

Agricultural Science

for Secondary Schools in Guyana



Book Two

AGRICULTURAL SCIENCE

FOR SECONDARY SCHOOLS IN GUYANA

BOOK II

Fitzroy Weever

Joy Johnson

L.M. Philip Nwei

Yvonne M^c 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

Copyright

Published by:

MINISTRY OF EDUCATION

NATIONAL CENTRE FOR EDUCATIONAL RESOURCE DEVELOPMENT

Georgetown , GUYANA

First Published 1993

© Ministry of Education

Printed By: RPL (1991)LTD

ISBN 976 - 8141 - 15 - 8

Cover Design by Rawle Franklin

CONTENTS

CHAPTER	PAGE
1. PRINCIPLES AND PRACTICES OF CULTIVATION	1
– Selection of crops	
– Land preparation	
– Propagation of crops	
– Care and maintenance of crops	
– Harvesting and marketing	
2. CULTIVATION OF CROPS	43
– Cabbage	
– Sweet potato	
– Citrus	
– Coconuts	
3. MANURES	81
– Organic manures	
– Inorganic manures	
4. INTRODUCTION TO RECORD KEEPING	96
– Importance of record keeping	
– Simple records	
– Examples of simple records	
5. SWINE	100
– Introduction to swine	
– Management of pigs	

6. FISH CULTURE

128

- Fishes
- Rearing of fish
- Fishing
- Marketing

7. FARM MACHINERY AND EQUIPMENTS

138

- The tractor
- Tractor attachments

NOT FOR SALE

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

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 pimples and thorns which cause injury to farmers and livestock.
- Some plants cause irritation to farmers e.g. cow itch (*Muccuna 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) – path ways 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 hector.

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.



Fig 1.1 (a) Root development in friable soil conditions

(b) Root development in untillied 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.

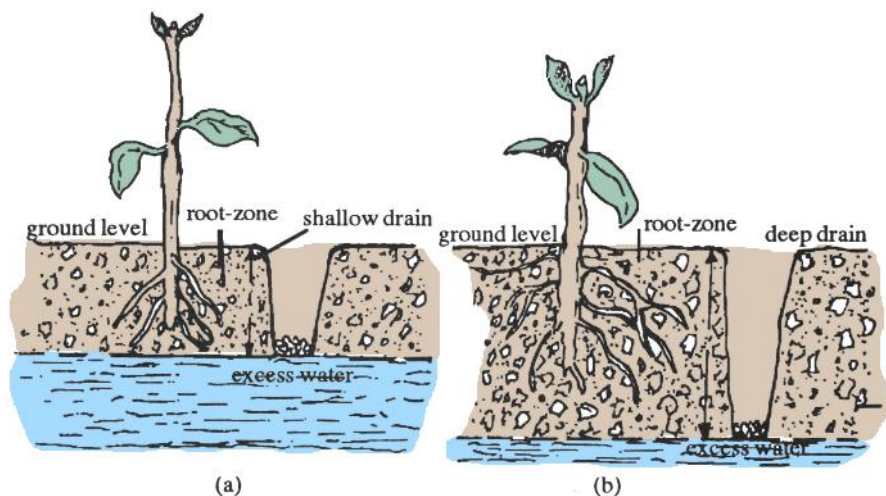


Fig 1.2 (a) The effect of a shallow drain on root development

(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.

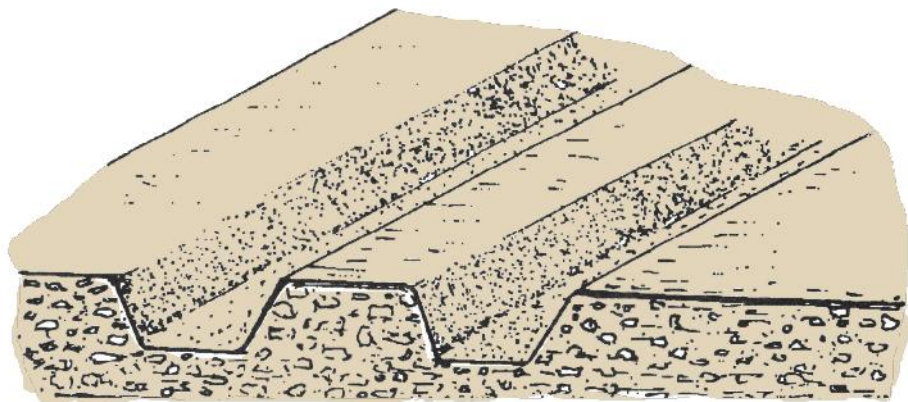


Fig.1.3 Cambered beds

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 20cm 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 30cm 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.

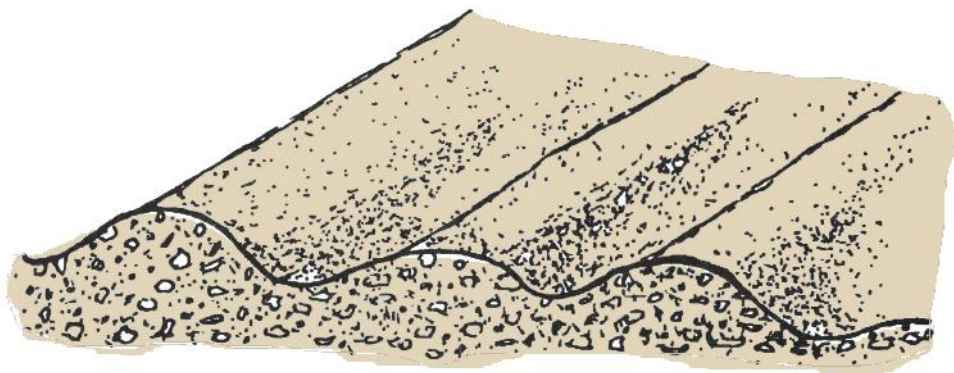


Fig.1.4 Ridges and ridge formation

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 hylac 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.

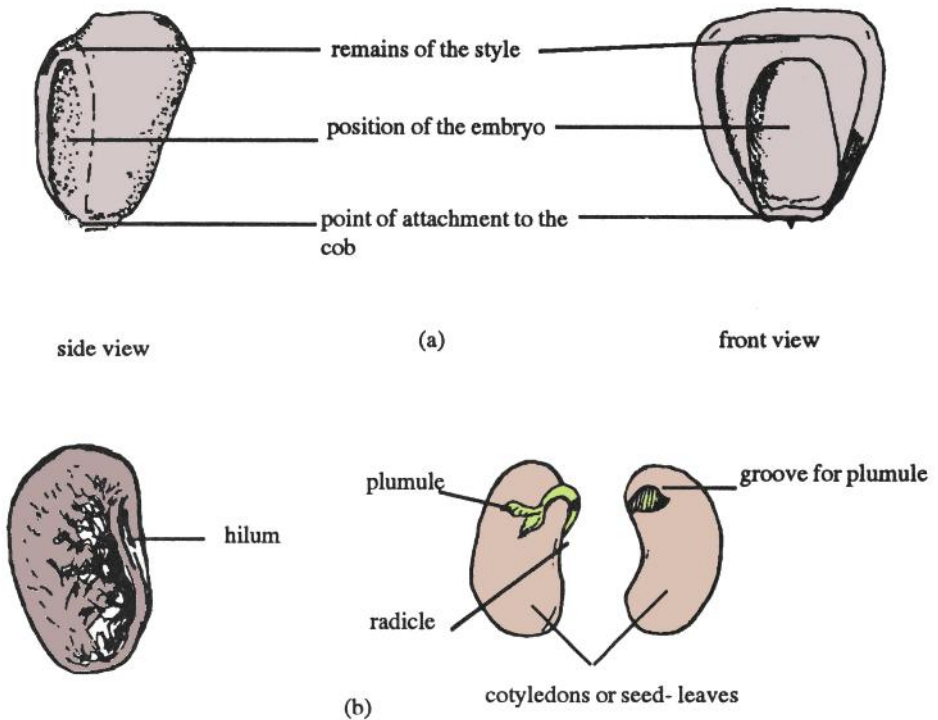


Fig 1.5 (a) Monocotyledons - corn seed (b) Dicotyledons - bean seed

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.

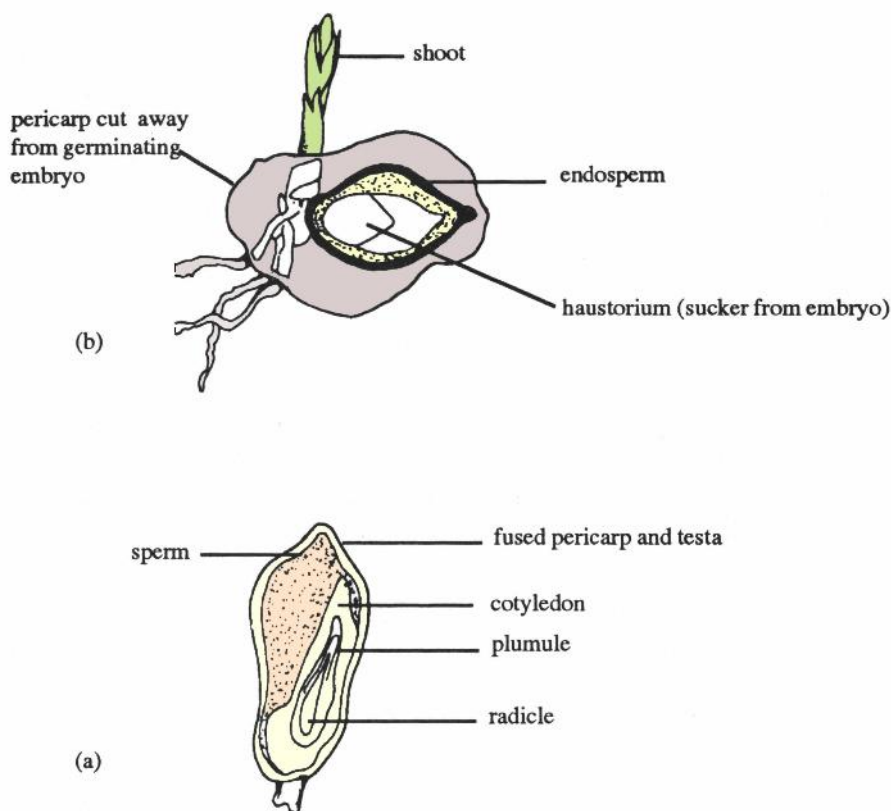


Fig.1.6 (a) Maize cotyledon and endosperm

(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.

Germination of bean seed

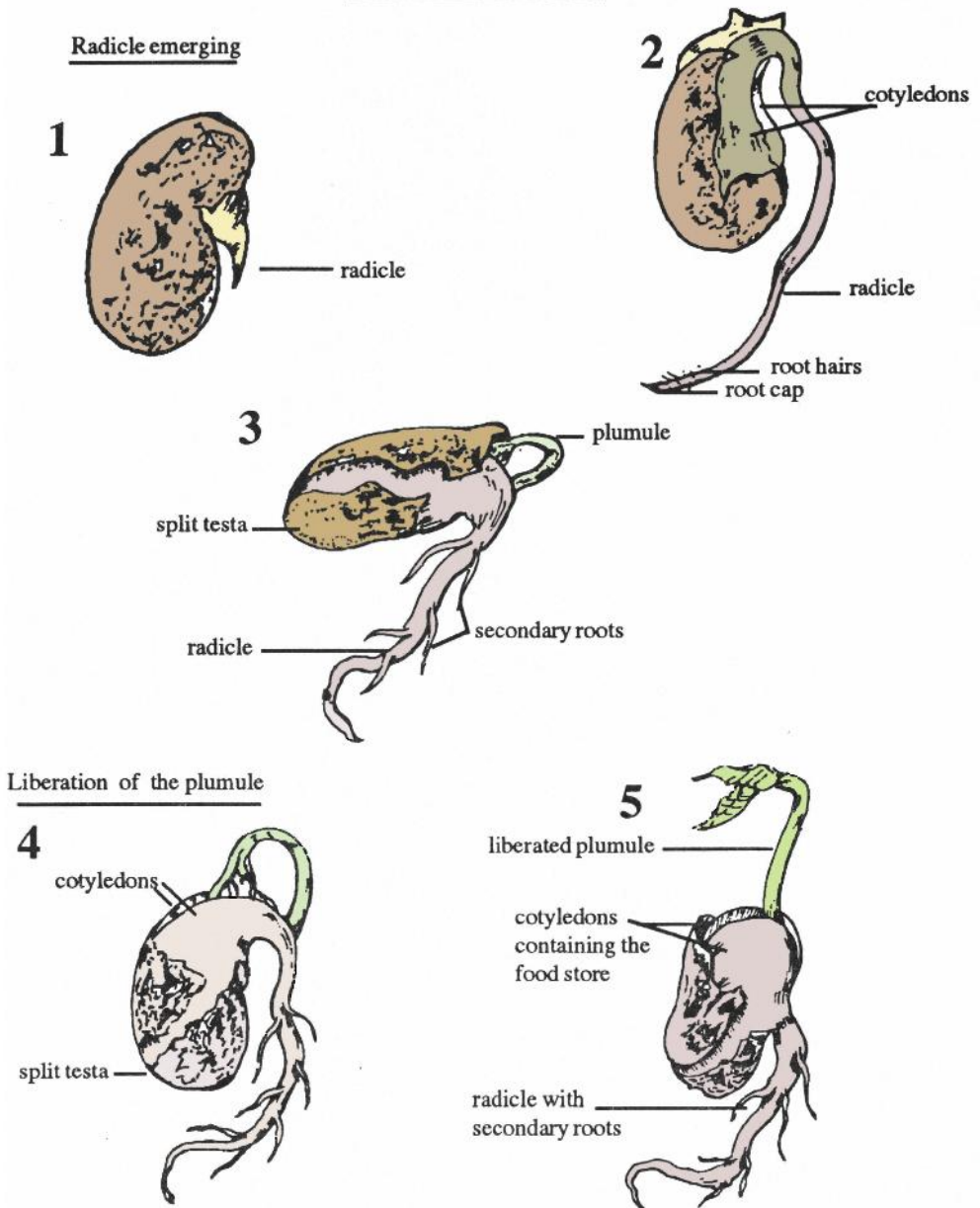


Fig. 1.7 Epigeal germination

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.

Germination of maize

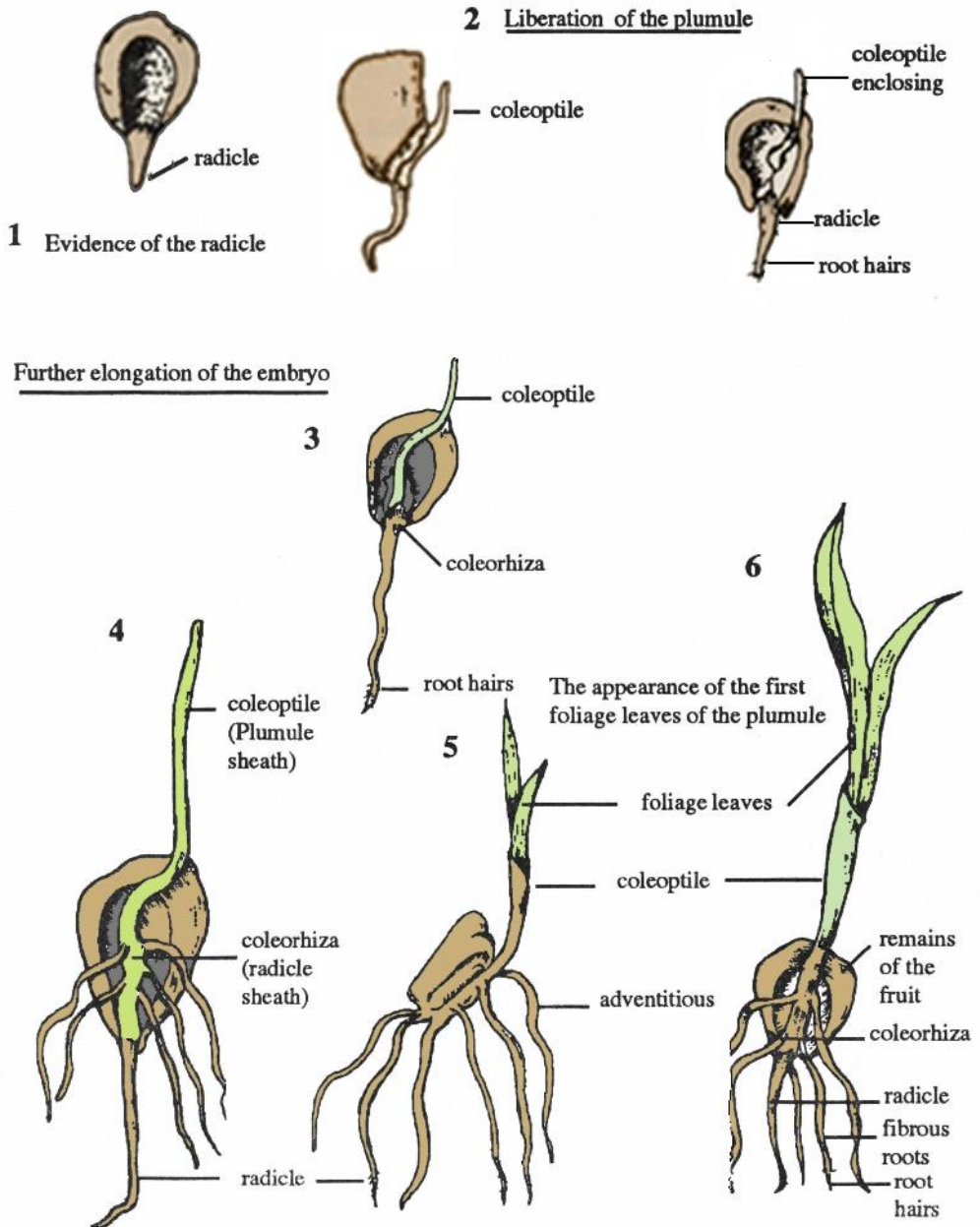


Fig 1.8 Hypogeal germination

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 × 25cm × 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.

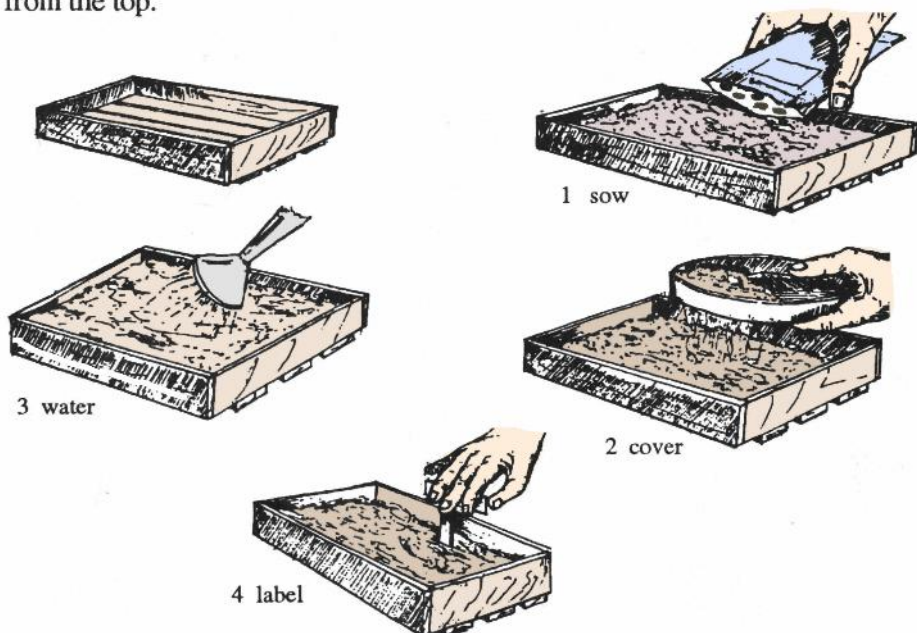


Fig. 1.9 Preparation of seed-box with different layers

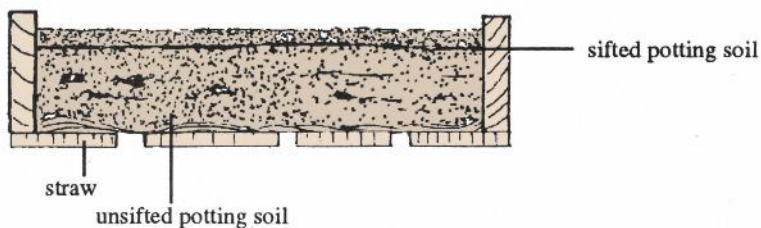


Fig.1.10 Layers of soil in a seed box

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 fore finger.

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 egg plant, 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 under developed 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 bulbis 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.

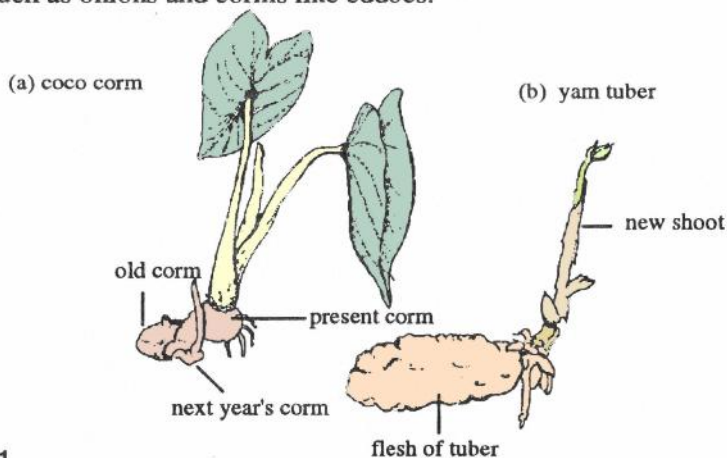
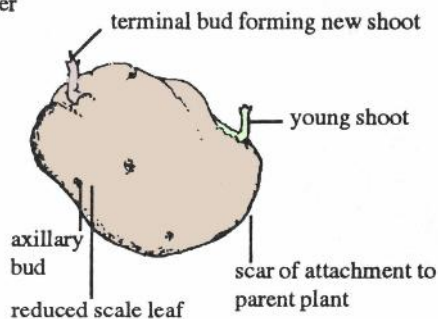


Fig.1.11

(c) irish potato tuber



(d) ginger rhizome

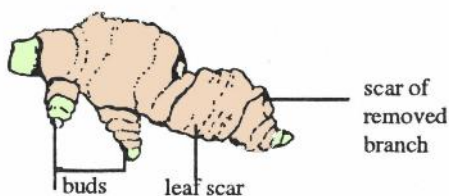
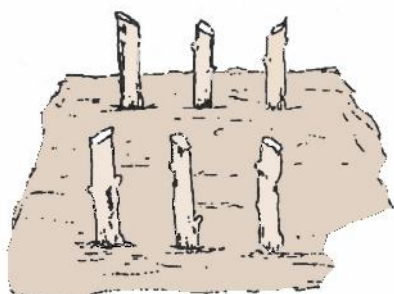
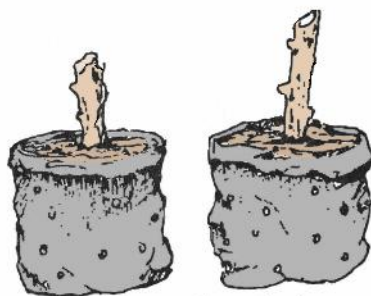


Fig.1.11 Some underground stems



cuttings set in garden plot



cuttings set in potting bags

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

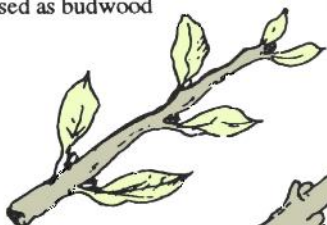


(b) root stock prepared for budding

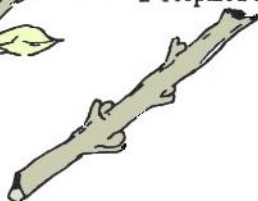


Fig 1.13 Preparation of root stock.

1 Selected stem to be used as budwood



2 Prepared budwood



3 Budwood wrapped in a damp muslin cloth

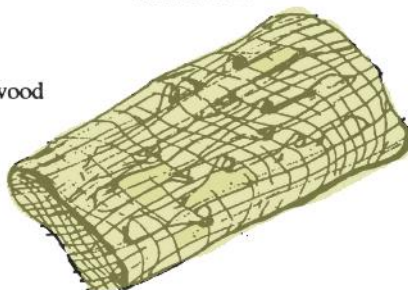


Fig 1.14 Preparation of budwood.

Propagating citrus plants by means of budding



1 cutting the bud



2 bud ready for budding

Fig.1.15

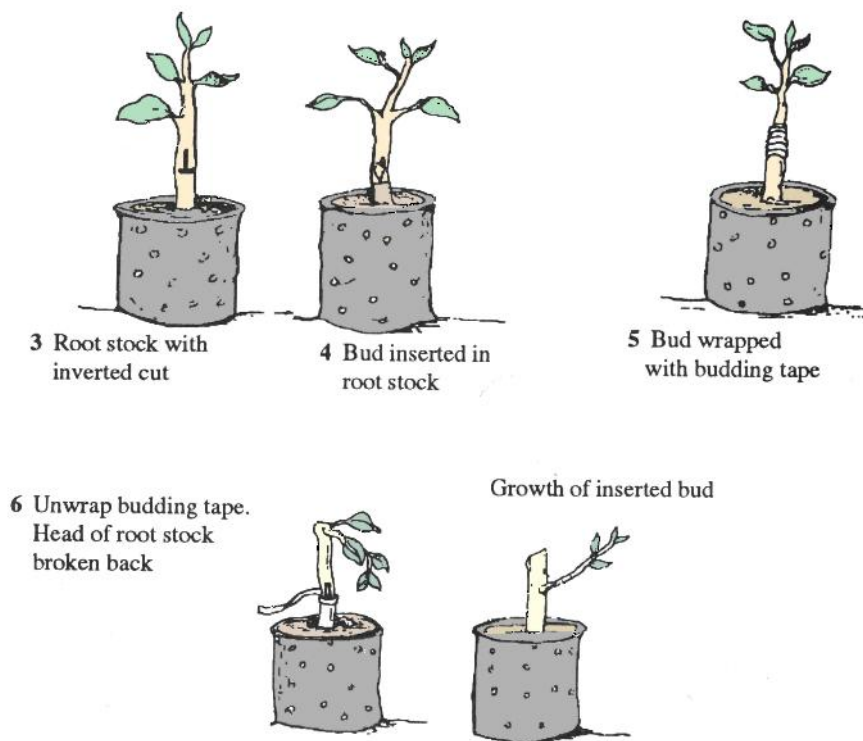


Fig 1.15 Budding operation.



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.

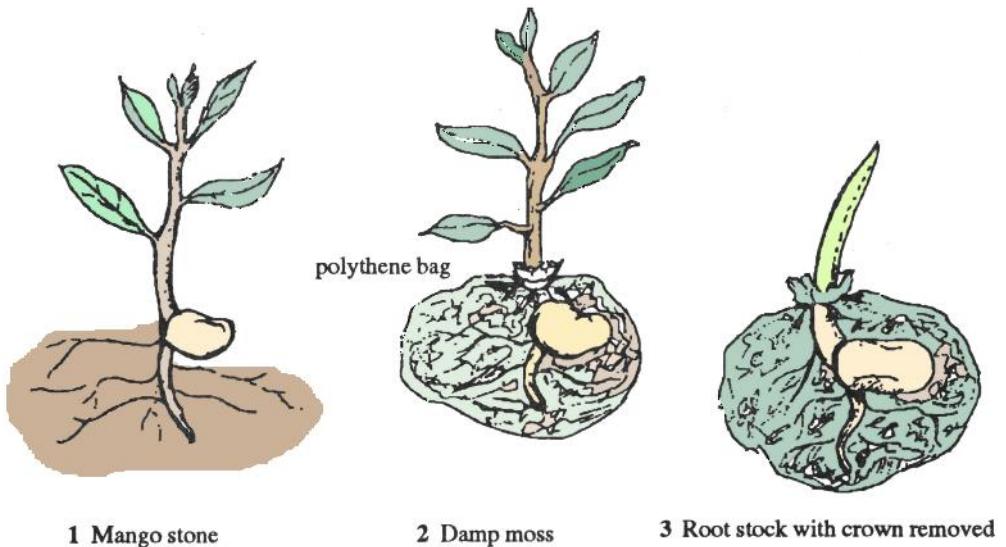


Fig 1.17 (a) Approach grafting

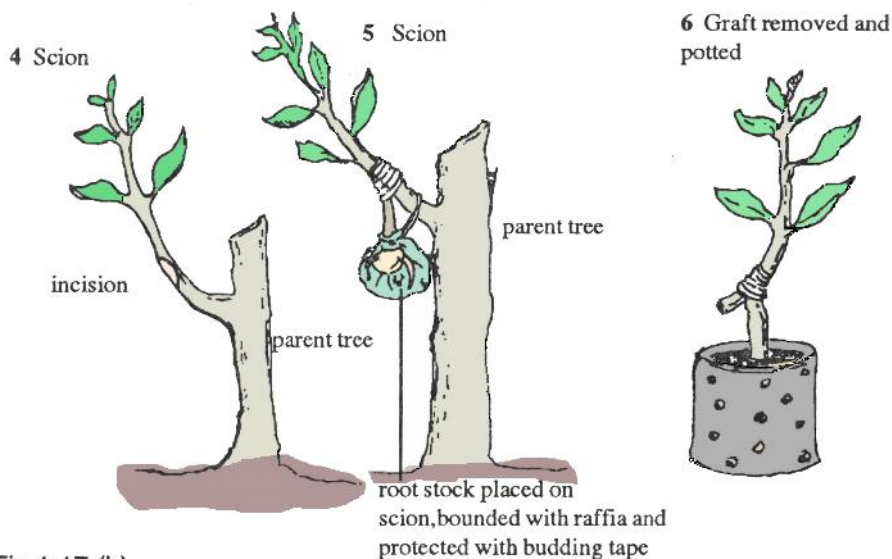


Fig 1.17 (b)

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.

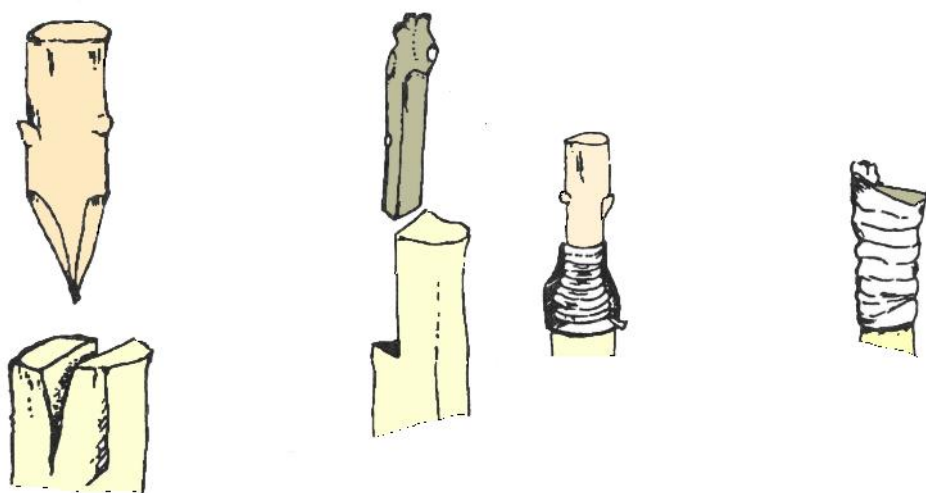


Fig.1.18 Cleft and vaneer grafting

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.

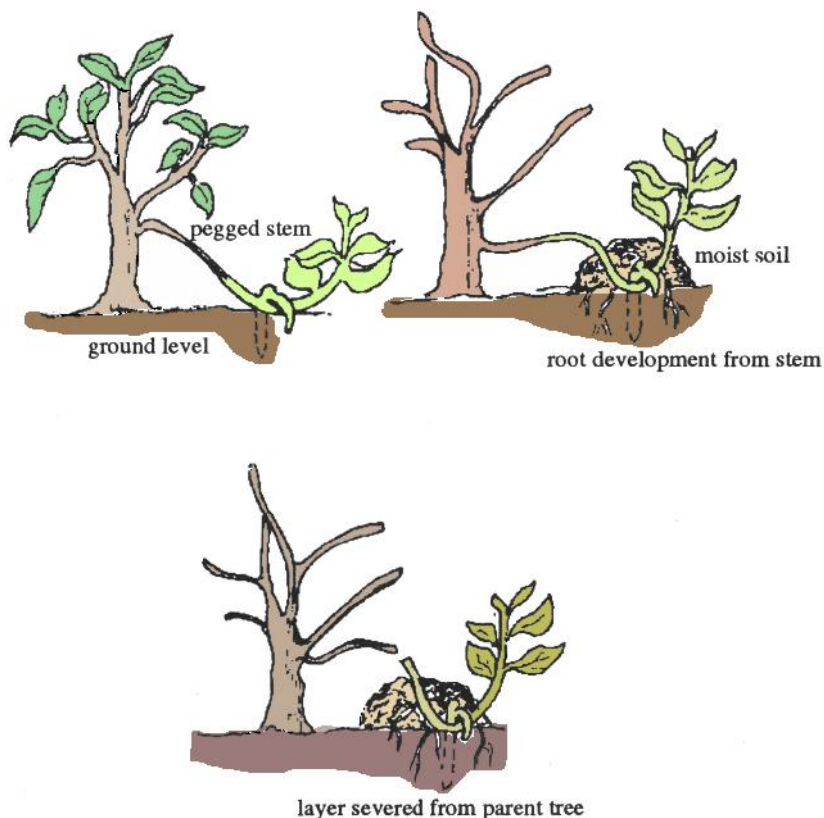


Fig 1.19 Simple layering

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 form 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.

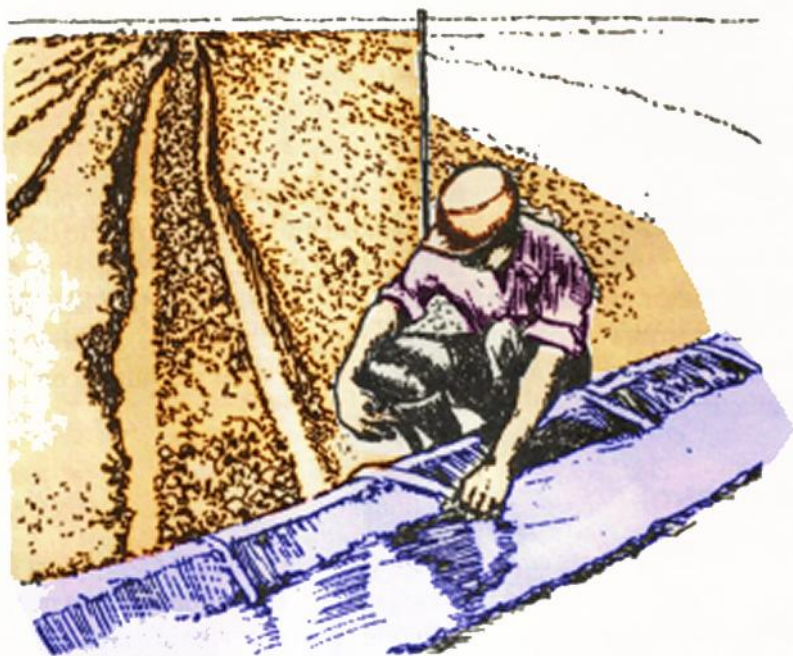


Fig 1.20 Setting out plastic syphon spiles for irrigation

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 livestock 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 leaf 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:

Crops	Herbicides
Sugar-cane	Atrazine Alachlor
Maize	Gesaprim
Onions	Dacthal, Ramrod
Pepper	Lasso
Groundnut	Linuron, Planvin

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.

Crops	Materials Harvested.
-------	----------------------

Cereals

Rice, wheat, sorghum	matured grains
----------------------	----------------

Legumes

Soya-bean, cow pea, bora	Pods (dry or green)
--------------------------	---------------------

Root Crops

Cassava, sweet-potatoes , yams , carrots	tuberous roots.
--	-----------------

Stem crops

Sugar cane	stem cutting
------------	--------------

Irish potato	stem tuber
--------------	------------

Ginger	stem (rhizome)
--------	----------------

Eddo	stem tuber (corn)
------	-------------------

Leafy vegetables

Cabbage, celery, calaloo	leaves
--------------------------	--------

Fruit vegetables

Ochro, cucumber,	green fruits
------------------	--------------

Boulanger	
-----------	--

Fruits

Mango , pineapple	yellow fruits
-------------------	---------------

Papaw	
-------	--

lettuce



mustard



pakchoi



spinach



cabbage



celery



parsley



chive



carrot



radish



beet



tomato



boulânger



cucumber



pepper



ochro



pumpkin



jhingi



gourd



karaile



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.



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

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

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

Crops	Materials	Harvested.	Method used.
Rice	grain		manual/ mechanical.
Corn			
Blackeye			
Sugar cane			
Cassava			
Pakchoi			
Groundnut			
Eschallot			
Ochro.			

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 stamens (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 Sauerkrant (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 (chlordane 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.



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. Larvae 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*

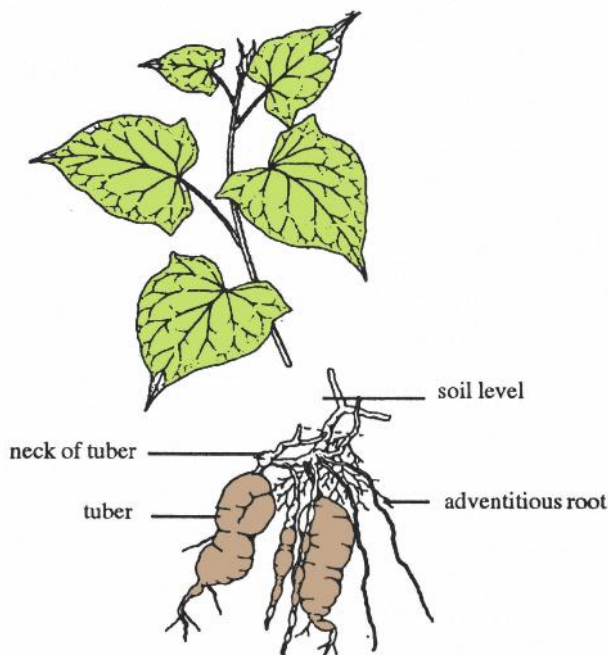


Fig. 2.2

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 riverain 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.

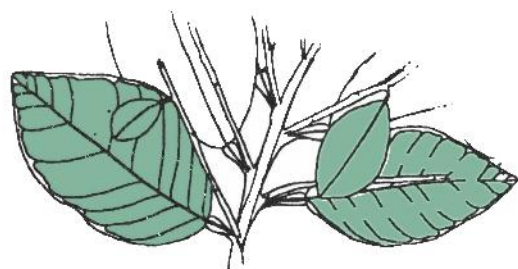
Citrus grows well on a wide variety of soils, from coarse sand to heavy clays. Good drainage is essential for better growth and high yields. Best soil for citrus is a medium-textured, reasonably deep fertile soil, free from injurious salts, and the best pH range from 6 to 7. High elevations with slightly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

Species and varieties

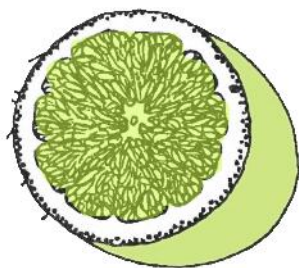
Colour and shape of the leaf blade, petiole wing, size, weight and shape of the fruit are important for diagnosis of the species and varieties. Some of the species of citrus are:

English name	Botanical name
Sweet orange	<i>Citrus sinensis</i>
Sour/ seville orange	<i>Citrus aurantium</i>
Mandarin (Tangerine)	<i>Citrus reticulata</i>
Grapefruit (pomelo)	<i>Citrus paradisi</i>
Lime	<i>Citrus aurantifolia</i>
Shaddock (pummelo)	<i>Citrus grandis</i>
Lemon	<i>Citrus limon</i>

Sweet oranges



a vegetable shoot



fruit in transverse section

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

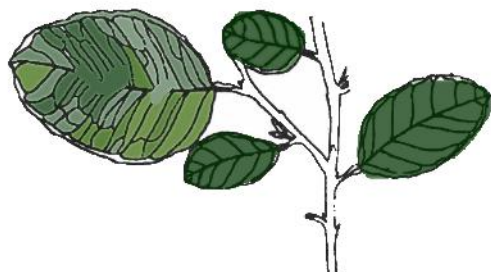


Fig.2.5

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

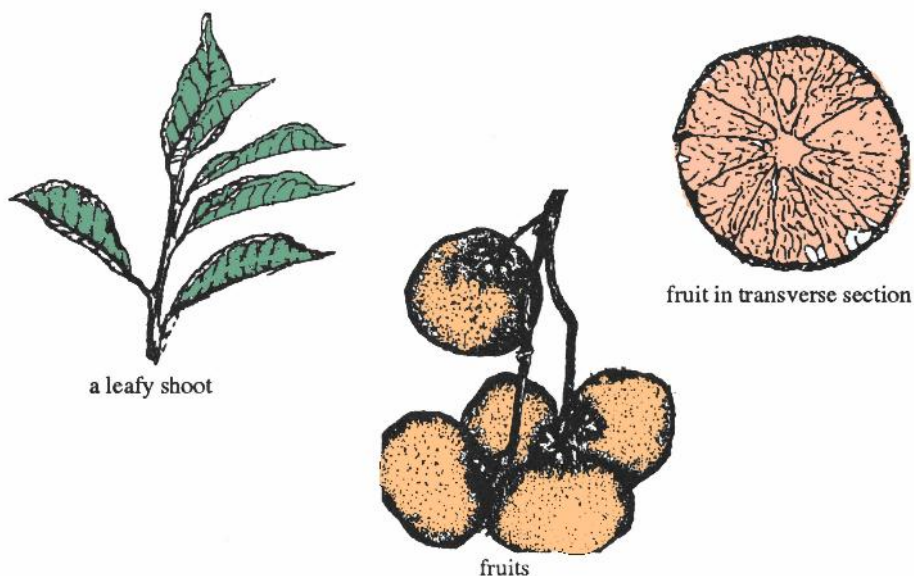


Fig.2.6

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



a flowering branch



fruit in transverse section

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



a leafy shoot



whole fruit



fruit in transverse section

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

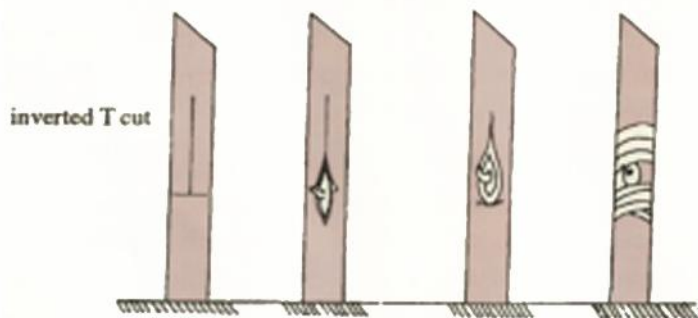


Fig.2.10

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 budding. 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.

Year	Application per year	Total fertilizers applied per year/ tree (kg/Ha)
First year	4	1/2 kg of 10-5-5 NPK mixture
Second year	3	1 kg of 10-5-5 “
Third year	3	1.5 kg of 10-5-5 “

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) - *Ceratitidis 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 citrophthora* 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*

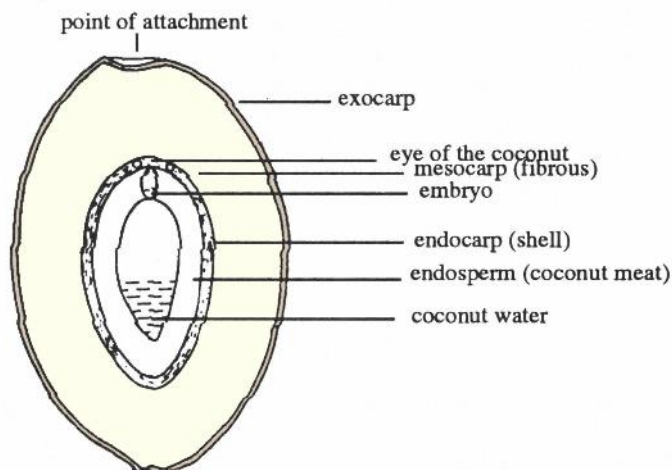


Fig.2.10

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** (ponnac), 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 shavened 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