantations catch crops are often planted until the plant reaches 3-4 years. These include cassava, sweet potato, maize, millets, legumes and other food crops. These crops should not be planted closer than 2 m to the palms and should be adequately manured so that the fertility of the plantation is not reduced. It is better to avoid undue competition for soil moisture and light. Vacant hills must be supplied as early as possible and unthrifty seedlings or seedlings affected by pests and diseases should be replaced by healthy plants of the same age.

Coconut palms benefit from the application of both organic and inorganic fertilizers. Manuring during the early years is important in order to encourage vigorous growth, early bearing and high initial yields. A mixture with a high proportion of nitrogen and phosphorus is advised for the first four years after
transplanting seedlings. i.e

Sulphate of ammonia - 2 parts
Sulphate phosphate - 2 parts
Muriate of potash - 1 parts

The mixture is applied at the following rates twice a year the rain. It is recommended to apply .5 kg per palm starting at the end of the first year to the end of second year. Apply 3/4 kg at 2.5 and 3 years and 1 kg at 3.5 and 4 years.

After 4 years alter the mixture to equal parts of nitrogen, phosphorous and potassium and apply about 1 - 1 1/2 kg per palm depending on the fertility of the soil. Apply fertilizer after weeding, in a band around the palm at a distance of 0.30 m from the base of the young palm and the soil forked over. As the plant grows the distance around the base is extended to 1.5 m at flowering. In the absence of artificial fertilizer 25 to 50 kg of pen manure compost per tree per year is recommended.

On good virgin soils the palm begins to bear in five or six years and remains productive for about 60 years or more. Dwarf varieties come into bearing much earlier, the Malayan dwarf starts bearing at 4 years and remains productive for 20 - 25 years. After fertilization of the ovule the nut takes about 12 months to mature. An average of twelve nuts per branch can be considered excellent.

Major pests of coconut

The coconut palm suffers damage from many pests including insects, rats, monkeys, pigs and porcupines in the seedling as well as in adult stage.

INSECT PESTS

Coconut caterpillar (Brassolis sophorae): It occurs in Guyana, Trinidad and other South America countries. The adult butterfly is large brown in colour and has a diagonal orange band on the forewing. The caterpillars are brownish red with longitudinal yellow stripes. They live in groups. In the early stages of outbreaks the damage is hardly noticeable, but as the caterpillars get older they eat more of the leaves and defoliate the coconut palm leaving only the midrib when it is severely attacked. Large caterpillars make nest up to 50 cm long by webbing the leaflets together with silken thread, wherein the caterpillars hide during the day, coming out at night to feed on leaves. Palms attacked by large caterpillars are easy to locate because of the hanging nests and stripped leaves. Palms attacked by smaller caterpillars are difficult to detect because nests are not easily visible.
Control: Keep field free of trash, weeds and bushes which may shelter the pupae. Collect and burn the nets. Drill a hole 7.5 cm in the trunk of coconut palm with a three eight inch diameter drill about metre from ground level. The hole should go down and sideways into the trunk. Squeeze monocrotophos 60% EC to fill the hole. The caterpillars will start dropping after 24 hours.

Coconut moth borer or Castniaborer (Castnia daedal us): The adult moth is dark brown with a whitish crescent shaped mark on the forewings and two rows of spots on the hind wings. The larvae are whitish and 10-12.5 cm long when fully grown. They tunnel the trunk shallowly under the base of leaves and trusses bearing nuts in the crown region, and continue vertically upwards. As a result of attack the leaves and trusses drop and shed prematurely. When young seedlings are attacked they wither and when the leaves are pulled the palms are vulnerable for attack after the age 4-5 years and up to 25 feet high palms are preferred by the borer.

Control: Drill 3 holes each 7.5 cm deep in the trunk of coconut palm about a meter high from ground level as done for coconut caterpillar and squeeze Monocrotophos 60 % EC to fill the holes. Castnia borer will die about 7 days after the treatment.

Red palm weevil (Rhychophorus palmarum): It causes considerable damage to coconut palms. The adult weevil is reddish brown to almost black in colour and 3.5 cm long. The female lays eggs on wounds caused by coconut black beetle or by wild
animals or other agencies. The larvae that hatch out are pale brown in colour, they bore into the tissue of stem or crown. If they attack the stems, the grubs tunnel in all directions and finally hollow out a fairly large cavity in which large numbers of grubs may be seen. If the crown is attacked the grubs bore into the growing bud and kill it. At first the indication of weevil attack may be few small holes in the stem from which pieces of chewed fibre protrude and a brownish liquid oozes out. At later stages large wounds appear on the outside of the stem. One could also hear the gnawing sound within.

![Images of grubs and weevils]

**Fig. 2.15**

**Control:** Avoid wounding palms especially the young ones. Destroy the fallen palms by burning or burying deep in the soil. Inject monocrotophos 60 % EC or Metasystox 50% into the stem.

**Coconut beetle** (cockle) - *Strateous glopus*: Coconut beetle called by most people as cockle is seen in coconut plantations throughout Guyana. It attacks young palms between 6 months and 3 years and often kills them within a comparatively short period of time. In some coconut cultivations as much as 50% of the young palms are killed by cockle. The adult is a large black beetle. The adult beetle on emergence attacks young palms. They enter large holes they make on the stem and eat into the ‘heart’ of the plant and eventually kill it.

**Control:** Burn to destroy their breeding places like rotten coconut trunks, to kill all stages of insects which may be prevent in it or spray the breeding places with Aldrin (1/4 pint in 2 gallons of water).
Destroy the cockles when they attack the palm by regularly examining the palms and collecting the cockles and killing them. The cockles can be collected by digging up the holes with a shovel or filling up the holes with water or a mixture of water and insecticide like aldrin or dieldrin. This will cause the cockle to come to the surface where they can be collected and destroyed.

Prevent young plants from attack. Apply \( \frac{1}{4} \) lb of 5% aldrin or dieldrin dust in a 30 cm radius around the plant. This will prevent the plants from attacks by cockles for one year.

**Rhinoceros beetle or coconut black beetle (Oryctes rhinoceros)**: This is not a serious pest in South America but it is serious in South India, Sri Lanka, Malaya and the Philippines. It is a very large, dark brown or black beetle, 3-5 cm long. The head is small but has a large erect horn (rhinoceros). The adult beetle causes damage to the crown of the palm.

![Fig. 2.16](image)

**Rats**: Rats live in the palms and jump from one tree to another. The rats gnaw the young nuts and make round holes on the nut right through the shell and feed on the soft meat. The attacked young nuts fall to the ground prematurely. The rats also cause some damage to the inflorescences.

**Control**: Set baits with poisons like warfarin mixed with corn meal and sugar either on the ground or on the crown. The farmer has got to make sure that other animals and children have no access to baited plantations. Avoid planting coconuts where monkeys are nuisance or eradicate such monkey population before starting cultivation of coconut palms.

**Diseases of coconut**

**Lethal yellowing**: The disease has caused great damage in Jamaica to tall varieties of the palms. It is found in other Caribbean countries like the Cayman Islands, Cuba and Florida. Researchers now believe mycoplasma to be the causal agent of this disease. Nuts are shed prematurely from the affected plants. Leaves turn yellow
starting from the distal part of the old leaves and moving to the young ones. The heart leaves collapse and the plants die usually within 4-5 months of the first symptom appearing. Inflorescence opens prematurely and it is black from base upwards. At a later stage of the disease roots show patches of brown colour.

![Image](51x0 to 561x792)

**Fig. 2.17**

**Control:** Use resistant varieties. In Jamaica the tall varieties which are susceptible to lethal disease were replaced with the Malayan dwarf variety palm which is comparatively resistant to the disease.

**Bud root:** The disease is caused by the fungus *phytophthora palmivora*. The fungus infection causes the young unfolding leaves to wither and collapse first followed by surrounding young leaves in succession. Brown spots also appear at the base of young leaves. The leaf can be pulled easily from the crown. The central bud rots and produces foul smells. The disease is regularly found (endemic) under poor condition of growth and in high rainfall areas and it spreads quickly (epidemic) following hurricanes and other damages.

**Control:** Severely infected plants should be cut down and burned. Spray the crowns of healthy plants with copper fungicide to reduce the incidence of disease.

**Cedros wilt** (Heart-rot) - **Killer disease:** The disease is caused by flagellate protozoa. First reported in Guyana in 1977 and now it is a serious disease and has killed many palms in Bartica, Mahaica, Springhall estate and other parts of the country. It occurs in Trinidad, St Vincent, Surinam, Venezuela, Brazil and several Central America countries. In the affected plants leaves droop, nuts fall early, roots die and eventually the tree dies within one month of the first sign of disease. Sometimes some leaves may still appear green and wilted. The disease spreads to coconut palms by insects living in milk weed (locally ‘called ‘Cow poison”) known as milk weed bug. This insect acts as a vector.
Control: Cut the affected palms at once and burn leaves and trash. Get rid of the milk weed from the field that act as alternate host to the milk wed bug.

Harvesting

Nuts usually take twelve months to manure fully. The infloroscences are produced on the tree at intervals of approximately one month. Only mature nuts are harvested for copra production, since the immature nuts produced low quality copra. Harvesting is usually done five to six times a year. Nuts could be harvested by men who climb the tree and cut down the ripe bunches or using hooks or curved knives attached to long poles. In some places trained monkeys are used to pluck coconuts from the tree. Nuts are also allowed to mature on the tree and drop naturally. These are collected at intervals.

YIELDS

Yields vary greatly with the environment, age of the plantation and standard of cultivation. Average annual production is about 50 nuts per tree, under good management 60-100 nuts per tree may be produced.

Exercises

1. (i) Name three (3) varieties of cabbage recommended to be grown in Guyana.
   
   (ii) What are the two factors that limit the successful cultivation of cabbage in Guyana?

2. Name a major pest of cabbage and discuss the damage it causes and methods of control.

3. Describe the methods of propagation employed in establishing sweet potato in the field.

4. How would you identify the damage caused by sweet potato weevil in the field and what measures could you recommend to control it?

5. (i) What are the varieties of citrus grown in the Caribbean?
   
   (ii) Discuss the differentiating characteristics between sour and sweet orange.

7. Explain why nurseries are necessary in the propagation of citrus.
8. Briefly discuss pruning and training citrus plants.

9. List the chief products and by-products obtained from coconut.

10. Discuss the method of establishing seedlings in the nursery and techniques of transplanting in the field.

11. Compare and contrast the damage of coconut caterpillar and coconut palm weevil to coconut palms.
3. MANURES

Plants obtain nutrients for their growth and development from the soil. Nutrients needed by plants in large quantities are nitrogen, phosphorous, potassium, calcium, sulphur and magnesium. There is a shortage of these nutrients in the soil when crops are grown continuously on one piece of land and taken away. If plant nutrients are not replaced then succeeding crops will give poor yields. Imagine what our food supply would be if no farmer bothered to replace these nutrients.

In order to maintain good crop yields, farmers have been adding substances to the soil so as to increase the supply of plant nutrients. These substances are called manures. Generally manures can be classified either as organic or inorganic.

Organic manures

Organic manures consist of the dead remains of plant and or animal materials. Green manure, wood ash, compost manure, animal manure and night soil or sewerage are all types of organic manures. These manures are relatively cheap. In addition to supplying the major nutrients to the soil, the use of some organic manures give the following advantages:

• manures enrich the soil with organic matter so that both clayey and sandy soils can form small soil clods.
• they improve the water retention qualities of the soil.
• they increase the population of bacteria and other soil organisms which help to produce humus.
• they release the nutrients slowly so that nutrient loss by leaching is reduced and there is a continuous supply of nutrients.

Some disadvantages of using organic manures are:

• relatively large quantities have to be applied to the soil, so there is often an insufficient supply.
• the cost of transporting it to the field is high.
• they are bulky.
Types of organic manures

GREEN MANURES

Green plants or tree branches with green leaves which are ploughed into the soil are called green manures. Annual legumes have been popular green manures because they can release more nitrogen to the soil when they rot. Generally, crops grown as green manures are expected to grow rapidly, produce soft stems with an abundance of leaves, and have well developed roots. Some crops grown as green manures are cowpeas, bodi-beans, urid and crotalaria. They are usually rotovated, ploughed or harrowed into the soil just before they produce flowers. At this stage of growth, the plants decompose readily to release mainly nitrogen and some phosphorous. However, much organic matter is not added to the soil since the plants are immature. Mature plants have more organic matter.

Crops should not be sown soon after green manure has been incorporated into the soil. Soil conditions during the early stages of decomposition are unfavourable for germination of seeds and growth of very young plants.

Fig 3.1 Rotating a leguminous crop into the soil

Green manures should be buried when there is enough soil moisture to allow decomposition. Some disadvantages of applying green manures to the soil are:

- the increase of humus and nitrogen in the soil produces higher yields only in the first crop but the effect is seldom seen in succeeding crops.
- during the rainy season, small farmers are usually unwilling to grow a crop which will not be marketed.
- labour needed to establish green manures could be used more profitably to
cultivate another crop.

**WOOD ASH**

On farms where wood is the main source of fuel, wood ash can be collected easily. Wood ash is an available source of potassium. A good sample may contain up to 12% of soluble potassium compounds. It is best used immediately but wood ash can be stored dry in wooden boxes. This manure can be placed around plants in a circular band. Water should be applied immediately after application in dry weather conditions.

**COMPOST MANURE**

Compost manure is the partially rotted remains of crops and animals, which is added to the soil mainly to increase the plant nutrient level. Its high level of organic content makes it also useful for improving soil structure. Depending on the types of organic material used to build the compost, compost manure supplies nearly all the plant nutrients to the soil.

![Freshly collected composting material]

**Fig 3.2 Constructing a compost**

1. Enclose an area about 2.5 m × 2.5 m to make the first heap. Four such enclosed areas would be needed. The site selected should be a well-drained plain ground.

2. Start the first heap by placing a 10 cm layer of pen manure at the bottom as a **starter**. The starter introduces desirable micro-organisms to the compost.

3. Place a 25 cm layer of freshly collected compost material over the starter.

4. Sprinkle about 1.5 kg of Sulphate of Ammonia, 0.5 kg of ground limestones and wood ash. These substances would produce suitable conditions for microbial activities and quick rotting of the organic material.
5. Complete the first heap to a height of about 1.5 m to 2 m with alternate layers of starter and composting materials.

6. Place a long stick into the centre of the compost. Leave it for 3 weeks to 4 weeks. Pull out the stick weekly to check on the temperature. If the stick feels hot, the micro-organisms are active and rotting is in progress.

7. Turn the first into the second enclosed area. Ensure that the undecomposed materials are placed at the bottom of the new heap. Turning is done to supply air to the compost so as assist in quick and even decomposition. Leave for about 3 weeks. Prepare heap no.1 again with fresh starter and compost material.

8. Turn heap no.2 into the third enclosed area. Keep checking the temperature of the heap. Moisten if necessary.

9. Turn heap no.3 into the fourth enclosed area. Check the temperature of the heap. When temperature ceases to increase the compost manure is ready for storage until needed.

Compost manure can be made in heaps on the ground or in pits dug into the ground. The latter is suitable in areas of low rainfall or during the dry season. Compost material may include:

- leguminous plants
- lawn clippings
- household refuse
- leaves and fruits
- ash
- urine
- pen-manure

Water is used to provide a moist environment for rotting to take place. Decomposition or rotting slows up when the heap is too dry, too compact or too water-logged. Large compost materials should be chopped into small pieces before stocking.

**ANIMAL MANURE**

Animal manure includes animal dung, urine and animal by-products such as bone meal, dried blood and the remains of meat and fish industries. A well rotted mixture of dung, urine and litter drained from livestock pens is called farmyard manure (FYM). Poultry manure has a high nitrogen content. Fish remains and fish meal contain a good supply of nitrogen and phosphorous. It is said that generally FYM contains all the nutrients required by crops.

Well rotted FYM is best applied to the soil shortly before planting a crop. If applied too early during the dry season, the nitrogen compound breaks down and
there is loss of nitrogen gas to the atmosphere. Nitrogen is therefore no longer available to the plants. If FYM is applied too early in the wet season, the nitrates will dissolve in soil water and move deeper into the soil, away from the roots. This condition is called leaching. When applied to an annual crop after planting, the crop does not benefit fully. This is because the nutrients are released slowly. It is therefore very important to apply FYM at the correct time.

After spreading FYM on the soil it can be harrowed or rotovated into the soil.

**LIQUID MANURE**

Liquid manure is another type of animal manure which is collected from the washings of livestock pens. It includes urine and small amounts of dung mixed in water. It is a rich source of nitrogen. Because liquid manure is highly concentrated, it must be diluted before it is applied to plants.

![Fig 3.3 A collecting pit with liquid manure](image)

**BONE MEAL**

Bone meal is a very valuable source of phosphorous. Dried bones are crushed into powder and mixed into the soil. When this powder dissolves in soil water phosphorous is released slowly to the soil. Because of this slow release, phosphorous is not readily leached out of the top soil.

**NIGHT SOIL (SEWERAGE)**

Night soil is the faeces and urine of human beings. It has been used in the preparation of compost manure, but it can be applied directly to the soil. Night soil is an excellent source of nitrogen and organic matter. The application of this type of manure to the soil became unpopular because it has been found to be the cause of many diseases of
human beings. Amoebic dysentery and other diseases are easily spread in this way.

Generally organic manures should be protected from moisture and sunshine during storage. This is because they are made up of compounds which contain plant nutrients. These compounds, if dissolved in water can be washed away from the manure. They can also be broken down and the nitrogen gas contained in them would be lost to the atmosphere.

Another type of organic manure is the remains of plant industries such as:

- filter press and bagasse from the sugar factories
- coffee and cocoa husks
- oil palm bunch refuse
- sawdust

**Inorganic manures**

![Image](image-url)

*Fig. 3.4 Inorganic fertilizers*

Inorganic manures are also called fertilisers. They are made from either mineral rocks or from the waste materials of industrial factories. Fertilisers are concentrated chemical substances which are prepared in the form of powders, granules, pellets or crystals. Because they exist in concentrated forms, relatively small quantities are needed per hectare. These substances are added to the soil when the major nutrients are insufficient for the proper growth and development of the crop. Since fertilisers are soluble the soil must contain sufficient moisture to dissolve them when they are applied to it. In this way roots can absorb plant nutrients in solution.

Fertilisers may be classified as simple fertilisers, mixed fertilisers or com-
plete fertilisers. Some advantages of fertiliser applications are:

- relatively small amounts are needed to increase crop yields
- plant nutrients are released to the soil faster than they are when organic manure is used
- they are less bulky and cheaper to transport

Some disadvantages of applying fertilisers are:

- they are very expensive
- they do not improve soil structure
- continuous use of nitrogenous fertilisers, tends to increase soil acidity
- fertiliser application must coincide with good crop husbandry practices if high yields are to be obtained

Generally, inorganic manures (fertilisers) do not enrich the soil with organic matter.

**Types of inorganic manures**

The major plant nutrients absorbed from the soil by roots are nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), sulphur (S) and magnesium (Mg). The first three nutrients listed are known as primary nutrients. They are needed in very large quantities. The other nutrients on the list are known as secondary nutrients. They are required by the plants in smaller amounts.

**Simple fertilisers**: Simple fertilisers supply one main nutrient to the soil. These fertilisers can be described as nitrogenous, phosphatic or potassic.

**NITROGENOUS FERTILISERS**

Inorganic fertilisers which supply mainly nitrogen to the soil are called nitrogenous fertilisers. Plants need nitrogen to promote shoot growth. When an adequate supply of this nutrient is available to the crop, stems and leaves appear dark green. Pale green and yellow leaves may indicate a nitrogen deficiency.

Nitrogenous fertilisers are many. Below is a list of some of them.

**Urea**: Urea has a concentration of about 46.6% nitrogen. It is prepared as white round granules or crystals. In the soil it is changed by the action of bacteria to nitrates. Plant roots absorb nitrates in solution. Urea is also used in small quantities as a source of nitrogen in rations for ruminants.
Ammonium nitrate: This simple fertiliser supplies about 23% to 35% nitrogen. Because it absorbs moisture from the atmosphere readily, farmers avoid using this fertiliser when its application is done by machinery. Ammonium nitrate has been pelleted and coated to improve its handling and storage qualities.

Fig. 3.5 Sulphate of ammonia

Sulphate of Ammonia: This fertiliser has a concentration of about 20.6% nitrogen. It absorbs very little moisture from the atmosphere. The fertiliser is very soluble in water. Sulphate of Ammonia supplies sulphur to the soil also. Sulphur is another major plant nutrient.

Calcium nitrate: A concentration of 15% to 20% nitrogen exists in the fertiliser. It is a mixture of lime and ammonium nitrate. Calcium nitrate also supplies lime which reduces soil acidity.

PHOSPHTHIC FERTILISERS

Plant roots are stimulated to grow and develop in the soil when the nutrient, phosphorous is available. Phosphorous improves seedling growth and assists plants to flower and produce fruits earlier. Phosphatic fertilisers supply mainly phosphorous to the soil. Super phosphate is a popular phosphatic fertiliser. The following are three grades of superphosphate:

Single superphosphate: Phosphoric acid $\text{H}_2\text{PO}_4$ is the chemical compound from which phosphorous is released to the soil. Single superphosphate has a concentration of about 18% to 21% of available phosphoric acid. It also contains calcium sulphate. The application of this fertiliser to the soil is very beneficial to soils which are deficient in sulphur.

Double superphosphate: There is a concentration of about 30% to 31% of available
phosphoric acid in this fertiliser.

**Triple superphosphate:** This type of superphosphate is popularly used by farmers. It is prepared as large gray granules which have a concentration of 43% to 52% of available phosphoric acid.

![Phosphate stimulates root development](image)

**Fig.3.6 Super-phosphate**

Other types of phosphatic fertilisers are:

- basic slag
- ammonium phosphate
- rock phosphate

Basic slag is a by-product of the iron-smelting industry. Phosphatic fertilisers are best applied to soils which have a high organic matter content. These soils have less elements which would combine with phosphate to form insoluble compounds. Insoluble compounds do not dissolve in soil water and so root hairs cannot absorb phosphates. In this way applications of organic matter to the soil reduces phosphate fixation.

**POTASSIC FERTILISERS**

Potassic fertilisers or potash supply mainly potassium to the soil. Potassium helps plants to store carbohydrates and to resist some diseases. Listed below are two popular types of potassic fertiliser.

- **Muriate of potash** - contains about 60% of potassium oxide (k₂O)
- **Sulphate of potash** - contains about 50% of potassium oxide.
Fig. 3.7 Potash stimulates flowering and fruiting

**Mixed fertilisers (or compound fertilisers):** Mixed fertilisers are those fertilisers which supply nitrogen (N), phosphorous (P), and potassium (K), in definite ratios. The name is also given to fertilisers which supply any two of these primary nutrients.

Fig 3.8 Mixed fertilisers

*The ratio refers to the relative proportions of these nutrients in the order of N, P, and K. Fertilisers are named 15:15:5, 10:10:70 etc. The first number indicates the ratio of nitrogen present in the fertiliser (e.g. 15% N), and the last number indicates the ratio of potassium oxide concentrated in the fertiliser (i.e. 15% K₂O). If the total*
percentage of plant food in a particular fertiliser is below 15, the fertiliser is known as a low analysis fertiliser. When the total percentage of nutrients is 15% to 30%, the fertiliser is known as medium analysis fertiliser. With a total percentage of 30% and above, the fertiliser is called a high analysis fertiliser. The use of high analysis fertilisers is supposed to be more economical to farmers since transportation cost is reduced and the fertiliser contains more nutrients per kilogram.

Some advantages of applying mixed fertilisers to the soil are:

- farmers do not have to calculate amounts needed to mix simple fertilisers themselves
- the cost of labour to apply fertiliser is reduced since the primary nutrients are applied at the same time,
- cost of transportation is also reduced
- they help to maintain the balance of plant nutrient in the soil.

Some disadvantages are:

- leaching of dissolved nutrients occurs during rainy periods
- some farmers usually buy low analysis fertilisers which are cheaper instead of the more beneficial higher analysis fertilisers.

The choice of fertiliser should be determined by the results of a soil test. The results tell exactly the level of nutrients present in the sample of soil.

**Complete fertilisers**: Complete fertilisers contain all the major nutrients which are needed by plants.

**Application of inorganic manures**

Popular methods of applying inorganic manures are by:

- broadcasting
- band application
- drilling
- liquid application
- foliar sprays

**Broadcasting** is the shying of solid fertilisers evenly all over the soil surface. This can be done by hand or machine. This activity is best done in the final stages of land preparation. It is beneficial to cover the fertiliser by harrowing or rotavating. In this way fertilisers are protected from the sun. This method of application is suitable for field crops e.g rice and pastures.

The method of band application involves placing fertilisers in bands about
10cm wide along rows of crops or along the leaf drip areas of orchard crops. It is beneficial to cover fertilisers with soil particles soon after application.

(a) broadcasting by hand to field crops  
(b) band application of fertiliser to row crops

circular application of fertiliser to tree crops

fertiliser drilled into the soil near the plant

Fig 3.9 Method of fertiliser placement
Drilling involves the placement of fertilisers in holes made near to the roots of plants. This exercise can be done by machine at the time of planting.

Liquid application of fertilisers is made by diluting the fertiliser with water. The fertiliser solution is applied to the soil near to the plant roots periodically. Care should be taken to prevent the solution from getting on the plant. If this happens, scorching of the plant results. This method of application is suitable for seedlings in a nursery and at transplanting into the field. It helps crops to mature earlier and gives higher yields. Also beneficial is the fact that there is less scorching. A recommended concentration for making the solution is 500g of fertiliser to 45 litres of water.

Foliar sprays are used to apply plant nutrient in solution to the leaves. The nutrients applied are those required by the plant in very small quantities e.g. iron, copper and boron. These nutrients are absorbed by the leaves of the plants.

Fig 3.10 Foliar application of fertilisers

Handling and storage of fertilisers

When fertiliser placements are made manually, farmers should ensure that strong rubber gloves are worn. This practice prevents direct contact of fertilisers with the skin. Fertilisers, being very concentrated chemical substances, can cause great damage to the skin.

Farmers should take care not to open more packages of fertiliser than are needed. Fertilisers such as Urea and Muriate of Potash have the ability to absorb moisture readily from the atmosphere. These fertilisers gradually dissolve and are wasted if packages are not properly sealed.
Large amounts of fertiliser on the farm should be kept in store-rooms which are well-ventilated and covered. These chemical substances should be protected from direct sunshine and moisture.

Sacks of fertiliser should be stacked on wooden flats about 15cm off the floor. There should be free circulation of air among the stacks so that no build up of humid conditions is possible.

In developing countries most of the farmers plant crops on a small scale. Much use is not made of inorganic fertilisers because they are expensive when bought in small quantities. However, the use of fertilisers in these countries is growing slowly. The small quantities purchased by farmers should therefore be used efficiently. For this to happen farmers must ensure that the following steps are taken.

- plant higher-yielding varieties which will respond well to fertiliser applications.
- select the right types of fertiliser to meet crop needs.
- calculate the correct quantity to be applied to the soil.
- apply fertilisers at the best time
  - to meet the needs of the growing crop
  - in relation to weather conditions.
- make split applications to limit the amount of nutrients present in the soil during periods of heavy rainfall. This practice helps to reduce loss of nutrients by leaching.
- apply fertilisers to coincide with irrigation during dry weather conditions.
- use the best method of application.
- practice improved methods of weed, pest and disease control.
- practice better crop husbandry.

Generally, land used for continuous cropping needs to be kept fertile so as to maintain high crop yields. Farmers need not rely on any one measure to sustain this level of soil fertility. They need to work out their own farming system by using a combination of methods to improve and maintain soil fertility to suit their farms.
Exercises

1. Define Manures

2. State three ways by which organic manures differ from inorganic manures.

3. Complete this table

<table>
<thead>
<tr>
<th>Types of Manures</th>
<th>Method of application/placement</th>
<th>Effect of manure on plant growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Green manure</td>
<td>rotovate into the soil</td>
<td>promotes shoot growth</td>
</tr>
</tbody>
</table>

| (b)               |                                 |                                 |
| (c)               |                                 |                                 |
| (d)               |                                 |                                 |
| (e)               |                                 |                                 |
| (f)               |                                 |                                 |

Inorganic

<table>
<thead>
<tr>
<th>(a) Urea</th>
<th>broadcast on field crops</th>
<th>promotes shoot growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. INTRODUCTION TO RECORD KEEPING

The importance of record keeping

A farm record is written information on activities of the farm, set down for remembrance or reference. Record keeping is important for proper farm management. The farmer is able to examine the operations in each unit of the farm. Thus the manager or farmer would be able to make the right decision for the financial success of the farm. There are various reasons why a farmer should keep records:

- There are required as legal evidence to determine the amount of income tax to be deducted.
- The accounts are timely and show the current market situation. Inputs are related to outputs. These records of accounts are used for budgeting and planning.

Examples of simple records

- Keeping of record on individual units helps the farmer to assess his weak areas and determine what unit is making a profit or a loss.
- A farmer with up-to-date records of his business transactions can present these when requesting a loan. Basic records that are required for managing a farm are:
  - Accounts records
  - Production records
  - Crop and livestock records

Accounts records

The Farm Accounts provide farm managers with realistic information on the current financial status of the whole farm and individual units.
PROFIT AND LOSS ACCOUNTS

<table>
<thead>
<tr>
<th>Dr Date</th>
<th>Description</th>
<th>Value</th>
<th>Expenses Date</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3/91</td>
<td>Coconut</td>
<td>1,250.00</td>
<td>1/3/91</td>
<td>Wages</td>
<td>900.00</td>
</tr>
<tr>
<td>2/3/91</td>
<td>Cabbages</td>
<td>800.00</td>
<td>1/3/91</td>
<td>Fertilizer</td>
<td>1,200.00</td>
</tr>
<tr>
<td>2/3/91</td>
<td>Cassava</td>
<td>2,000.00</td>
<td>3/3/91</td>
<td>Repair of tractor</td>
<td>1,400.00</td>
</tr>
<tr>
<td>5/3/91</td>
<td>Plantains</td>
<td>1,600.00</td>
<td>3/3/91</td>
<td>Chemical</td>
<td>1,200.00</td>
</tr>
<tr>
<td>6/5/91</td>
<td>Dasheen</td>
<td>900.00</td>
<td>5/3/91</td>
<td>Seed Material</td>
<td>1,000.00</td>
</tr>
</tbody>
</table>

| Total for March 6,550.00 | Total for March 6,550.00 |

The above record is a simple double entry account in which all the cash received is entered on the left side. This is called the **debit**. All the cash paid out is entered on the right side and that is called the **credit**.

After deducting the payment from the receipts, the difference of two sides is called the **balance**. This is placed on the credit on the last line following the last entry with the word by balance. The two sides of the book would now be equal. Entries should be made as soon as transactions occur to ensure that the farmer list all transactions.

AN INVENTORY.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
<th>Date of purchase</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>10 acres</td>
<td>1982-06-15</td>
<td>100,000.00</td>
</tr>
<tr>
<td>Building</td>
<td>1</td>
<td>1983-06-15</td>
<td>200,000.00</td>
</tr>
<tr>
<td>Tractor</td>
<td>1</td>
<td>1986-06-10</td>
<td>40,000.00</td>
</tr>
<tr>
<td>Plough</td>
<td>2</td>
<td>1986-08-03</td>
<td>9,000.00</td>
</tr>
<tr>
<td>Harrow</td>
<td>2</td>
<td>1987-09-07</td>
<td>4,000.00</td>
</tr>
<tr>
<td>Seedplanter</td>
<td>1</td>
<td>1988-10-12</td>
<td>400.00</td>
</tr>
<tr>
<td>Harvester</td>
<td>1</td>
<td>1988-10-13</td>
<td>6,000.00</td>
</tr>
<tr>
<td>Storage- bins</td>
<td>1</td>
<td>1990-11-15</td>
<td>200.00</td>
</tr>
</tbody>
</table>

$ 359,600.00
The inventory is a list of all the assets, the values and in some cases the liabilities of the farm. The assets can be classified as fixed and variable assets.

**Fixed** assets are those buildings, machines and livestock that last over five years. The **variable** assets are the current assets that are used on the farm. The values of the fixed assets are determined by **depreciation**. A method of calculating depreciation is the straight line method.

Suppose a tractor is bought for $20,000. This tractor has a service life of 10 years. The value of the tractor for each year is calculated by dividing $20,000 by 10. This would be equal to $2,000. Each year the tractor would depreciate by $2,000 at the end of the tractor year the tractor would have no value.

<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>20,000</td>
</tr>
<tr>
<td>91</td>
<td>16,000</td>
</tr>
<tr>
<td>92</td>
<td>14,000</td>
</tr>
<tr>
<td>93</td>
<td>12,000</td>
</tr>
<tr>
<td>94</td>
<td>10,000</td>
</tr>
<tr>
<td>95</td>
<td>8,000</td>
</tr>
<tr>
<td>96</td>
<td>6,000</td>
</tr>
<tr>
<td>97</td>
<td>4,000</td>
</tr>
<tr>
<td>98</td>
<td>2,000</td>
</tr>
<tr>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>

**Production record.**

A breeding record is a special type of production record that is kept on animals that are breeding.

**A BREEDING RECORD FOR PIGS.**

<table>
<thead>
<tr>
<th>Date bred</th>
<th>Boar no.</th>
<th>Expected farrowing date</th>
<th>Farrowing date</th>
<th>Litter No.</th>
<th>No Farrowed</th>
<th>No Survived</th>
<th>No Weaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-6-80</td>
<td>1</td>
<td>12-10-80</td>
<td>11/10/80</td>
<td>1</td>
<td>12</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>30-8-80</td>
<td>1</td>
<td>21-12-80</td>
<td>22/12/80</td>
<td>2</td>
<td>11</td>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>
Livestock or crop production records would help the farmer to determine the level of production of the livestock on crop farm.

<table>
<thead>
<tr>
<th>CROP RECORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop</td>
</tr>
<tr>
<td>Bananas</td>
</tr>
<tr>
<td>Citrus</td>
</tr>
<tr>
<td>Beans</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EGG PRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of birds 100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day of month</th>
<th>Days of week</th>
<th>No of eggs</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monday</td>
<td>90</td>
<td>50</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Tuesday</td>
<td>89</td>
<td>40</td>
<td>29</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Wednesday</td>
<td>76</td>
<td>36</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Thursday</td>
<td>76</td>
<td>36</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Friday</td>
<td>73</td>
<td>30</td>
<td>20</td>
<td>23</td>
</tr>
</tbody>
</table>

Farm records should be kept up-to-date and easy to interpret, so that data can be used for decision making and budgeting.

**Exercises**

(1) State the main reasons for keeping records.

(2) What is an inventory? State the purposes of an inventory?

(3) Complete the following record.

- A breeding record for pigs.

<table>
<thead>
<tr>
<th>Date</th>
<th>Boar no.</th>
<th>Date expected</th>
<th>Date of farrowing</th>
<th>Litter no.</th>
<th>No Farrowed</th>
<th>No Survived</th>
<th>No Weaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-7-90</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-9-90</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(4) Make a list of all the economical terms used and give the meanings of each.
Introduction to swine production.

Swine, commonly known as pig or hog, is a very important class of livestock and its primary product is pork.

Pork is either fresh or processed into ham and bacon. There are other by-products of the pig which have economic value. These include pork oil, lard, pig skin, pig tail, pickled pork and bristles.

Fig.5.1 A pig (appearance)

The pig is an omnivorous animal, that is, it feeds on both animal and vegetable products. These products are converted into meat (pork). The dung of the pig can be used by vegetable farmers as manure for their crops.

Pig farming is a lucrative business in such countries as Denmark, U.S.A, England and China. In Guyana and the Caribbean, pork production is primarily to satisfy the needs of local consumers.

Breeds and types of pigs reared.

Common name: Pig, swine or hog.

Family: Suidae

Genus: Sus

Species: *Sus scrofa* which originated from the wild pig of Europe.

*Sus vittatus* which orginated from the wild pig of Asia.
Sus domesticus which is the domestic pig.

Types:
- Bacon type – long and lean.
- Lard or pork type – short and fatty.
- Dual purpose type – medium length.

Breeds:
- Tamworth, Landrace, Hampshire, Large white, Large black, Duroc/Jersey.

![Pigs](image)

**Fig.5.2** Pork type pig  
Bacon type pig.  
Dual purpose type pig.

<table>
<thead>
<tr>
<th>Types</th>
<th>Breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tamworth</td>
<td>Hampshire</td>
</tr>
<tr>
<td>Landrace</td>
<td>Berkshire</td>
</tr>
<tr>
<td>Large white</td>
<td>Duroc/Jersey</td>
</tr>
<tr>
<td></td>
<td>Polard China</td>
</tr>
</tbody>
</table>

**Table 1. Types and breeds.**

Some of the main breeds in the Caribbean.

**DUROC JERSEY**

This is an American breed. It has drooping ears and is brownish red in colour.

It is a hardy animal which thrives well in the tropics.
LARGE WHITE OR YORKSHIRE

This is a British breed. It has erect ears, and is white in colour. It reproduces very large litters and is very adaptable to tropical conditions. However, it suffers from sun-burn when exposed to the sun for long periods.

HAMPShIRE

This is a British breed. It has erect ears. It is black in colour with a white band across the shoulders down to the fore leg. It has good carcass quality and is good for cross breeding.
LANDRACE

This is a Danish breed and it has drooping ears. It is white in colour like the Large White and produces large litters.

Fig. 5.6 Landrace

It must be noted that most of our breeds are derived from crossing the exotic breeds that have been mentioned so far.

Management of pigs

In managing pigs, different systems can be utilized. These systems include

- Extensive System
- Intensive System
- Semi intensive System.

Fig.5.7 Extensive system of rearing pigs.
**Extensive system**

This system involves the rearing of pigs on a pasture with little facility for housing. It involves little cost in housing and facilities for feeding and managing a sow and litter. The animals are made to forage for food which is supplemented with some commercial feed.

**Intensive system:**

In this system the pigs are kept in housing units designed for accommodating several pigs within a limited space. The floor of the pen is concreted and there are facilities for feed and water. Usually the pigs are transferred from one unit to the other depending on their stage of development and the purpose for which they are reared.

This system requires proper feeding standards good sanitation and pest and disease control, since the pigs are kept in one area for a long period.

![Intensive system of rearing pigs](image)

**Semi-intensive system**

This is a modification of both of the above systems and is very popular in Guyana and the Caribbean.

Usually, the breeding pigs are managed outside for some time, while the fattening pigs are kept in the building all of the time. The pregnant gilts and sows as well as the dry sows are allowed to run in enclosed paddocks.
Housing pigs

In Commercial pig production, it is important that consideration be given to proper housing and the facilities necessary to effect management.

The basic principles of housing are to provide:

- adequate warmth for the pigs
- comfortable sleeping and resting quarters
- adequate space for feed and water
- proper sanitation.

In housing the pig the farmer should consider:

- design of the house
- site on which the house is constructed
- materials
- layout of each pen
- floor construction and space
- facilities for feed, water, cleaning, electricity, farrowing and exercise.

DESIGN

Pig houses should be designed to protect the pigs from the elements of the weather. The design should always facilitate easy access in and out of the building. Provision should also be made for good ventilation and disposal of waste.
Siting: Houses should be sited on well drained land and should be situated east to west.

Materials: Materials should be durable and strong.

Layout: This should enable the farmer easy access to feed and other supplies. The farrowing pens should be next to the paddock, so that breeding pigs can be put in and out of paddock with the greatest ease.

Floor: The floor should be concrete and should be sloping, so as to allow water to run off very easily.

Facilities:

There are several facilities needed for the efficiency of management. These facilities include:

• lighting
• water supply
• store room
• feed and water troughs
• farrowing crates
• paddock
• slaughter house.

Pens used in pig rearing

Farrowing Pens

These pens are designed to ensure the reduction of losses of piglets by crushing, thus ensuring the rearing of large litters. The design should have the following features:

• Components for the sow and piglets.
• Farrowing rails or crates to confine the sow and prevent her from crushing the piglets.
• Creep area to provide the piglets with warmth, and feed and give piglets access to the mother.
• A source of heat for piglets.
COMMUNITY PENS

During the period of gestation a number of sows can be kept together in large units. The number of sows kept in each unit should not exceed (10) ten.

These community pens allow access to the paddock which allow exercise for the sows. Sows put in community pens should be of the same size and stage of development.

BOAR PENS

These pens must be strongly constructed and must also provide access to the paddock. The boar should not be kept in cold, damp conditions.

Fattening pens are like community pens. After rearing, growing pigs are transferred to the fattening pen.

Table 11 Housing requirement per pig

<table>
<thead>
<tr>
<th>Live weight (Kg)</th>
<th>Area required (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 -18</td>
<td>0.4</td>
</tr>
<tr>
<td>18- 45</td>
<td>0.5</td>
</tr>
<tr>
<td>45 - 68</td>
<td>0.7</td>
</tr>
<tr>
<td>68 - 95</td>
<td>0.8</td>
</tr>
<tr>
<td>Sow</td>
<td>1.5</td>
</tr>
<tr>
<td>Sow with piglets</td>
<td>13.0</td>
</tr>
</tbody>
</table>

Table 3 Requirement for each class of stock

<table>
<thead>
<tr>
<th>Stock</th>
<th>Sleeping and dunging area (m²)</th>
<th>Trough length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sow with pigs</td>
<td>13</td>
<td>46 - 61</td>
</tr>
<tr>
<td>Pregnant sow</td>
<td>3-25</td>
<td>46 - 61</td>
</tr>
<tr>
<td>Boar</td>
<td>1.3</td>
<td>46 - 61</td>
</tr>
</tbody>
</table>

Feeds and feeding

The nutrition of the pig is the most important factor in determining both the performance and carcass quality of the animal. As the pig grows and its body develops, there are changes in the ration of fat to meat.
Pigs are like man, in that they have a simple stomach and are omnivorous. They require a balanced ration that consists of carbohydrates, fats, proteins, minerals and vitamins in order to provide energy, growth, maintenance and repair to tissue, and good health.

Fig. 5. 10 The digestive system of the pig.

**Classification of feedstuffs**

Feedstuffs are materials used for livestock feed. These materials can be classified as follows.

- Succulents
- Roughages
- Concentrates
- Other feedstuffs.

**SUCCULENTS**

These are derived from vegetable materials. The main constituent is water. These materials include young vegetables such as pumpkin, tomatoes, leafy vegetables, young grasses, roots and stems tubers (cassava, dasheen, eddo, sweet potato). Green materials are good source of vitamins and minerals.

**ROUGHAGES.**

These are feed stuffs of high fibrous materials and many of them would have been succulents in their early stages.
CONCENTRATES

These have a high percentage of protein, carbohydrate or fat. Those having a high percentage of protein are known as protein concentrates e.g skinned milk, fish meal, soya bean meal, meat scraps, poultry offal, blood meal. Those having a high percentage of fats or carbohydrates are called energy concentrates e.g rice bran, wheat bran, corn meal, coconut meal, sorghum, corn seed meal, molasses and ground nut meal.

OTHER FEEDSTUFFS

In this group are the manufactured feeds, such as the starter ration, growing ration and finishing ration. It also includes swill or kitchen waste. Swill should be fresh and should be boiled before it is fed to pigs.

Table 4  Materials used for feeding

<table>
<thead>
<tr>
<th>Succulents</th>
<th>Roughages</th>
<th>Concentrates</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem and root</td>
<td>hay</td>
<td>fish meal</td>
<td>pig starter</td>
</tr>
<tr>
<td>tubers of cassava</td>
<td>straw of rice</td>
<td>poultry offal</td>
<td>pig grower</td>
</tr>
<tr>
<td>sweet potato</td>
<td>maize</td>
<td>cotton seed meal</td>
<td>sow ration</td>
</tr>
<tr>
<td>yam, eddo</td>
<td>wheat</td>
<td>rice bran</td>
<td>pig finisher</td>
</tr>
<tr>
<td>dasheen</td>
<td></td>
<td>corn meal</td>
<td>swill</td>
</tr>
<tr>
<td>leafy vegetables</td>
<td></td>
<td>wheat bran</td>
<td></td>
</tr>
<tr>
<td>fruit vegetables</td>
<td></td>
<td>coconut meal</td>
<td></td>
</tr>
<tr>
<td>young grass</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5  Percentage of protein in the manufactured feed.

<table>
<thead>
<tr>
<th>Feed</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig starter</td>
<td>16</td>
</tr>
<tr>
<td>Growing ration</td>
<td>14</td>
</tr>
<tr>
<td>Sow ration</td>
<td>14</td>
</tr>
<tr>
<td>Pig finisher</td>
<td>12</td>
</tr>
</tbody>
</table>
Many farmers mix their own feeds by putting together many of the different kinds of materials used as feed stuffs. A daily ration fed to pigs should contain between 10-20% protein, 0-5% minerals and vitamins and the rest energy and roughage.

Roughage is important in that it gives bulk to the diet and also has a binding effect on the animal.

Table 6 Approximately daily food allowances for different classes of pigs.

<table>
<thead>
<tr>
<th>Class</th>
<th>Amt. of feed (kg.)</th>
<th>Kind of commercial feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boar</td>
<td>3</td>
<td>sow ration</td>
</tr>
<tr>
<td>Dry sow</td>
<td>2 - 2.5</td>
<td>“</td>
</tr>
<tr>
<td>Pregnant sow</td>
<td>3</td>
<td>“</td>
</tr>
<tr>
<td>Gilt under 180 lb</td>
<td>3</td>
<td>“</td>
</tr>
<tr>
<td>Suckling sows</td>
<td>1 / 50kg liveweight + 1 for every piglet</td>
<td></td>
</tr>
<tr>
<td>Piglet (1wk old)</td>
<td>25 / piglet</td>
<td>starter ration</td>
</tr>
<tr>
<td>Fattening pigs (weaners)</td>
<td>1</td>
<td>growing ration</td>
</tr>
<tr>
<td>8 wks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 weeks</td>
<td>1.25</td>
<td>“</td>
</tr>
<tr>
<td>12 weeks</td>
<td>1.5</td>
<td>“</td>
</tr>
<tr>
<td>14 weeks</td>
<td>1.75</td>
<td>“</td>
</tr>
<tr>
<td>16 weeks</td>
<td>2</td>
<td>“</td>
</tr>
<tr>
<td>18 weeks</td>
<td>2.5</td>
<td>“</td>
</tr>
<tr>
<td>20 weeks</td>
<td>2.5</td>
<td>“</td>
</tr>
<tr>
<td>22 weeks</td>
<td>2.72</td>
<td>“</td>
</tr>
<tr>
<td>24 weeks</td>
<td>3</td>
<td>“</td>
</tr>
</tbody>
</table>

Systems used in feeding

Different systems are used in providing feed for pigs. These systems include:

- **Dry Feeding**: feed is fed dry to animals. Lots of water must be available for drinking.

- **Wet feeding**: feed is soaked and mixed in water for feeding.

- **Floor feeding**: the feed is placed on the floor of the pen.
- Trough feeding: feed is put into a trough from which the pigs feed.
- Hand feeding: feed is fed by hand.
- Self feeding: feed is placed in a bin which releases the feed as the pig feeds
- Split feeding: half of the daily ration is provided in the morning and the other half is provided in the afternoon.
- Creep feeding: this is the introduction of solid food to suckling pigs.

Fig. 5.11  a) Floor feeding  (b) Trough feeding

Fig. 5.12  Hand feeding  Self feeding

Fig. 5.13  Creep feeding piglets
Breeding

The mating of a sow or gilt with a boar is called breeding. The objectives of breeding in pig management are to:

- increase the number of animals on the farm
- enable a sow to produce at least two litters every year
- produce litters of economic size, usually 8-9 piglets per litter
- produce piglets that are fast growing, disease resistant and that have good carcass quality

SELECTION OF BREEDING PIGS

When selecting pigs for breeding, the farmer should select boars and gilts that have the following characteristics.

- A strong straight top line.
- A well muscled body with little fat.
- Strong pasterns and full ham.
- Gilts should have at least 12-14 teats that are well placed.
- The gilts should weigh between 75-85 kg and should be well developed.
- The boars should have two well developed testicles of uniformed shape.

Fig. 5. 14  A breeding sow.  A breeding boar.

The appearance of the animals is not the only consideration used for selection. Selection is also based on performance of the parents' pedigree.

Breeding sows and boars should come from good mothers and litters of about eight piglets. The litters should have had average weight of 15-18 kg at the end of 8 weeks.
MATING OF BOAR AND GILTS

A pig attains puberty at the age of 5-6 months. However, the gilt is not ready for breeding until about 8 months and the boar until about 10 months. Breeding does not depend on age alone. The size and physical development are important considerations.

A boar used for the first time should service twice weekly for the first two months. Afterwards he can be allowed up to six services per week. One boar can service about 15 sows.

Sows and gilts are mated when they show signs of heat or oestrus. Heat is the time of readiness for the male and during this time the ovary sheds several eggs called ova. The shedding of the eggs by the ovary is called ovulation. During heat the sow or gilt exhibits the following signs.

- A swollen, reddish vulva from which mucus or slime may be produced.
- Frequent grunting and restlessness.
- She stands to be mounted and mounts other animals.

Heat lasts between 2-3 days in some cases up to 5 days. Ovulation takes place about 16-48 hours after the beginning of heat i.e on or about the second day. The farmer should allow the sow/gilt to be mated by the boar on the second and third day. It is best to mate twice with an interval of about 12 hours between services. The farmer is generally advised to put the sow with the boar during the time when she is expected to come into heat.

Heat occurs every 21 days. The interval between heat is called the oestrous cycle. If the sow/gilt fails to come back into heat after being mated then the farmer can assume that conception took place. Conception is the onset of pregnancy.

In practice the boar and the sow/gilt are given about 1kg of feed extra per day at least one week before mating. This practice is called “steaming up” and usually gives rise to large litter size.

Management of pregnant sow/gilt.

Pregnancy, also known as gestation, lasts for a period of 116-120 days. A pregnant sow/gilt is usually kept in a dry paddock with a number of other sows at the same stage of pregnancy. Adequate exercise, water and suitable ration should be provided. The sow should get about 2-3 kg of feed daily. The paddock should have shade.

At least two weeks before the sow is ready to give birth (farrow), she should be dewormed. One week later she should be washed and put into the
farrowing crate. She should be given dry litter to prepare a nest. Her feed should be decreased gradually and from here on the farmer should begin to look for signs of farrowing. The farrowing signs are:

- the sow becomes restless and grunts abnormally
- there is milk present in the teats
- enlargement and swelling of the vulva
- the vulva discharges mucus, which is an indication of the bursting of the water bag
- the abdomen becomes distended
- the pig will attempt to make a nest.

![Sow in farrowing crate]

**Fig. 5. 15  Sow in farrowing crate**

**Management at farrowing.**

On the day of farrowing, no feed should be given to the sow. On the second day however two handfuls of feed is given and gradually increased until her full ration is restored in about 7-10 days time.

During farrowing the sow should not be disturbed. The piglets are born with a thin membrane covering the face and body. Immediately after birth this membrane should be wiped off with a dry cloth.

Each piglet should be removed and placed in a box under the brooder which
was prepared before farrowing. The navel or umbilical cord is cut 7-10 cm from the body and dipped in iodine. The needle of eye teeth are crushed or cut with a needle teeth pliers.

Fig.5. 16  Piglets in box under brooder

Fig.5. 17 Cutting and disinfecting the navel cord.

Fig.5.18  Crushing or cutting of the needle teeth.
The piglets are weighed and after farrowing is completed, they are allowed to suckle the first milk (colostrum). Colostrum is rich in protein, minerals and antibodies which develop the immune system of the piglets.

The farmer then cleans the pen of the afterbirth and any wet litter. Usually, the afterbirth takes between 4-12 hours to be expelled and comes out in parts. The afterbirth should be buried.

![Image of piglets suckling](image)

**Fig.5. 19 Piglets suckling.**

**Managing piglets to weaning.**

The body temperature of piglets tends to drop for the first thirty minutes after birth. Under cold conditions they tend to shiver and may die. The temperature of the pen should be maintained at about 32°C for the first two days. Adequate preparation should be made before farrowing to keep out drought and to keep the pen warm. Excessive cold can lead to pneumonia.

The piglets should be given a litter of straw on which to lie under the brooder (50 watt bulb). The pen should be dry cleaned and not washed for about 10-14 days.

Three days after farrowing, the piglets should be treated with injectible or oral iron. Iron prevents anaemia a condition which leads to scouring, weakness, pale colour, shivering and death.
TREATMENT FOR ANAEMIA

Anaemia treatment is done either by injecting each piglet intramuscularly with an iron dextrose solution or by administering anaemia paste on the tongue of each piglet. The paste can also be placed on each teat of the mother. Iron can also be provided by putting clean soil in the pen for the piglets.

Fig. 5.20 Administering iron

CREEP FEEDING

After 6-7 days of birth, the piglets should be given a solid feed. This practice is called creep feeding. The feed provided is a high protein starter ration.

IDENTIFYING PIGLETS

If more than one sow is on the farm, the farmer should identify piglets born to each sow. Identification is by way of ear notching, tattooing or by using ear tags.

Fig. 5.21 Identifying piglets by ear notching.
Fig. 5.22 Ear-notch pliers.

IMMUNIZATION

Piglets should be immunized against diseases like swine-fever, and swine erysipelas by the time they are 6-8 wks old.

Immunization is treating the piglets with vaccines to develop resistance to specific diseases. The vaccines can be administered orally by way of the drinking water or by way of injection.

CASTRATION

Male piglets that will not be used for breeding should be castrated when they are about five or six weeks old.

Castration is the removal of the testes by surgical means. The scrotum is cut and the testes are removed. Castration prevents inbreeding among closely related pigs and pigs tend to develop faster. A castrated boar is called a barrow. Castration should only be done by an experienced stockman.

Fig 5. 23 Steps in castration
WEANING

Weaning is the practice of removing the sow from her piglets. The sow is first removed for one day and then returned to her piglets. She is finally removed completely. Piglets are weaned when they are eight weeks old, at which time they should weigh 15-16 kg.

Weaners should be kept warm and should be treated with an antibiotic. During weaning, the feed should be very nutritive. After one week of weaning, piglets should be dewormed and removed to the fattening pen.

Management of fattening pigs

Fattening pigs or porkers are generally fattened for meat. The pigs are usually slaughtered when they are 6-7 months old at a live-weight of 62-67 kg. Fatteners are reared intensively in groups. They are given a special growing ration (see Table 6 for amount of feed/pig).

A deworming programme should be put into effect every 3-4 months. It is important that strict sanitation be observed and pigs should be given an adequate supply of fresh water daily. Lots of green vegetables should be provided.

![Image of piglets](image)

**Fig.5. 24** Fatteners in a community pen.

Management of boar

Breeding boar should be separated from the rest of the stock at 4 months. They should be fed a balanced diet.

A special paddock next to the one holding the gilts/sows should be built. Overfeeding leads to excessive fat and laziness. A boar can begin to serve between 8-10 months.
Control of pests and diseases

Most of the mortality caused by pests and diseases happen very early in the life of pigs. Pests and diseases can be controlled and prevented by good sanitation, nutrition and good management practices.

Sick pigs should be identified and treated very early. Some of the signs of ill health in pigs are:

<table>
<thead>
<tr>
<th>Signs of Ill Health</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• drop in food consumption</td>
<td>• lack of milk</td>
</tr>
<tr>
<td>• humping of back</td>
<td>• paralysis</td>
</tr>
<tr>
<td>• high temperature</td>
<td>• convulsion</td>
</tr>
<tr>
<td>• drop in water intake</td>
<td>• diarrhoea and constipation</td>
</tr>
<tr>
<td>• coughing</td>
<td>• scratching</td>
</tr>
<tr>
<td>• rough coat and an unthrifty appearance</td>
<td>• fast breathing</td>
</tr>
<tr>
<td>• panting</td>
<td>• vomiting</td>
</tr>
<tr>
<td>• abortion</td>
<td>• reluctance to move around</td>
</tr>
<tr>
<td>• huddling</td>
<td>• lameness</td>
</tr>
<tr>
<td>• sneezing</td>
<td>• dullness</td>
</tr>
<tr>
<td>• worms in the manure</td>
<td>• paleness of the ear</td>
</tr>
<tr>
<td>• swelling of the eye lids</td>
<td>• discolouration of the skin</td>
</tr>
<tr>
<td>• blisters in the mouth</td>
<td>• raised area of the skin</td>
</tr>
<tr>
<td>• discharge from the nose</td>
<td>• inability to walk</td>
</tr>
<tr>
<td>• staggering</td>
<td>• loss of hair</td>
</tr>
<tr>
<td>• blood in urine or dung</td>
<td>• eye discharge</td>
</tr>
<tr>
<td>• impotence (boar)</td>
<td>• increased respiration</td>
</tr>
<tr>
<td>• lack of growth</td>
<td>• cannibalism</td>
</tr>
</tbody>
</table>

Diseases are caused by:

• microbes such as bacteria, viruses, fungi and protozoa
• internal and external parasites
• metabolic disorders due to nutritional difficiency and physiological abnormality
• injuries caused by the physical environment.

Some common diseases

PIGLET ANAEMIA

This is a condition that results from the lack of iron in the blood. In order to prevent this condition, the farmer should administer iron when the piglets are 3-7 days old again at 3 weeks. Iron can be given as a solution or a paste or clean soil.

Symptoms
• slow growth rate.
• piglets are pale looking.
• sluggishness and a white diarrhoea.

SCOURING

Scouring or diarrhoea is caused either by poor insanitary conditions or by bacteria due to insanitary conditions.

Scours caused by poor nutrition is called nutritional scours and occurs in any rash change in feed, nutritional deficiency or by over feeding. Scours caused by bacteria is known as infectious scours and usually is highly scented.

Symptoms
• White diarrhoea. In the case of infectious scour it is highly scented.
• Weakness, followed by mortality.

Prevention / treatment
• Avoid rash change in the feed of the mother.
• Reduce the amount of concentrate and increase the amount of roughage.
• Keep the place clean and provide clean water.
• Treat with antibiotic.
SWINE ERYSIPelas

Swine erysipelas, also known as diamond skin disease is caused by bacteria that live in the soil.

Symptoms

- Pigs that suffer from this disease develop very high temperatures. They reject food and do not move about.
- There is a light pink to dark purple discolouration, with clearly defined borders that appears on the skin.
- The discolouration disappears after some time and leaves scabby dead skin.
- Infection of the knees, back and toes makes the animal lame or even crippled.

Treatment / Prevention

Disease can be controlled by antibiotics. It can be prevented by vaccination, good sanitation and by disinfecting pens.

HOG CHOLERA OR SWINE FEVER

It is both contagious and infectious and is characterised by high fever and sudden death.

Symptoms

- Listlessness and loss of appetite.
- Gummy eyelids.
- Shivering and coughing.
- Constipation followed by scouring.
- A purple, reddish rush on ear, belly and backs
- High temperature.

Prevention and Control.

- Infected animals must be isolated and dead animals burnt.
- Inoculate piglets with vaccine. Boil swill before use
- Disinfect pens and other facilities.
Internal parasites

ROUNDWORMS

These parasites live in the intestines of the pig and feed on the nutrients present. They are pink in colour and can develop to the thickness of a lead pencil.

The worms deposit their eggs in the intestines. They are then passed out in the dung and develop outside on unclean floors. They are swallowed in the infective stage by other pigs. The larvae develop and pierce the walls of the small intestines and the cycle is repeated.

Symptoms
- Pneumonia
- Bleeding
- Constipation
- Diarrhoea
- Shaggy hair
- Poor development

Treatment /Prevention

Regular cleaning and disinfecting of pens. Deworm pigs regularly; boars every 6 months; sows two weeks before farrowing and one week after weaning; fattening stock, every 3-4 months.

![Diagram of the life cycle of intestinal roundworms](image)

**Fig. 5.25** Life cycle of the intestinal roundworm.
**LUNGWORM**

The lungworm is a round whitish worm that lives in the lungs of pigs. They eat away the lung tissue and the animal suffers shortness of breath and coughing. The eggs are usually coughed up or passed out in the dung.

**Symptoms**

- shortness of breath
- loss of appetite and general loss of condition.

**Treatment/Control.**

Infected pigs should be isolated and treated with piperazine compounds.

**External parasites**

External parasites such as mites and lice cause mange. They puncture the skin causing itching and dry scaly skin on parts of the body. These openings are usually attacked by flies and are hosts for secondary infection.

**Treatment/Control**

Mange can be controlled by keeping the walls of pen clean and by spraying the pig with 0.5 % solution of malathion.
Meat Products

Pigs are marketed for pork and for bacon. The average weight and age for slaughtering is about 90-100 kg at 7-8 months. Pigs are slaughtered at lower and higher age or weight levels.

Table 7. Slaughtering weight and age.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Approx. age at slaughtering (weeks)</th>
<th>Liveweight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suckling</td>
<td>10 - 14</td>
<td>18</td>
</tr>
<tr>
<td>Pork</td>
<td>14 - 16</td>
<td>45 - 55</td>
</tr>
<tr>
<td>Cutter</td>
<td>16 - 20</td>
<td>70 - 80</td>
</tr>
<tr>
<td>Bacon</td>
<td>22 - 26</td>
<td>85 - 95</td>
</tr>
<tr>
<td>Heavy hog</td>
<td>28 - 32</td>
<td>115 - 130</td>
</tr>
</tbody>
</table>

Table 8. Weight gain and killing percentage

<table>
<thead>
<tr>
<th>Age (wks)</th>
<th>Av weight (kg)</th>
<th>Av. daily wt. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 (weaners))</td>
<td>17.2</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>24.5</td>
<td>0.5</td>
</tr>
<tr>
<td>12</td>
<td>31.8</td>
<td>0.5</td>
</tr>
<tr>
<td>14</td>
<td>40.9</td>
<td>0.63</td>
</tr>
<tr>
<td>16</td>
<td>50.4</td>
<td>0.68</td>
</tr>
<tr>
<td>18</td>
<td>60</td>
<td>0.68</td>
</tr>
<tr>
<td>20</td>
<td>70.4</td>
<td>0.73</td>
</tr>
<tr>
<td>22</td>
<td>81.8</td>
<td>0.82</td>
</tr>
</tbody>
</table>

After slaughtering the carcass is dressed i.e the head, tongue, guts (kidneys, liver, intestines and stomach) hooves, hair and lungs are removed. The dressing percentage or killing percentage is the weight of the dressed carcass as a percentage of the live weight.

The live weight is the weight of the pig before slaughter.

Dressing/ Killing percentage = \( \frac{\text{Carcass weight}}{\text{liveweight}} \times 100 \)

Usually in pigs it is about 75%.
Fig. 5.27  Bacon carcass

Fig. 5.28  Wholesale cuts of pork carcass

**Exercises**

1. Explain in your own words the meaning of each of the following.
   - breeds
   - systems of manufacturing pigs
- farrow
- gestation
- oestrous
- omnivorous animal
- balanced ration
- roughage
- concentrate
- colostrum.

2. Explain why in pig management the following are important.
   (a) Housing
   (b) Nutrition.
   (c) The farrowing crate.
   (d) The paddock.

3. In which group will you put each of the following foodstuff.
   (a) cassava, sweet-potato, yam.
   (b) hay, straw of rice and wheat.
   (c) young grass, calaloo, vegetable.
   (d) fish meal, corn meal, rice-bran, coconut-meal.

4. List some of the practices used by farmers in managing each of the following classes of pigs.
   (a) a pregnant sow & gilt.
   (b) piglets at farrowing and on to weaning.

5. Identify some signs of ill-health in pigs.

6. In each of the following disease, list the measures a farmer should take to control and prevent the spread of:
   (a) Swine fever.
   (b) Piglet anaemia.
   (c) Scouring in piglets.
   (d) Worm infestation in pigs.
Fish farming or fish culture is a branch of agriculture involving the breeding, rearing and marketing of fish. In Guyana and the Caribbean, fish farming is basically for food since fish is nutritious and is a relatively cheap source of protein.

Fishing is a lucrative business and there are large firms that are engaged in fishing for fish and prawns in the waters around us in the Caribbean.

**Fish products**

Fish provides us with a valuable protein that is more easily digested than most other forms of meat.

Some fishes are rich in oil e.g. salmon. They also have a high content of vitamins A and D. Fish is also a good source of minerals such as iodine, phosphorous and calcium.

Other products which are obtained from fish are fertilisers, glue, soap, linoleum, shortening, paint, lubricant, ink, gelatin, artificial pearls, sharkskin, leather, insulin and other medicine.

Fish catching is a popular sport as well as a leisure-time activity. Many people keep fish in aquariums and for exhibition.

**Characteristics of fish.**

![Diagram of a fish showing various parts: dorsal fin, caudal fin, lip, eye, scales, lateral lines, mouth, face, operculum (gill cover), pelvic fin, ventral fin.]

**Fig. 6.1 External features of a fish (tilapia)**
The fish is a cold blooded vertebrate which lives in either salt or fresh water. Some are covered with scales. Fishes breathe by gills and move by way of fins. Some feed on plants and are called herbivores, some feed on animals and are referred to as carnivores while others feed on both plants and animals and these are described as omnivores. Some lay eggs, while others are viviparous.

**Classification of fish.**

Fish can be grouped into several classes. Some of these classes are as follows:

- Fresh water or inland fish e.g patwa, houri, hassar, tilapia.
- Salt water or sea water fish e.g cat fish, snapper, shark, snook.
- Scale fish e.g patwa.
- Unscaled fish e.g gail backer.
- Deep sea fish e.g snapper, grouper.
- Off shore fish e.g puce, mullet.

![Fish Images](image-url)

Fig.6.2 Some common fresh water and salt water fishes.
Fishing

Fishing is done by any one of three ways:

- inland fishing.
- coastal or inshore fishing.
- deep-sea fishing or off-shore fishing.

INLAND FISHING

Inland fishing is also called fresh-water fishing and is usually done in ponds, swamps, lakes, creeks and rivers. It also involves aquaculture in artificially constructed ponds. Inland fishing has been the chief source of fish for domestic use in the villages and interior locations. The methods used for fishing are:

- poisoning fish
- shooting with bow and arrow
- trapping by allowing the water to channel out leaving the fish behind
- casting nets
- hook and line
- feeling by hand in shallow water
- trapping seine.

Fig. 6.3 Fishing by cast nets.
Fig. 6.4  Shooting fish with bow and arrow.

Fig. 6.5  Dragging seines.

Fig. 6.6  Fishing with hook and line.
INSHORE OR COASTAL FISHING.

This is done by fishing in coastal water or along the shores in small open boats. Some fishermen cast nets along the shore and catch such fishes as four-eye and mullet. Others throw out baited hooks from small boats. These hooks are floated by corks or calabash. The lines are dragged slowly through the water. Selected varieties of fish are caught by this method e.g curass, catfish, snapper. In Guyana this method is called" the cadell".

Fig.6.7 Baited hooks or cadell being dragged by small boat.

Other fishermen use the pin seine method. In this method the net is cast and pinned in a shallow area to trap the fishes when the water recedes.

Many fishes are caught in this way. They include queriman, mullet, snook, gail-barker, butter- fish, shark, morocut, catfish, highwater, curass. The catch is loaded into the boats and brought to shore.

Fig.6.8 Pin seine fishing.
DEEP-SEA FISHING OR OFF-SHORE FISHING.

This kind of fishing is done by fishermen who spend weeks or months at sea in trawlers.

Deep sea fishing is done by trawling fishes pots, nets, heavy line or trawl-nets. These are pulled mouth open through the water behind the ship.

Fig. 9 Deep sea-trawling.

Trawlers are equipped with sophisticated equipment to detect large shoals of fish under the sea.

Fishes caught by trawling include snappers, bangamary, trout, tuna, mackerel. Shrimps and prawns are also caught. Some ships trawl specially for prawns.

Rearing fish

Aquaculture is the rearing of fish in artificially constructed ponds. The practice is still new in the Caribbean. The most popular fish reared under artificial conditions is the Tilapia (*Tilapia mossambica*). In recent times the hassar has also become popular.

Rearing tilapia

*Tilapia mossambica* grows in fresh to brackish water. The males are longer than the females and have pointed vents. The males attain the weight of 56 grams in 3 months and 168 grams in 6 months. The females deposit eggs in holes made in the pond and these eggs are picked up in their mouths after they have been spawned, and incubated.
SETTING UP THE POND

The first thing is to locate the site on which the pond will be constructed. The pond site should:

- be located near to adequate source of water
- consist of soil that will hold water all the year round
- be located where it can be easily drained.

CONSTRUCTING THE POND

The minimum size that can be recommended is one tenth of an acre. Each pond should be rectangular in shape.

Ponds should have:

- a depth of 4.5' to hold a minimum of 3.4' of water
- sides sloping at 30° angle
- the bottom graded to allow complete drainage
- grass or suckers planted along the dam to minimise erosion.

Fig.6.10 Feeding tilapia on a fish farm.
FLOODING AND FERTILIZING THE POND

When flooding, a net should be put over the pipe that leads water into the pond. This is to prevent the entry of wild fishes.

The acidity of the water should be checked and should be between 6.5-9.00 pH. In order to reduce the acidity, 2 tons of limestone per acre should be applied. Limestone can be applied before the pond is filled with water.

FERTILIZING THE POND

The pond is flooded to a depth of 3.0’ and is fertilised by either organic or inorganic fertilisers or by both. Organic fertilizer, such as cattle or poultry manure can be used along with phosphorous. The rate of application is 2,000 lbs/ac of organic manure initially and then 500 lbs/ac weekly. T.S.P is also applied at the rate of 37 lbs/ac/month.

Within 7-10 days the water will appear green with the presence of algae on which the fish will feed.

STOCKING:

It is recommended that production ponds be stocked with only one sex of tilapia and that is the male. The pond should be stocked at the rate of 6,000 or 250 lbs of fingerlings/ac if supplementary feeding will be done. If no supplementary feeding will be done, stocking rate should be 3,000 fingerlings/acre.

Fish should be introduced two weeks after initial fertilizing. Water should be added to the pond so as to gradually raise the level of the water. At the end of eight weeks, the pond should be filled to the maximum depth of 4.5’.

FEEDING

This is a very important aspect in managing the fish. Care should be taken not to overfeed since this can cause an under supply of oxygen.

Fish should be fed 5% of their body weight daily. The most popular feedstuff is the poultry growing ration. A feeding box is placed about 6-8” below the water at the same spot daily. Feeding should be done at least twice daily.
MANAGING OF POND

In managing the pond, the following practices should be observed.

- Always keep pond free of weeds.
- Always maintain the level of the water to its maximum level.
- Examine samples of fish at two weekly intervals to check the size of fish as well as for diseases.
- Do not fertilise on cloudy days.

DISEASE CONTROL

In brackish water, tilapia can be infected by a small cope pod parasite known as fish louse. It can be recognised by its disc-like shape and greyish colour. The louse is found mainly on the head, base of fins and tail. Heavy infestation can kill the fish within a short time since the parasite feeds on the blood of the fish.

CONTROL OF THE FISH LOUSE

Use benzene (B.H.C) a wettable powder, at the rate of 2.5 lb/ac of water (3’ deep).

CONTROL OF PREDATORS

Insects such as water beetle, water bug, are predators of the tilapia. Others include the houri, frog, alligators, ducks, and water rats. Insects can be controlled by using dipterex at the rate of 11 lb/ac in 3’ of water.

Alligators can be controlled by fencing the pond. Other fishes can be controlled by putting mesh over the inlet pipe when the pond is being filled.

HARVESTING

There are several ways of harvesting tilapia. These ways include:

- castnets
- seines
- hook and rod
- draining the pond completely and collecting the tilapia.

When harvesting small quantities, the cast net is recommended. When harvesting the entire pond, the best method is to drain the pond through a cast net at
the out-flow point and remove the fish by hand. Tilapia is ready for harvesting in about 19 weeks.

Exercises.

1. Name some fishes belonging to each of the following groups.
   
   (a) Fresh water fish.
   
   (b) Sea - water fish.
   
   (c) Scaled fish.
   
   (d) Unscaled fish.
   
   (e) Deep - sea fish.
   
   (f) Off - shore fish.

2. Describe two of the methods used in Guyana in:
   
   (a) inland fishing
   
   (b) coastal or inshore fishing.

3. List the steps that are required in the cultivation of tilapia.

4. Visit your local fish market and
   
   (a) name the fishes that are bought by consumers
   
   (b) name the fishes that are supplied in the greatest quantities
   
   (c) name the fishes that carry the highest prices.

5. Name the ways in which fish is sold in our local market and give examples.
   
   Ways       Fishes
   Fresh      patwa, houri, catfish.
7. FARM MACHINERY AND EQUIPMENT

There is great need for farmers to produce more food to feed the ever increasing population of human beings and their livestock as well. Traditionally, even large scale farm operations did not produce the highest yields from the area of land cultivated. Some factors which contributed to low yields were:

- the population use of manually operated or animal drawn tools and equipment which generally demanded much time and labour to get farm work done.
- the lack of improved farming techniques such as:
  - fertilising for crop yields
  - feeding livestock with balanced rations
  - protecting crops and livestock from pests
  - using efficient irrigation and drainage systems etc.
- the unavailability of farm labour at the time when it is most needed e.g. for land preparation, planting and harvesting.
- high cost of labour when it is available.

To reduce negative factors to farming, farm machinery and equipment have been designed and produced for most farm activities. Many manually operated tools and equipment can be replaced by mechanical devices. The work done by forks and rakes can be done faster and better by ploughs and harrows. Hoes can be replaced by ridgers. Shovels can be replaced by motorized drain diggers and draglines. Planting, weeding, watering, harvesting and other types of farm work can be done by motorized devices or by motor drawn equipment.

**Harvesters**

The combine grain harvester has many important parts by which it can cut, thresh and grade grain in the field. The **reel** has curved metal arms which revolve. The metal arms gather the stems, push them towards the **cutter** and cause them to fall on the moving **conveyor** belt with all the grains in one direction.
Fig. 7.1 A grain harvester

The conveyor belt takes the grains on the stalks upwards to the drum. The drum revolves within a concave metal grating. Beater bars are fitted on the drum so as the drum revolves, the paddy grains are fanned. Another sieve separates the grains from the dust and weed seeds. The grains are now graded over screens of different sizes. With the Badger Combine Harvester, the grains are put into bags which are sealed by tying and then dropped to the ground through a chute.

The Tank Model Combine Harvester has a grain tank which collects the grains and empties them into a trailer. The trailer will then transport the grains to be dried and stored in silos. Much of the grains fall through the concave metal grating to a lower grain pan while the stalks and remaining grains pass on to a vibrating slatted platform called the straw walker. On the straw walker the remaining grains are separated from the stalks by a tossing action. The stalks and straw now pass out of the machine while the grains, chaff and cavings join the first set of grains in the pan below.

The vibrating sieve separates the cavings from the grains and allows these cavings to pass out of the machine. Chaffs and grains continue to another series of sieves. One of these sieves holds the chaffs. Chaffs are now blown out of the machine. Crop harvesters which are popular on farms are the combine grain harvester and the sugar cane harvester.
Fig. 7.2 Sugar cane harvester

The sugar cane harvesters are designed to cut the cane stems, cut off the tops and load the chopped stems on trucks for transport to sugar factories. The harvester has cutting knives and conveyor belts to do this job.

The Forage Harvester is a tractor-drawn equipment. The main part is a rotation spindle which is driven by the tractor power-take-off (p.t.o) shaft. As the spindle rotates, the forage is cut and pushed up through the delivery chute into the waiting trailer. The equipment helps the farmer to harvest forage which could be later processed into hay or silage. Hay and silage are very useful as feed during harsh weather conditions when forage cannot grow. In tropical areas hay-making is difficult because nutritious forage is plentiful during the wet seasons. Harvesting and drying operations are impossible in such conditions.

Other equipment

In livestock farming, farmers are now cultivating pasture and grain to ensure that there is enough feed for livestock throughout the year. There are mechanical equipment for mixing and producing balanced rations. Automatic feeding and watering systems have been designed for livestock pens to ensure that feeders and waters are filled continuously. Concentrate feed as well as the water are held separately in large hoppers outside of the pens. Feed is taken to the feeders inside the pens by conveyor tubes.

Other important machinery and equipment for large livestock farms are the grain dryer, the milling machine and vehicles for transporting farm supplies and farm produce.
The grain dryer can be very useful to farmers when grain is harvested during humid conditions. Damp grains in storage would spoil. Grains packed in bags are dried by warm air blowing through them. Warm air is produced by a heater and fan unit.

Milking machines are specially designed equipment for extracting and collecting milk from dairy cows. Vacuum in the teat cups squeezes and sucks milk from the cows' teats. When air enters the teat-cups again milk passes through the tubes and is collected in the stainless steel bucket. The continuous removal of air (causing vacuum) and the subsequent intake of air allows the milking process to occur.

Vehicles for transporting farm supplies include lorries and tractors with trailers. The milk collecting bulk truck is specially designed for its purpose. The tank has two components, an inner and an outer one. The inner one is made of stainless steel and contains milk. The space between the containers is fitted with equipment for cooling milk held in the tank. Milk temperature is controlled by a thermostat. This refrigerated truck is useful for transporting milk in large quantities, for long distances.

The use of motors can produce much more power than muscles. Farm work has become less strenuous, many difficult jobs are made possible and more interesting now than they used to be. A large labour force is no longer needed since machines are powerful enough to do all the work in a shorter time. Although fewer labourers are needed, farm workers must develop special skills in operating these farm machines and maintaining them in good condition for many years.

This development has encouraged many young farmers to accept farming as a profession. Farmers are now in a better position to produce very large amounts of agricultural products of satisfactory quality and at reasonable cost.

Although there are many benefits to be derived from the use of farm machinery and equipment, many farmers in Guyana and the Caribbean will not be able to buy them since they are very expensive. Those farmers who can afford to buy them are likely to find it uneconomical, because after the short period of crop cultivation it would be difficult to find useful work for them for the rest of the year. In cases where individual farmers may have many parcels of land some distance away, much fuel has to be used to travel from one farm to the next instead of working. In spite of this governments could encourage farmers to operate on a large scale by:

- offering farmers large areas of farmland in one block
- offering farmers loans and subsidies to purchase suitable farm machinery
- purchasing the machinery and renting or hiring them to farmers at a low cost
• encouraging farmers' cooperatives which would allow farmers to own and operate machinery

The tractor

The tractor is a motor vehicle which is specially designed to travel over rough ground or soft soils in order to get farm work done. A wide range of farm work can be done with this vehicle if suitable equipment is attached to it. Tractor engines are made to deal with vast loads in the field. They are operated with diesel fuel which is usually cheaper than petrol. Diesel engines do not have spark plugs and carburettors, instead there are fuel injectors and several air filters and fuel filters. Tractor engines may be described as 2-stroke engines or 4-stroke engines. The 2-stroke engines are designed to do lighter farm work.

Farm tractors supply power in different ways. They can:

• tow some types of equipment such as trailers and fuel tanks which can be attached to the draw bar.

![Tractor diagram](image)

Fig 7.3 Longitudinal section of tractor

• lift or pull other types of equipment by linking them to the hydraulic system e.g. the front end loader and the plough respectively.

• operate some machines with power direct from the engine by connecting them to the **power-take-off shelf** (p.t.o.). The water pump and the rotary plough are two pieces of equipment which can be operated with power from the tractor.
Because of these reasons farm tractors can be described as versatile machines.

**Types of tractors**

Tractors may be grouped according to the following:

- The way they move
- The engine power and suitability to work
- Popular brand names.

![Diagram of tractor components](image)

(a) The crawler tractor  
(b) The rubber wheeled tractor

Fig. 7.4 Types of tractors

Considering the first group, tractors may either be the crawler type or the rubber wheel type.

**Crawler type.** These tractors move on large sprockets which turn heavy steel track laying belts. They are large powerful machines which are very expensive. They can work on steep slopes better than the wheeled tractors. Because there is greater grip between the metal tracks and the ground, slipping while working in wet soil conditions is rare. These tractors are suitable for bulldozing forested land, levelling and making terraces on steeply sloping land e.g. (hillsides).

**Rubber wheeled** tractors may have 2, 3, 4 or more wheel which are fitted with rubber tubes and tyres. Tubes are fitted within the types and are subsequently filled with compressed air. The smaller front wheels of some tractors are called the steering wheels while the much larger rear wheels are called the traction wheels. **Traction wheels** bear most of the heavy loads when the tractor is working.

In the second group of tractors the engine power is matched with suitability to do special kinds of farm work. Study Table 9.1
<table>
<thead>
<tr>
<th>Types of tractors</th>
<th>Engine power (hp)</th>
<th>Engine power (kw)</th>
<th>Suitability to farm work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Walking tractor or hand-guided</td>
<td>1-16</td>
<td>0.25-12</td>
<td>To work on small vegetable farms with light soils which have been previously cultivated.</td>
</tr>
<tr>
<td>tractor or the convertible tractor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Market garden tractor</td>
<td>5-20</td>
<td>3.75-15</td>
<td>For horticultural purposes and intensive vegetable farming</td>
</tr>
<tr>
<td>3. Row crop tractor</td>
<td>30-40</td>
<td>22.5-30</td>
<td>For different cultivation practices e.g boom spraying. Machine can straddle tall crops.</td>
</tr>
<tr>
<td>4. Standard tractor</td>
<td>50</td>
<td>37.5</td>
<td>For pulling primary and secondary tillage implements.</td>
</tr>
<tr>
<td>5. General purpose</td>
<td>50-80</td>
<td>37.5-60</td>
<td>For regular field operations; can supply power to other equipment through the p.t.o shaft. Can raise and lower equipment attached to it by the 3-point linkage.</td>
</tr>
<tr>
<td>7. Crawler</td>
<td>75-150</td>
<td>56-112</td>
<td>For heavy soil types on plantations and more and more with steeply sloping farm lands (hill side farming). For working in wet soil conditions.</td>
</tr>
</tbody>
</table>
(c) with a sickle mower attached  (d) with a cultivator attached

(e) with a rotary plough attached

Fig. 7.5  The walking tractor

Popular brand names of farm tractors are: Ford, Massey Ferguson, Fiat and Caterpillar. The less popular ones are Ague Fill and Merryliller. Different ranges of engine power are available for most brands.

Operating the tractor

Tractor operators need to develop great skill in using tractors to do various types of farmwork. There are many important points for them to remember and to practice if they are to work safely and efficiently. Here are some regular checks and some safety measures to guide all operators at different stages of the work.

1. Perform the daily maintenance checks on the tractor as follows:
   - check the water level in the radiator then fill it up to the recommended level
Fig. 7.6  The turbo-charged tractor

- check the fuel level in the fuel tank, then fill up if necessary to the recommended level
- check the oil level in the engine with a dip-check
- check the air cleaner oil bath
- check the brakes and brakes-fluid level in the reservoir.
- grease steering linkage and axles
- check the tyre pressure and remove foreign objects from the treads.

Fig 7.7  Parts of a tractor
2. Before starting the engine ensure that:
   • the operator is seated in the driver's seat
   • the gear lever is in the neutral position or the clutch pedal is fully pressed downwards
   • the throttle lever is set between \(\text{\textfrac{3}{4}}\) full and fully open.

3. Some driving control reminders:
   • the throttle is used to set the engine speed
   • the clutch pedal is used to engage and disengage the drive from the engine to the gear box, as well as to stop the power-take-off shaft.
   • Brakes are used:
     - to stop the tractor
     - to park
     - to assist with steering the vehicle especially on small areas or on headlands.
   • The differential lock pedal reduces wheel spin and increases wheel grip on the ground when it is depressed. It is used to ensure that equal power is passed to both rear wheels from the drive shaft.

4. Before linking any equipment to the tractor ensure that:
   • the wheels are set at the correct distances apart.
   • the lower link of the hydraulic arm and the check chains are set. (check chains should prevent too much side swing of the equipment).
   • the tyre pressure is suitable for the work to be done (normally, tyre pressure of 35-53 kg/cm\(^2\) (12-18lb/in\(^2\)) is enough for most light work but this can be reduced to 29-35 kg/cm\(^2\) (10-12lb/in 1) so as to improve wheel grip to the ground when heavier work has to be done).

5. Linking equipment to the tractor. (see Fig 9.4)
   • ensure that bolts are tightly secure when equipment are linked to the drawbar.
   • when an equipment, is to be linked to the hydraulic system, ensure that its design matches that of the tractor. Attach the top link first to the equipment. Leave it in an upright position.
   • reverse the tractor in line and within reach of the equipment. Attach the right hydraulic arm next and lastly attach the left hydraulic arm to the equipment.
The operator should mount the tractor to properly secure the top link. Ensure that all lynch pins are well fastened. Lift the equipment off the ground using the hydraulic system. Drive the tractor to the field where the work has to be done.

- The p.t.o shaft of some tractors has splines which must match the grooves on the shaft of the equipment. Other p.t.o shafts have links which must be well fastened to that of the equipment. Both shafts should be securely locked to each other so that they would turn together when the engine is working. In this way the equipment receives power from the engine of the tractor.

**Tractor attachments**

Tractor attachments are the equipment linked to the tractor, for doing special types of farm work. Equipment used during crop cultivation may be grouped as:

- primary tillage implements
- secondary tillage implements
- other cultivation equipment.

Those equipment used for livestock production may include the crop cultivation equipment if the farmer has been planting pasture and grain for feed. In addition, equipment for the following activities are necessary:

- transportation
- harvesting
- grain drying

![Types of ploughs](image)

**Fig.7. 8. Types of ploughs**
Primary tillage implements are used during the first stage of preparation. They are well known as ploughs. There are the mould board ploughs, disc ploughs, chisel ploughs and rotary ploughs. All of them are fixed-body right handploughs. The ploughs are designed to throw the furrow slices to the right when you are looking from the rear of the plough. Alternatively, farmers may use the reversible plough. Reversible ploughs are really two ploughs, one of which is fitted upside down on the other. They are designed to throw furrow slices in one direction even when the tractor is on the return trip. This happens because the plough attachment is turned over so that the other plough would now throw the furrow slices in the same direction. Much time and fuel are saved by doing this.

Mould board ploughs are suitable for use on light soils which are free from stumps and other obstacles. Fig. 9.10 shows different parts of this plough. The coulter may be disc-shaped or knife-shaped. Either type makes a vertical cut in the soil. There is a coulter for each mouldboard. The skim coulter cleans the disc as the plough works. The share is attached to the mouldboard. It slices the soil horizontally and begins to lift the furrow slice. The mouldboard is a curved steel plate which turns over the furrow slice and leaves it upturned. The depth wheel is used to control the depth of the furrow. When ploughs are not designed to have depth wheels, the depth of the furrow is controlled by the hydraulic system.

Disc ploughs may have two or more large concave discs arranged on a common metal beam. Each disc is fitted with scrapers which clean the disc as the equipment works. While ploughing, the disc cut furrow slices which are ploughed upwards and turned over. The furrow wheel at the rear of the plough keeps the plough from moving side to side. Disc ploughs are suitable for working on heavy soils and on ears which are stony and have much stubble.

Chisel ploughs are also called sub-soilers. They are used to break up hard pan found in the sub-soil. The chisel plough has a very strong frame which carries three to five rigid tines. It is able to plough to a depth of about 35 cm (14 in) or more. Chisel
ploughs are best attached to crawler tractors to be used in dry soil conditions.

Rotary ploughs need a supply of power direct from the tractors engine. They have to be attached to the p.t.o shaft. Rotary ploughs are suitable to work on light soils or loamy soils. Most of these ploughs have L shaped blades which till the soil to a depth of about 25 cm.

Secondary tillage implements are used mainly to break up rough surfaces and so refine the soil after ploughing. This occurs during the second stage of land preparation. Implements attached to the tractor are harrows and rotovators. There are many types of harrows: disc harrows, tine harrows and chain harrows. The most popular are the disc harrows. The discs are smaller than those of the plough but they are many. Discs are arranged closely on a common metal shaft to form a gang. Disc harrows may have one or two pairs of gang, one behind the other. The front row of discs chops the large soil clods which were made by the plough, and moves them to one side. The next row of discs continues the chopping and moves the soil back. After harrowing the soil should be ready for planting seeds in the field. The depth of harrowing is usually about 15 cm.

Tine harrows also break up large soil lands. They stir the soil particles as well. The curved spring tines raise large plant materials to the surface if the purpose is to get rid of them, then such material can easily be collected. The depth of working is controlled by raising or lowering the harrow.

The chain harrow is made in the form of a chain link mat. It is used on pastures to spread the manure of grazing animals.

(a) rigid tine harrow
(b) spring tine harrow

![Diagram of harrows]

*Fig. 7.9 Types of harrows*

Rotovators are the smaller rotary ploughs. They are used to refine the soil to form seed beds. On light soils seed bed preparation can be done in one operation. The rotovator can plough, harrow and refine the soil at the same time.

*Other cultivation equipment* are ridgers, planters, fertiliser and manure spreaders, cultivators and boom sprayers. Each type can be attached to tractors.

Ridgers are used to make ridges and furrows in the field after it has been harrowed. Tuber crops such as the cassava and sweet potato grow well on ridges. The
two main types are the moldboard ridgers and the disc ridgers.

Fig. 7.10 The seed planter

Planters or drills are seed sowing machines. The main parts are the hopper or seed container, soil ridgers for making small furrows in which seeds would be dropped, a mechanism for dropping seeds at the correct rate, a mechanism for covering the seeds and a presswheel to compact soil particles lightly over the seeds. Some planters deliver fertilisers at the same time. Fertilisers are put into different hoppers and are delivered at different positions from those of the seeds.

Fig. 7.11 The fertiliser distributors

The fertiliser spreader is used to broadcast fertilisers to the field. Fertiliser can be applied in the powder or granular form. It is loaded into the large hoppers from where it goes to the feed regulating plate and into the spreading mechanism (oscillating spout). This scatters the fertiliser onto the field. This equipment can also be used to broadcast seeds at planting time.
Fig. 7.12 The manure spreader

The manure spreader is a specially designed trailer. A conveyor belt has to be built into the trailer floor. This is operated by the trailer wheels or the p.t.o shaft. As the equipment is towed by the tractor, the conveyor belt moves the manure to the back of the trailer where there are two shredding drums. The revolving tines on the drums break up the manure into shreds. Shreds are then caught up with the blades of the revolving auger which fling them out over the field.

Fig. 7.13 A coiled spring cultivator

Cultivators are soil stirring implements which have tines for working deeper into the soil than harrows. They are used to keep soil particles loose between rows of crops, for moulding or eating up and for weeding between rows. The spring tine cultivator is suitable for row crops. The rotary cultivator is suitable for widely spread crops.
Fig. 7.14 The boom sprayer

Boom sprayers are very useful for spraying liquid chemical substances over crops. A boom sprayer has liquid storage tank, pump, filters, valves and a row of nozzles fitted to a long boom. Spray material from the tank is drawn through the filters and valves to the nozzles which spray it downwards to the plants. The pump which is operated by the p.t.o draws the liquid through the system. The height of the boom can be adjusted to suit the crop.

Other tractor attachments

Other useful tractor attachments which have not been named as yet are the dozer blade, the mole plough, the post-hole digger, the hedge trimmer and the mower. Except for mowers and dozer blades, the other attachments are not popular on our local farms. They are all operated from the tractor’s power take-off.

The dozer blade is a large concave metal blade which is particularly useful in reminding land surface. It is powerful enough to remove a high mound of soil from one place and haul it over to another.

The mole plough is used for clearing drains or digging new ones. The post-hole digger has a large soil auger or drill which makes holes for planting posts during the fencing exercise. Many hectares of farmland can be fenced off in a relatively short period of time and with fewer labourers. Farm activities such as removing soil, drain digging and fencing can be very laborious on dry, hard, heavy clay soils.
Care and maintenance of equipment

At the end of each day's work all metal surfaces which were in contact with the soil should be cleaned and coated with oil or rust preventive. This is very important on farms where the soil is heavy clay. The operating controls of equipment should be lubricated also the bearings of wheels and disc coulters. Before applying lubricant remove soil etc from the surface.

Checks should be made on all blades, bolts and nuts, chains and pins daily. After the working period is over for the equipment, check all working parts for severe damage. These parts would have to be replaced in time for the next working period. Additional bearings, bolts and nuts etc, should be secured in event of emergencies.

Exercises

1. Look at a tractor (or a large diagram of a tractor) and identify the following:
   (a) the radiator   (e) the traction wheels
   (b) the oil tank   (f) the drawbar
   (c) the engine block   (g) the hydraulic arms
   (d) the brake pedals   (h) the power take-off shaft.

2. Explain 2 ways by which tractor attachments can be linked to tractors.

3. (a) List tractor attachments used on farms for land preparation.
  (b) Briefly describe the functions of each.

4. Name the main parts of either:
   (a) the mould board plough
   (b) the disc plough and explain the functions of each.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural economy</td>
<td>agricultural activities that are pursued for economic reasons.</td>
</tr>
<tr>
<td>Asexual reproduction</td>
<td>reproduction without the union of individual male and female reproductive cells</td>
</tr>
<tr>
<td>Breed</td>
<td>a group of animals having common characteristics.</td>
</tr>
<tr>
<td>Clod</td>
<td>a lump of soil particles.</td>
</tr>
<tr>
<td>Coconut meal</td>
<td>the white edible substance inside a ripe coconut</td>
</tr>
<tr>
<td>Coir</td>
<td>the fibre prepared from coconut husk.</td>
</tr>
<tr>
<td>Compact</td>
<td>tightly packed together.</td>
</tr>
<tr>
<td>Constipation</td>
<td>difficulty in emptying the bowels</td>
</tr>
<tr>
<td>Copra</td>
<td>the trade name for dry coconut meat.</td>
</tr>
<tr>
<td>Cover crop</td>
<td>any crop planted to prevent soil erosion or to suppress weed growth.</td>
</tr>
<tr>
<td>Credit</td>
<td>money going out of a business.</td>
</tr>
<tr>
<td>Cultural control</td>
<td>involves the application of correct farm operation aimed at enabling the crop to escape insect attack or at reducing or destroying insect populations e.g. crop rotation, ploughing, timing of planting, adequate spacing.</td>
</tr>
<tr>
<td>Debit</td>
<td>money coming into the business</td>
</tr>
<tr>
<td>Debris</td>
<td>plant parts</td>
</tr>
<tr>
<td>Dormant</td>
<td>the act of suspending activities.</td>
</tr>
<tr>
<td>Embryo</td>
<td>a young seed part.</td>
</tr>
<tr>
<td>Endosperm</td>
<td>is an additional tissue to the cotyledon that stores food.</td>
</tr>
<tr>
<td>Fiable</td>
<td>easily crumbled</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fumigate</td>
<td>expose to fumes</td>
</tr>
<tr>
<td>Fumigation</td>
<td>to apply gas to a substance especially to seed or to soil for the purpose</td>
</tr>
<tr>
<td></td>
<td>of destroying insect populations e.g. rotation, ploughing, adequate</td>
</tr>
<tr>
<td></td>
<td>spacing, timing of planting and frequency of weeding.</td>
</tr>
<tr>
<td>Germination</td>
<td>is the process by which a seed grows and become a seedling.</td>
</tr>
<tr>
<td>Gilt</td>
<td>a female pig that never farrowed.</td>
</tr>
<tr>
<td>Mediterranean climate</td>
<td>countries with dry hot summers and mild wet winters.</td>
</tr>
<tr>
<td>Myeoplasma</td>
<td>they are very minute micro-organisms without a cell wall and cannot be</td>
</tr>
<tr>
<td></td>
<td>seen by conventional microscope.</td>
</tr>
<tr>
<td>Omnivorous</td>
<td>feeding on both plant and animal products.</td>
</tr>
<tr>
<td>Organic fertilizer</td>
<td>animal or plant waste used in agriculture to provide nutrients to the soil</td>
</tr>
<tr>
<td>Ovule</td>
<td>is an outgrowth of the ovary that produces a seed.</td>
</tr>
<tr>
<td>Pest</td>
<td>is any animal or agent causing damage to crops and livestock.</td>
</tr>
<tr>
<td>( p \text{H} )</td>
<td>A measure of the degree of acidity or alkalinity of a substance, a ( p \text{H} ) of 7 being neutral, above 7 is alkaline and below 7 acidic.</td>
</tr>
<tr>
<td>Plant propagator</td>
<td>is the means by which new plants are produced.</td>
</tr>
<tr>
<td>Poonac</td>
<td>that which remains after the oil has been pressed out of copra.</td>
</tr>
<tr>
<td>Post harvest losses</td>
<td>losses due to damage to crops as a result of adverse environmental factors.</td>
</tr>
<tr>
<td>Puree</td>
<td>a thick liquid made by pressing cooked sweet potato through a sieve.</td>
</tr>
<tr>
<td>Refuse</td>
<td>what is rejected as worthless or left</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Root room</td>
<td>is the adequate space occupied by the root in the soil.</td>
</tr>
<tr>
<td>Root stock</td>
<td>are seedlings raised for the purpose of supporting the scion budded to it.</td>
</tr>
<tr>
<td>Sauerkraut</td>
<td>cabbage cut fine and allowed to ferment in a brine made of its own juice with salt.</td>
</tr>
<tr>
<td>Scion</td>
<td>a detached shoot consisting of more than one bud or a bud and used for grafting or budding.</td>
</tr>
<tr>
<td>Scouring</td>
<td>looseness of the bowels.</td>
</tr>
<tr>
<td>Sexual reproduction</td>
<td>is the production of a new organism by the union of the male and female reproductive cells.</td>
</tr>
<tr>
<td>Side dressing</td>
<td>fertilizer application along side row crops during growth.</td>
</tr>
<tr>
<td>Soil aeration</td>
<td>is the correct balance of air and gases in the soil.</td>
</tr>
<tr>
<td>Splines</td>
<td>raised ridges on a metal bar onto which grooves in the sleeve of another bar can fit closely.</td>
</tr>
<tr>
<td>Stubble</td>
<td>lower ends of plant stalks left in the ground after harvesting.</td>
</tr>
<tr>
<td>Straddle</td>
<td>stand over with crop below.</td>
</tr>
<tr>
<td>Supply</td>
<td>the quantity of any produce that is offered for sale by producers at any given time at a given price.</td>
</tr>
<tr>
<td>Testa</td>
<td>is the hard protective coat covering the seed.</td>
</tr>
<tr>
<td>Transpiration</td>
<td>is the loss of water by evaporation from the leaves of plants in the form of water vapour.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------</td>
</tr>
<tr>
<td>Variable assets</td>
<td>assets that do not vary with production e.g. feed, seeds etc.</td>
</tr>
<tr>
<td>Vertebrate</td>
<td>an animal with backbone.</td>
</tr>
<tr>
<td>Wind break</td>
<td>a barrier of closely planted trees which protect garden crops from strong winds.</td>
</tr>
<tr>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Anthracnose</td>
<td>Decomposition</td>
</tr>
<tr>
<td>Aquarium</td>
<td>Deep sea fishing</td>
</tr>
<tr>
<td>Balanced diet</td>
<td>Diamond-black moth</td>
</tr>
<tr>
<td>Berkshire</td>
<td>Digestive system</td>
</tr>
<tr>
<td>Bituminous paint</td>
<td>Disease</td>
</tr>
<tr>
<td>Black citrus aphid</td>
<td>Drip irrigation</td>
</tr>
<tr>
<td>Black rot</td>
<td>Dry Feeding</td>
</tr>
<tr>
<td>Boar</td>
<td>Dual purpose</td>
</tr>
<tr>
<td>Bone meal</td>
<td>Duroc</td>
</tr>
<tr>
<td>Breed</td>
<td>Extensive System</td>
</tr>
<tr>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>Cabbage leaf miner</td>
<td>Farrowing</td>
</tr>
<tr>
<td>Cadell</td>
<td>Fatteners</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>Feeds</td>
</tr>
<tr>
<td>Carcass</td>
<td>Fertiliser</td>
</tr>
<tr>
<td>Cedros wilt</td>
<td>Fertiliser placement</td>
</tr>
<tr>
<td>Channel irrigation</td>
<td>Field capacity</td>
</tr>
<tr>
<td>Citrus mealybug</td>
<td>Fins</td>
</tr>
<tr>
<td>Citrus moth</td>
<td>Fish meal</td>
</tr>
<tr>
<td>Climate</td>
<td>Flooding</td>
</tr>
<tr>
<td>Club root</td>
<td></td>
</tr>
<tr>
<td>Coconut black beetle</td>
<td>G</td>
</tr>
<tr>
<td>Coconut meal</td>
<td>Gestation</td>
</tr>
<tr>
<td>Coconut moth borer</td>
<td>Gills</td>
</tr>
<tr>
<td>Commercial feed</td>
<td>Green manure</td>
</tr>
<tr>
<td>Community pens</td>
<td>Growing pigs</td>
</tr>
<tr>
<td>Compost</td>
<td>Gummosis</td>
</tr>
<tr>
<td>Conception</td>
<td></td>
</tr>
<tr>
<td>Copra</td>
<td>H</td>
</tr>
<tr>
<td>Copra meal</td>
<td>Hand pulling</td>
</tr>
<tr>
<td>Cotton seed meal</td>
<td>Hassar</td>
</tr>
<tr>
<td>Creep feeding</td>
<td>Heat</td>
</tr>
<tr>
<td>Cricket</td>
<td>Herbicides</td>
</tr>
<tr>
<td>Cutworm</td>
<td>Housing</td>
</tr>
<tr>
<td>Category</td>
<td>Term</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>I</td>
<td>Immunization</td>
</tr>
<tr>
<td></td>
<td>Inland fishing</td>
</tr>
<tr>
<td></td>
<td>Inter-tillage</td>
</tr>
<tr>
<td></td>
<td>Iodine</td>
</tr>
<tr>
<td></td>
<td>Irrigation</td>
</tr>
<tr>
<td>K</td>
<td>Killing percentage</td>
</tr>
<tr>
<td>L</td>
<td>Landrace</td>
</tr>
<tr>
<td></td>
<td>Large Black</td>
</tr>
<tr>
<td></td>
<td>Large white</td>
</tr>
<tr>
<td></td>
<td>Leaching</td>
</tr>
<tr>
<td></td>
<td>Leaf cutting ants</td>
</tr>
<tr>
<td></td>
<td>Lethal yellowing</td>
</tr>
<tr>
<td></td>
<td>Liquid manure</td>
</tr>
<tr>
<td></td>
<td>Litter</td>
</tr>
<tr>
<td>M</td>
<td>Mange</td>
</tr>
<tr>
<td></td>
<td>Manure</td>
</tr>
<tr>
<td></td>
<td>MCPA</td>
</tr>
<tr>
<td></td>
<td>Mediterranean Fruitfly</td>
</tr>
<tr>
<td></td>
<td>Melanose</td>
</tr>
<tr>
<td></td>
<td>Mites</td>
</tr>
<tr>
<td></td>
<td>Mulching</td>
</tr>
<tr>
<td>N</td>
<td>Night soil</td>
</tr>
<tr>
<td>O</td>
<td>Off-shore fishing</td>
</tr>
<tr>
<td></td>
<td>Offal</td>
</tr>
<tr>
<td></td>
<td>Ovulation</td>
</tr>
<tr>
<td>P</td>
<td>Paddock</td>
</tr>
<tr>
<td></td>
<td>Paraquat</td>
</tr>
<tr>
<td></td>
<td>Parasite</td>
</tr>
<tr>
<td></td>
<td>Permanent wilting point</td>
</tr>
<tr>
<td></td>
<td>Pig grower</td>
</tr>
<tr>
<td></td>
<td>Pig starter</td>
</tr>
<tr>
<td></td>
<td>Piglet anaemia</td>
</tr>
<tr>
<td></td>
<td>Poonac</td>
</tr>
<tr>
<td></td>
<td>Promotryne</td>
</tr>
<tr>
<td></td>
<td>Proteins</td>
</tr>
<tr>
<td></td>
<td>Ration</td>
</tr>
<tr>
<td></td>
<td>Red palm weevil</td>
</tr>
<tr>
<td></td>
<td>Rice bran</td>
</tr>
<tr>
<td></td>
<td>Root Knot</td>
</tr>
<tr>
<td></td>
<td>Root stock</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
</tr>
<tr>
<td></td>
<td>Scion</td>
</tr>
<tr>
<td></td>
<td>Scouring</td>
</tr>
<tr>
<td></td>
<td>Semi-intensive</td>
</tr>
<tr>
<td></td>
<td>Shark</td>
</tr>
<tr>
<td></td>
<td>Side dressing</td>
</tr>
<tr>
<td></td>
<td>Smothering</td>
</tr>
<tr>
<td></td>
<td>Soil organisms</td>
</tr>
<tr>
<td></td>
<td>Soil sterilants</td>
</tr>
<tr>
<td></td>
<td>Sow</td>
</tr>
<tr>
<td></td>
<td>Starter ration</td>
</tr>
<tr>
<td></td>
<td>Succulents</td>
</tr>
<tr>
<td></td>
<td>Sweet potato weevil</td>
</tr>
<tr>
<td></td>
<td>Swill</td>
</tr>
<tr>
<td></td>
<td>Swine erysipelas</td>
</tr>
<tr>
<td></td>
<td>Swine fever</td>
</tr>
<tr>
<td>T</td>
<td>Tamworth</td>
</tr>
<tr>
<td></td>
<td>Tattooing</td>
</tr>
<tr>
<td></td>
<td>Trawlers</td>
</tr>
<tr>
<td></td>
<td>Trawling</td>
</tr>
<tr>
<td></td>
<td>Tristeza</td>
</tr>
<tr>
<td></td>
<td>Tuna</td>
</tr>
<tr>
<td></td>
<td>Vaccination</td>
</tr>
<tr>
<td></td>
<td>Virus</td>
</tr>
<tr>
<td>W</td>
<td>Weaners</td>
</tr>
<tr>
<td></td>
<td>Weaning</td>
</tr>
<tr>
<td></td>
<td>Weed</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----</td>
</tr>
<tr>
<td>Weed control</td>
<td>41</td>
</tr>
<tr>
<td>Wood ash</td>
<td>93</td>
</tr>
<tr>
<td><strong>Y</strong></td>
<td></td>
</tr>
<tr>
<td>Yorkshire</td>
<td>114</td>
</tr>
</tbody>
</table>