Agricultural Science

for Secondary Schools in Guyana

UNDP/GOVERNMENT OF GUYANA
SECONDARY SCHOOLS TEXT BOOK PROJECT

Book Three
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Foreword

Curricula must be flexible enough to respond to the existential needs of the children in a changing society. Textbooks which are aids in the delivery of those curricula must be revised and edited as often as the need arises to make them contemporary in information and presentation.

Because of these things one welcomes the revised editions of the secondary school textbooks with pictures in appropriate colours.

We wish to commend all those persons responsible for this painstaking effort for having done a worthwhile job. The nation's children and their teachers will benefit significantly because of this effort.

May the industry of the editors be suitably rewarded by the wise use of the revised secondary school texts.

Priya Manickchand
Minister of Education
Preface

This series of secondary textbooks has evolved from the first and second sets of secondary textbooks which were planned for students in Secondary Schools. An important modification is that the new secondary books have been designed for students exposed to all types of secondary education (Senior Secondary Schools, Junior Secondary Schools and the secondary divisions of Primary Schools).

The books have been prepared with the common curriculum in focus and will be found to be consistent with most of the concepts dealt with in the curriculum guides for these schools. It is hoped that the introduction of these books to the different levels of secondary education now evidenced in Guyana, will help to remove some of the disparities which exist in accessing suitable learning materials.
1. **ANATOMY AND PHYSIOLOGY OF FARM ANIMALS**

Livestock farmers are constantly striving to improve their level of production. In so doing, it becomes very important for them to know the basic body structure of the animals they rear. Since body structure is closely related to body function, a knowledge of the structure and function of an animal's body will help farmers to understand clearly how each structure works in order to produce a particular livestock product, e.g., meat, milk and eggs. This sort of understanding is essential when the farmer's goal is to improve his/her management practices which would later result in efficient production. Hence, the farmer's work would be concentrated only on those practices which promote good health and comfort for animals so that they can produce at their maximum levels with minimum cost to their owners.

The term **anatomy** refers to the science concerned with the form, structure and spatial relationships of living organisms. In this chapter, two aspects of the anatomy of farm animals will be presented-the **gross anatomy** and the **systemic anatomy**.

**THE GROSS ANATOMY**

The **gross anatomy** deals with the relative positions of various body parts with emphasis on the external features of an animal's body. In addition to the popular classes of livestock, reference will also be made to fish and bees. Morphology deals with body shape, size, form and structure of an animal.

A knowledge of morphology will help farmers to:

- select breeding stock
- give to the veterinary surgeon or livestock officer oral descriptions on the exact position of injury or abnormality of the body
- identify correct positions on the animal's body for administering injections
- give precise reports to the Artificial Inseminator
- comment accurately on body conformation at Animal Shows or Livestock Sales
classify animals according to breeds and types, for example, for an animal to be registered as member of a particular breed, it must show the external features required by the Breed Association.

For convenience, the external body structure of farm animals will be listed under headings of the following areas:

- Head and neck
- Fore quarter
- Body
- Hind quarter

THE EXTERNAL STRUCTURE OF CATTLE

Figure 1-1 (a) The external features of a bull
Figure 1-1 (b) The external features of a cow
Table 1.1 Parts of the cattle found in the head and neck, fore quarter, body and hind quarter

<table>
<thead>
<tr>
<th>Head and neck</th>
<th>Fore quarter</th>
<th>Body</th>
<th>Hind quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>poll</td>
<td>brisket</td>
<td>heart-girth</td>
<td>rump</td>
</tr>
<tr>
<td>forehead</td>
<td>shoulder</td>
<td>back</td>
<td>pin-bone</td>
</tr>
<tr>
<td>horn</td>
<td>fore arm</td>
<td>loin</td>
<td>hook-bone</td>
</tr>
<tr>
<td>face</td>
<td>knee</td>
<td>barrel</td>
<td>thigh</td>
</tr>
<tr>
<td>eyes</td>
<td>shank</td>
<td>umbilical flap (navel in cows)</td>
<td>hock</td>
</tr>
<tr>
<td>ears</td>
<td>fore flank</td>
<td>sheath (in bulls)</td>
<td>dew claw</td>
</tr>
<tr>
<td>nostrils</td>
<td>withers</td>
<td>mammary veins</td>
<td>pastern</td>
</tr>
<tr>
<td>muzzle</td>
<td></td>
<td>ribs</td>
<td>stifle</td>
</tr>
<tr>
<td>jaw</td>
<td></td>
<td>chest</td>
<td>teats</td>
</tr>
<tr>
<td>throat</td>
<td></td>
<td></td>
<td>hind flank</td>
</tr>
<tr>
<td>dewlap</td>
<td></td>
<td></td>
<td>vulva (in cows)</td>
</tr>
<tr>
<td>neck</td>
<td></td>
<td></td>
<td>scrotum (in bulls)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>hoof</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>tail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>switch</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>anus</td>
</tr>
</tbody>
</table>

**Note:** These terms above are also used to identify similar external features of the sheep and goat.
THE EXTERNAL STRUCTURE OF SWINE

Figure 1-2 (a) A boar

Figure 1-2 (b) A sow
<table>
<thead>
<tr>
<th>No.</th>
<th>Body parts</th>
<th>No.</th>
<th>Body parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>snout</td>
<td>13</td>
<td>back</td>
</tr>
<tr>
<td>2</td>
<td>face</td>
<td>14</td>
<td>loin</td>
</tr>
<tr>
<td>3</td>
<td>eye</td>
<td>15</td>
<td>side</td>
</tr>
<tr>
<td>4</td>
<td>ear</td>
<td>16</td>
<td>belly</td>
</tr>
<tr>
<td>5</td>
<td>cheek</td>
<td>17</td>
<td>fore flank</td>
</tr>
<tr>
<td>6</td>
<td>jowl</td>
<td>18</td>
<td>hind flank</td>
</tr>
<tr>
<td>7</td>
<td>neck</td>
<td>19</td>
<td>rump</td>
</tr>
<tr>
<td>8</td>
<td>shoulder</td>
<td>20</td>
<td>ham</td>
</tr>
<tr>
<td>9</td>
<td>fore leg</td>
<td>21</td>
<td>hind leg</td>
</tr>
<tr>
<td>10</td>
<td>dew claw (split hoof)</td>
<td>22</td>
<td>tail</td>
</tr>
<tr>
<td>11</td>
<td>pastern (corresponding to wrist)</td>
<td>23</td>
<td>teat</td>
</tr>
<tr>
<td>12</td>
<td>toes (form hoof)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head and Neck</td>
<td>Fore quarter</td>
<td>Body</td>
<td>Hind quarter</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>------</td>
<td>--------------</td>
</tr>
<tr>
<td>face</td>
<td>fore leg</td>
<td>side</td>
<td>rump</td>
</tr>
<tr>
<td>ear</td>
<td>dew claw</td>
<td>belly</td>
<td>ham</td>
</tr>
<tr>
<td>eye</td>
<td>pastern</td>
<td>back</td>
<td>hind leg</td>
</tr>
<tr>
<td>cheek</td>
<td>toes (split hoof)</td>
<td>loin</td>
<td>hind flank</td>
</tr>
<tr>
<td>snout</td>
<td>fore flank</td>
<td>penile sheath (male)</td>
<td>tail</td>
</tr>
<tr>
<td>jowl</td>
<td>trotter</td>
<td>teats</td>
<td>anus</td>
</tr>
<tr>
<td>poll</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>neck</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
THE EXTERNAL STRUCTURE OF THE RABBIT

![Diagram of a rabbit showing external features](image)

Figure 1.3 The external features of a rabbit

Table 1.4 Parts of the rabbit found in head and neck, fore quarter, body and hind quarter.

<table>
<thead>
<tr>
<th>Head and neck</th>
<th>Fore quarter</th>
<th>Body</th>
<th>Hind quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>ears</td>
<td>scruff</td>
<td>back</td>
<td>rump</td>
</tr>
<tr>
<td>eye</td>
<td>fore leg</td>
<td>belly</td>
<td>tail</td>
</tr>
<tr>
<td>nostrils</td>
<td>5-clawed hand</td>
<td>teats (hidden by fur)</td>
<td>hind leg</td>
</tr>
<tr>
<td>whiskers</td>
<td>wrist</td>
<td></td>
<td>thigh</td>
</tr>
<tr>
<td>scent gland</td>
<td>fore-arm</td>
<td></td>
<td>shank</td>
</tr>
<tr>
<td>cleft lip</td>
<td>upper arm</td>
<td></td>
<td>ankle</td>
</tr>
<tr>
<td>neck</td>
<td></td>
<td></td>
<td>foot with 4 claws</td>
</tr>
</tbody>
</table>
THE EXTERNAL STRUCTURE OF THE FOWL

Figure 1-4 The external features of a cock

Table 1.5 Parts of the cock found in head and neck, body and leg.

<table>
<thead>
<tr>
<th>Head and Neck</th>
<th>Body</th>
<th>Leg</th>
</tr>
</thead>
<tbody>
<tr>
<td>comb</td>
<td>back</td>
<td>thigh</td>
</tr>
<tr>
<td>eye</td>
<td>saddle</td>
<td>shank</td>
</tr>
<tr>
<td>ear</td>
<td>wing</td>
<td>hock</td>
</tr>
<tr>
<td>ear-lobe</td>
<td>breast</td>
<td>spur</td>
</tr>
<tr>
<td>nostrils</td>
<td>crop area</td>
<td>toes</td>
</tr>
<tr>
<td>beak</td>
<td>keel</td>
<td></td>
</tr>
<tr>
<td>wattles</td>
<td>abdomen</td>
<td></td>
</tr>
<tr>
<td>hackle</td>
<td>tail</td>
<td></td>
</tr>
</tbody>
</table>
THE EXTERNAL STRUCTURE OF A FISH

Figure 1-5 The external features of a Tilapia

Table 1.6 Parts of a fish as found in the head and body.

<table>
<thead>
<tr>
<th>Head</th>
<th>Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>eye</td>
<td>scales</td>
</tr>
<tr>
<td>lip</td>
<td>lateral line</td>
</tr>
<tr>
<td>mouth</td>
<td>dorsal fin</td>
</tr>
<tr>
<td>face</td>
<td>pectoral fin</td>
</tr>
<tr>
<td>operculum</td>
<td>pelvic fin</td>
</tr>
<tr>
<td></td>
<td>anus</td>
</tr>
<tr>
<td></td>
<td>ventral fin</td>
</tr>
<tr>
<td></td>
<td>tail</td>
</tr>
<tr>
<td></td>
<td>caudal fin</td>
</tr>
</tbody>
</table>
THE EXTERNAL STRUCTURE OF BEES

(a) The external distinguishing features of the Queen bee
(b) The external distinguishing features of the Drone bee
(c) The external distinguishing features of the Worker bee

Bees are insects, so the body of a bee is divided into three parts namely the head, thorax (chest) and abdomen (belly)

Table 1.7 Parts of bees as found in the head, thorax and abdomen.

<table>
<thead>
<tr>
<th>Head</th>
<th>Thorax</th>
<th>Abdomen</th>
</tr>
</thead>
<tbody>
<tr>
<td>compound eyes</td>
<td>3 pairs of legs</td>
<td>sting</td>
</tr>
<tr>
<td>mouth</td>
<td>pollen basket on hind pair of legs of worker bee</td>
<td>wax gland</td>
</tr>
<tr>
<td>wings</td>
<td></td>
<td>body hairs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>scent gland (queen)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>blunt abdomen (drone)</td>
</tr>
</tbody>
</table>
SYSTEMIC ANATOMY

Systemic anatomy refers to the study of a group of related structures within a particular system and the relative positions each occupies inside an animal's body.

The position of internal structures can be seen when an animal is slaughtered and a cut is made lengthwise along the belly to expose the body contents. When such an exposure is made, it is said that the body has been ventrally dissected. Positions of body structures can be described as dorsal, ventral, anterior, posterior, medial or lateral.

A horizontal plane passing through the centre of an animal's body, divides it into two sections. Structures found in the upper section, including the back, are said to have dorsal positions. Structures found in the lower section, including the belly, are said to have ventral positions.

A vertical plane passing through the centre of an animal's body, divides it into two sections again. Structures found in the section with the head and fore legs are said to have anterior positions. Structures found in the section with the tail and hind legs are said to have posterior positions. For clear identification of body positions, combinations of these terms are used. For example, the cow's udder may be identified in the posterio-ventral position. The withers may be found in an antero-dorsal position of the cow's body.

Medial positions are those relating to the middle or mid-line of the body. Lateral positions are those which are further from the mid-line of the body or structure. They are positioned at the side of the body.

Figure 1-7 The basic body positions in relation to the cuts
THE INTERNAL STRUCTURES

As was mentioned earlier, when an animal is ventrally dissected, the internal structures become visible. These structures can be found in either of the two large body cavities. These cavities are separated by a broad sheet of muscular tissue called the **diaphragm**. The anterior cavity is called the **chest**. The posterior cavity is called the **abdomen** (belly).

*Figure 1-8 The cavities of a pig*
THE INTERNAL STRUCTURES IN THE CHEST CAVITY

The following structures are found in the chest cavity of the body:

- the heart
- the trachea
- a pair of lungs
- the oesophagus
- large veins and arteries

The heart is a muscular organ which maintains the circulation of blood in an animal's body. It occupies a medial position in the chest. Large veins and arteries attached to the heart can also be found in the chest. They transport blood continuously to and from the heart.

The lungs are a pair of pinkish coloured organs which contain air sacs. They are the organs of breathing. The lungs are positioned lateral to the heart, one being on each side of it. Lungs are spongy to the touch.

The trachea (windpipe) and the oesophagus (gullet) are positioned, side by side, from the mouth to the chest. The trachea connects the nostrils to the bronchia which are attached to the lungs. This tube is kept open by rings of cartilage, so that a continuous flow of air is maintained.

The oesophagus passes from the mouth through the diaphragm to the stomach. Its main function is to transport ingested food and water to the stomach.
INTERNAL STRUCTURES IN THE ABDOMINAL CAVITY

The following structures are found in the abdominal cavity of the body:

- the digestive organs
- the excretory organs
- the reproductive organs

![Diagram of internal organs of a rabbit](image)

*Figure 1-9 The internal organs of a rabbit*

The digestive organs consist mainly of the stomach and the intestines.

The liver and pancreas are also associated with the digestive organs since they function to aid the digestive process.

The liver is positioned posterior to the diaphragm. It is a dark red, lobed organ which produces bile which is stored in the gall bladder. Bile emulsifies fat and so helps in its digestion.

The stomach is a large sac which holds food and water for the process of digestion. It is
intestines are ventrally positioned. The pancreas is located in the V-shaped loop of the small intestines called the duodenum. It produces pancreatic juice which contains digestive enzymes, and a hormone called insulin. This hormone regulates the amount of glucose in the blood.

The spleen is also found next to the stomach. It is a spherical, purple coloured organ which stores excess red blood cells and destroys the old white blood cells.

The excretory organs consist of the kidneys and the urinary bladder. The kidneys are a pair of bean-shaped organs, fixed in some fatty tissue to the dorsal wall of the body. Their purpose is to get rid of nitrogen compounds such as urea and uric acid, excess salts and water from the body. Kidneys are connected to the bladder by two tubes called the ureters. The urinary bladder is positioned posterior to the kidneys. It stores urine until the body is ready to discharge it through the urethra to the exterior.

The reproductive organs include the ovaries, uterus and vagina in most female animals. The male reproductive organs (the testes and the penis) are not found within the abdominal cavity. They are external structures which are ventrally positioned in the posterior region of the body.

In birds, there is no diaphragm to separate the chest from the abdomen. As seen in Fig. 1.10, the lungs are dorsally positioned and so are the kidneys, ovary and oviduct. The liver, gizzard and small intestines are ventrally positioned.
Physiology refers to the study of how internal structures function within the living body.

The important body processes, characteristics of living organisms include the following:

- movement
- feeding
- reproduction
- sensation
- excretion
- respiration
- growth

These processes operate in different systems of the animal’s body. Each system has organs which are made up of tissues. A tissue is a mass of similar body cells which perform the same functions. Farmers need to be aware of the existence of these systems which contribute to the good health and productive performance of their animals.
MOVEMENT

Most farm animals are able to move from one place to another by means of bones and muscles within their bodies. When an animal moves, it contracts the large muscle fibres which are attached to the bones of the legs. Another set of large muscles attached to the same bones extends so that these bones could be returned to their normal positions.
The point where two bones meet is called a **joint**. When the joint between two bones has much space, it allows for much movement, e.g., the knee joint and the shoulder joint. Bones are kept together by strong elastic bands called **ligaments**. The ends of bones are usually covered with a smooth but tough substance called **cartilage**. **Synovial fluid** occupies the space between the ends of the bones. This fluid cushions any shock to that area. Cartilage and synovial fluid together reduce friction between the two bones during movement.

**SENSATION**

Animals can respond to environmental stimuli. This is so because nerve fibres are distributed throughout their bodies. Nerve fibres are connected to the spinal cord, which is found within the backbone (vertebral column) and the brain which is found in the skull. The brain is the control centre of all voluntary actions. It receives messages (stimuli) from all parts of the body, interprets them and sends back messages to the muscles in the respective area for action (response).

When there is a reflex action, the stimulus (pain) is transmitted from the skin to the spinal cord by special nerve fibres called sensory neurons. These neurons transmit the stimulus to a connecting neuron inside of the spinal cord. The message from the spinal cord is now transmitted to the muscle fibres by the motor neuron for response action.

![Figure 1-13 (a) The nervous system of a cow](image)
Farmers have learnt to make use of conditioned reflex actions of their animals. They teach them to behave a certain way in the presence of a stimulus. Eventually, as soon as the stimulus is applied, the animal performs the desired behaviour unconsciously. For example, during milking, the farmer allows the cows to hear a particular soft music. After some time, whenever the cows hear that music, they unconsciously let-down their milk as though it were milking time.

**RESPIRATION**
Figure 1-14 (b) The structure of the lung and alveoli

Figure 1-15 The process of gaseous exchange in an alveolus
Energy required for the operation of all body processes is obtained during respiration. Respiration involves breathing and the chemical breakdown of simple sugar within the cells to produce energy. Study this chemical formula.

\[ C_6 H_{12} O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy} \]

Simple Sugar (glucose) + Oxygen \rightarrow\text{Carbon Dioxide, Water and Energy}

Air reaches the lungs by passing through the nostrils, pharynx, trachea, bronchi and bronchioles. The bronchioles within the lungs end in clusters of air sacs called alveoli. Alveoli are surrounded with a network of blood capillaries. It is in the alveoli that oxygen gas inhaled is diffused into the blood cells in the capillary network. Carbon dioxide gas is diffused from the blood cells into the alveoli to be exhaled through the nostrils. Oxygen in the blood cells (oxygenated blood) is now taken to all the body cells to take part in cell respiration.

**FEEDING**

All livestock consume food so as to supply their bodies with nutrients for normal growth and body development. For this goal to be achieved, food ingested needs to be physically broken down into much smaller sizes, so that digestive enzymes can split up chemically complex foods to simpler substances. These simpler substances can pass through the mucous membrane of the small intestines, go into the blood capillaries on the outside of the intestines, and to be transported by the blood to all the body cells where they are needed. These activities occur in the digestive system which consists of an alimentary tract. Based on the differences of the alimentary tract, farm animals are classified as ruminants and non-ruminants or monogastric animals.

**FEEDING IN MONOGASTRIC ANIMALS**

Pigs, poultry and rabbits are popular farm animals in this group. Monogastric animals have simple stomachs as part of their alimentary tracts. This tract is a tube which extends from the mouth to the anus, widening at different parts to allow special functions to occur.
Food is ingested through the mouth where it is chewed, mixed well with saliva, worked into a bolus and swallowed. The mouth consists of a snout, lower pointed lip, tongue and teeth.

The dental formula for pigs is:

\[ 2 (I - 3/3, C - 1/1, P - 4/4, M - 3/3/) \]

The top figures represent the number of teeth on one half of the upper jaw. The bottom figures represent the number of teeth on one half of the lower jaw. The figure "2" outside of the common brackets is instructing us to double the figures within the bracket to find out the total number of each type of teeth on either the upper or lower jaw.

Example

The total number of incisors on the upper jaw is six.

The total number of teeth being forty-four.
Within the common brackets:

I  - represents incisor teeth, found in front of the mouth and used for cutting
C  - represents canine teeth or eye-teeth, used for tearing
P  - represents pre-molar teeth or jaw teeth used for grinding
M  - represents molar teeth used for grinding also.

In the mouth, the enzyme ptyalin, in saliva, breaks down starch into a simple sugar maltose. After the food is chewed, with the help of the tongue, it is pushed to the pharynx at the back of the mouth and swallowed. During this process, it passes down the oesophagus.

The oesophagus is a long tube which transports food and water to the stomach. Movement of substances through this tube occurs by peristaltic action. Peristalsis is a series of alternate constriction and relaxations of the smooth muscles along a tube that pushes the contents forward.
The stomach is a large sac with muscular walls to which are attached the oesophagus and the small intestine. It has only one compartment which stores masticated food for gastric digestion. Glands in the internal wall of this organ secrete gastric juice which contains mucus, hydrochloric acid and digestive enzymes such as pepsin and lipase. Mucus lubricates the food and makes it easier to be churned when the walls of the stomach contract periodically. Hydrochloric acid causes the stomach contents to become acidic so as to allow the production of pepsin and to prevent ptyalin from acting in the stomach.
The enzyme pepsin causes the protein bonds to split and so produce polypeptides (simpler substances). The simple stomach is capable of digesting concentrated feeds only, e.g., grains and grain by-products, fish and mammalian by-products. When food is mixed with gastric juice in the stomach, a semi-liquid substance (paste) called chyme is produced. Chyme leaves the stomach and enters the small intestine.

The small intestine is a long, slender, folded muscular tube which consists of the duodenum (a V-shaped loop), jejunum and ileum. The inner wall is lined with small finger-like projections called villi.

These structures help to mix intestinal contents with the digestive enzymes. They also provide a larger surface area through which simple substances are absorbed. Intestinal contents move through the intestines by peristalsis.

On entering the duodenum chyme is bathed with bile (produced by the liver).

Bile, a dark green substance stored in the gall bladder, breaks up large globules of fat into very small globules which could later be split by a lipase enzyme to produce fatty acids and glycerol. Pancreatic juice produced in the pancreas also enters the duodenum through pancreatic ducts. This juice contains more digestive enzymes trypsinogen, chymotrypsinogen or splitting protein bonds, lipase for fats and oils and amylpsin for splitting starch and dextatin to maltose).

Intestinal glands also secrete other enzymes which break down simple foods into their simpler forms for subsequent absorption into the blood as basic units, e.g., peptidases for splitting polypeptides into amino acids, maltase for splitting maltose into glucose molecules and steapsin (a lipase) for splitting fats and oils into fatty acids and glycerol. These simple substances, with the exception of fatty acids and glycerol, can easily be transported across the intestinal walls and absorbed by the villi into the blood capillaries and into the blood stream.

Minerals and vitamins are also easily absorbed into the blood and transported with digested food (glucose, amino acids) to different body tissues to be used for tissue growth, milk production, egg
production and reproduction. Fatty acids are absorbed into the lymphatic system by pressing through the intestinal walls. Fatty acids are re-combined to form fat globules which can be used as a source of energy immediately or stored in the adipose tissue for future use. Food in the small intestines is in a liquid form called chyme.

The large intestine includes the colon and the rectum. No digestive enzyme is secreted but the contents may still be broken down by enzymes which were secreted in the small intestines. Absorption of water from the chyme is the main activity of the large intestine. The contents which is mainly food is lubricated by mucus secreted here. Some bacterial actions occur causing contents to putrefy. This results in the offensive odour of the faeces (dung). Dung is stored in the rectum for egestion through the anus.

In response to bacterial infection in the alimentary tract, the large intestine secretes large quantities of water and electrolytes to dilute the effects of bacterial action. This results in rapid movement of faeces towards the anus, a condition called diarrhoea.

**FEEDING AND DIGESTION IN POULTRY**

Domestic birds are also classified as monogastric animals. However, it should be carefully noted that there are three distinct organs which together compare with the one-compartment stomach described previously. These three organs are the **crop, proventriculus** and **gizzard**.

As described for pigs, the alimentary tract is a continuous tube, extending from the mouth to the anus, enlarging at different places, so as to perform various functions. Fowls have no teeth. They have horny beaks to suit the way they feed.

Chickens have a pair of short conical seed-eating beak. The duck’s bill is flat and jagged, allowing it to sieve out its food from the water during feeding. Within the beak, there is a small tongue. In chickens, the tongue is pointed and has a horny covering which helps them to select their food. During ingestion, food and water are taken into the mouth through the beak or bill.
With the aid of the tongue, they are pushed to the pharynx at the back of the mouth and swallowed down the oesophagus. Movement through this tube is the same as was described for the pig. Food and water enter the crop, a thin walled sac which moistens and stores food for digestion. Moistened food moves from the crop to the proventriculus, a thin walled glandular organ which secretes gastric juices. While passing through this organ, food is mixed with enzymes which begin to split the starch and protein bonds to produce compound sugars and polypeptides. It also has lipase to begin splitting fats and oils. Moistened food, bathed in gastric juice, passes to the gizzard. The contents of the gizzard are churned and ground up by the strong muscular contractions of the gizzard wall.

This physical breakdown of food in the gizzard, allows the enzymes to split more bonds of complex foods so as to produce simpler compounds. Fine sand, swallowed by the birds, settles in the gizzard and helps in the physical breakdown process. From the gizzard, chyme leaves and enters the small intestine.

The small intestine is a long, many-coiled tube which connects the stomach to the large intestine. The process is similar to that described for the pig.

At the junction of the small intestine and the large intestine, are two large caeca or blind pouches. These structures extract moisture from the solid undigested matter so as to prevent excessive loss of water from the bird’s body. The undigested matter enters the short, large intestine, then into the rectum where it is stored until eggested through the cloaca. Excess amino acid in the blood stream is taken to the liver where it is converted to urea which is taken to the kidneys to be excreted. Excess glucose is stored as glycogen in the liver, and excess fat is stored all over the chicken’s body, especially under the skin.
FEEDING AND DIGESTION IN RABBITS

Rabbits are another type of monogastric animals. The dental formula of rabbits is:

\[2(I-2/1, C-0/0, P-3/2, M-3/3)\]

Rabbits obtain their nutrients from roughages, succulent food stuff and concentrates. They are herbivores; the absence of canine teeth supports this. The teeth are well adapted to the normal rabbit’s food. The incisors in the upper jaw appear to be two pairs lying side by side, but only one pair with a groove down the centre of each tooth can be seen from the front. A much smaller pair of incisors lies behind the main incisors and together they form a v-shaped groove into which the chiseled edge of the lower incisors normally fits. The molars and premolars are smaller teeth used for grinding purposes. They have flattened surfaces with prominent ridges. The mouth also has an upper cleft lip and a tongue. When the animal is eating, saliva is usually secreted and mixed with the food during mastication. As with pigs, the enzyme ptyalin begins the chemical breakdown of starch. When the rabbit is not very hungry, it chews its food thoroughly so that food reaches the stomach finely ground. When the animal is very hungry, food is not properly chewed. This can result in digestive disorders.

From the mouth, food passes to the stomach through the oesophagus. The rabbit's stomach walls have little power of contraction so food movement is dependent on pressure from the newly ingested food. The digestive process in the small intestine is the same as the pig's. The remains of food left after absorption consists of undigested food and fibrous material which are passed into the caecum where bacteria attack and digest the caecal contents. It is a thick fluid and during contraction the caecum forces its contents through the colon and rectum where it solidifies in the form of a pellet. This is eaten by the rabbit and is referred to as coprophagy. The rabbit takes this thick fluid directly from the anus, swallows, and passes the coprophagoas pellets into the stomach to be re-digested.

It undergoes the normal digestive process in the small intestine. It enters the large caecum where fibrous substances are broken down by bacterial action. In the colon, moisture is removed and the normal faecal pellets are formed. This passes through the rectum and is egested. The habit of coprophagy is normal for rabbits and can be observed at many periods during the day. It is said that
coprophagous pellets contain more than three times as much crude protein, but only one-third of the fibre as do the normal pellets. It also has high levels of Vitamin B complex. In this way, rabbits are able to efficiently digest fresh food ingested.

In addition to rabbits, horses too are monogastric animals which can digest fibrous food (cellulose) by the bacterial breakdown occurring in the particularly large caecum in the alimentary tract.

**FEEDING IN RUMINANTS**

Ruminants are animals which have complex stomachs consisting of four compartments; the rumen, reticulum, omasum and abomasum. Forage cut by ruminants during grazing passes from the mouth where it is lubricated with a copious supply of saliva, through the oesophagus to the rumen, the largest compartment. The rumen has a capacity of 182 litres to 273 litres (40 gal. to 60 gal.) This allows the animals to consume and store a large quantity of food while grazing, then ruminate while resting. The inner walls of this compartment are lined with finger-like projections called papillae. Papillae absorb nutrients from the rumen. Muscular pillars of this organ force the ruminal contents to rotate so that proper mixing occurs. Bacterial action within the rumen causes fermentation and cellulose (complex carbohydrate in plant cell walls) is split up to produce short chained fatty acids. Fatty acids are absorbed from the rumen into the blood stream of the animal for use as energy sources and for making milk-fat.

Protein in the rumen is chemically broken down to produce peptides, amino acids, ammonia and amines. The micro-organisms in the rumen (bacteria and protozoa) feed on these simple protein substances and multiply rapidly. When they die, they pass out of the rumen to be digested in the abomasum where digestive enzymes are present.

When non-protein-nitrogen such as urea is fed in the diet, similar action of micro-organisms in the rumen result in higher levels of amino acid produced. However, excess intake of ration rich in nitrogen can result in a loss of this nitrogen in the rumen, when ammonia gas is produced.

Normally, the micro-organisms utilize the simple nitrogenous substances to grow and multiply. On their death, they are taken to the abomasum where they are chemically broken down and the amino acids absorbed into the blood stream. Monogastric animals cannot utilize non-protein nitrogen in their diet.
Figure 1-17 (d) The alimentary tract of a goat

Figure 1-17 (e) The alimentary tract of cow and
Food not acted upon by micro-organisms goes to the reticulum, the second compartment, and is **regurgitated** by **anti-peristaltic** action of the oesophagus. In the mouth, the liquid is re-swallowed and the remaining bolus of food is re-chewed. Re-chewing makes the process of fermentation by ruminal micro-organisms easier when food is swallowed again. This process is called **rumination**.

The inner walls of the reticulum are thick and resemble the honey-comb. This compartment sorts out and holds any foreign material which the animal may have swallowed.

The groove between the rumen and reticulum is called the **oesophageal groove**. In calves the rumen and reticulum are undeveloped, so milk ingested is channelled through this groove which links the oesophagus to the omasum. The abomasum secretes the digestive enzymes for splitting the protein bonds.

In addition to carbohydrate and protein breakdown in the rumen, Vitamin B complex and Vitamin K are produced by micro-organisms there.

The **omasum** is the third compartment. It has muscular walls. Within this compartment, are many layers of muscular leaves which are covered with short, blunt papillae. These structures help to grind the food during muscular contraction and squeeze out water from it before it enters the last compartment.

The abomasum or the true stomach is the last compartment of the complex stomach. It is the only compartment which secretes gastric juices. Pepsin and renin are two enzymes produced in the abomasum.

Renin curdles milk and is plentiful in the calf’s abomasum. In calves, the abomasum accounts for about eighty (80%) of the total stomach volume. In mature cattle, it accounts for less than ten percent (10%) of the stomach capacity.
The inner walls of the abomasum are lined with many folds. These folds contain glands for secreting gastric juices. Chemical digestion begins in this compartment which performs similar functions as the simple stomach of monogastric animals. 

Starch, compound sugars and peptides would be further split to produce the simple basic units of each substance. They are simple sugars, amino acids, fatty acids and glycerol.

The ruminants' stomach is specialized to facilitate cellulose digestion. This occurrence makes it possible for these animals to utilize a source of food which no other class of animals can. In this way, they convert cellulose into animal protein which can be digested by human beings.

From the abomasum, the digestive process is similar to that described for the monogastric animals generally, e.g., the pig.

An understanding of the design and function of the alimentary tract of livestock animals helps the farmer to construct sensible feeding programmes. He would know that monogastric animals, because they have simple stomachs, need to be fed concentrate rations. These rations have a very low crude fibre content so their stomach can digest them easily. Although the cellulose contained in crude fibre cannot be digested by the simple stomach, these animals need a small percentage of it in their diet for the following reasons:

- crude fibre activates the intestines so that there is more peristalsis. this allows food to move easier through the intestines resulting in better digestion;
- more water is absorbed and the droppings are drier.
- it adds bulk to the ration but yields low levels of body building nutrients, this is useful for checking increase in body weight by over eating.
- it provides a medium for bacteria to act on in the caecum (although bacterial breakdown occurs in the caecum and Vitamin K and Vitamin B2 are produced, they are egested and the animals obtain no direct benefit from this activity.)
It is also important for the farmer to feed monogastric animals a protein ration which contains essential amino acids (amino acids which the animals cannot produce themselves.) However in ruminants, the stomach has been specially designed to allow cellulose digestion. Feeding forage to ruminants as the main part of their diet not only ensures that the capacious rumen is filled but also ensures that there is enough crude fibre for the ruminal micro-organisms to act on. A diet for ruminants with too little bulk will tend to produce a condition called bloat. For this reason, ruminants should not be fed solely on concentrate feeds.

In addition, farmers need not feed ruminants with a high quality protein diet as is needed for monogastric animals. Micro-organisms in the rumen can use whatever nitrogen is ingested in the diet (from proteins as well as from non-protein substances, e.g., urea) to make a variety of amino acids and proteins for their own cell growth and development. Later, when the older micro-organisms die or when they over-populate the rumen, they are taken along with the chyme to the abdomen to be digested. Subsequent amino acid absorption occurs in the small intestine.

It is therefore possible for ruminants (especially dairy cows) to convert roughage and non-protein-nitrogen to milk and meat, two highly nutritious and palatable foods for human beings. Their ability to utilize feed, which would otherwise be wasted, since they are not directly consumed by human beings, is one of the most important reasons for their existence as livestock.

**EXCRETION**

Farm animals can get rid of waste substances from cells within their bodies through two main organs - the **kidneys** and the **skin**. Waste nitrogenous substances such as urea and uric acid, excess salts and water from the cells are transported by the blood to the **kidneys**. In the **kidneys**, the blood is filtered to separate the waste substances from the blood cells and blood plasma.

The kidneys are generally bean-shaped in most domestic animals but in cattle and the chicken they are lobed. They are found in the dorsal position in the abdominal cavity and are part of the urinary system. Attached to the kidneys are muscular tubes called ureters which carry urine from the kidneys to the bladder. The bladder is a hollow muscular organ, the size of which depends on the amount of urine
within it. Attached to the bladder is the urethra. This tube extends from the bladder to the vulva in female animals. In male animals it opens out to the penis. Birds have no bladder. The ureters lead directly into the cloaca.

As the filtrate passes through to kidneys the glucose and amino acids are normally re-absorbed into the blood stream. About eighty percent of the water and sodium ions are re-absorbed also. By the time the urine gets to the ureters it is concentrated. Urine is transported to the bladder where it is stored until excreted from the body. Birds excrete uric acid together with the faeces through the cloaca.

THE KIDNEY

![Diagram of the urinary system](Figure 1-18(a) The parts of the urinary system)

THE SKIN

The skin has two layers of tissues, the epidermis and the dermis. The epidermis is the uppermost corneous layer which protects the underlying tissues. It is found on the surface of the skin. The dermis is found below the epidermis. It is a deeper layer of dense connective tissues in which are found arteries, veins, capillaries, lymphatics, nerves, sweat glands and sebaceous glands. The skin
functions as an excretory organ because of the sweat glands which secrete sweat containing water, salts, small amounts of urea and lactic acids. Around each sweat gland is a bundle of coiled capillaries. As the blood passes over the gland, these waste substances are filtered off to the surface of the skin in solution. The liquid later evaporates from the surface of the skin. Although all farm animals have sweat glands, only horses sweat readily.

GROWTH

In animals, normal body growth occurs when there is an increase in the body size of the animal which is due to normal addition of tissue similar to that originally present. Normal addition of body tissue occurs naturally by the process of mitosis. Body cells of an animal have identical chromosomes occurring in pairs in the nucleus of a cell. Chromosomes are threadlike structures which carry the genetic material (genes) of animal. The number of chromosomes found in the nucleus of a particular animal is constant (cattle - 30 pairs; sheep -27 pairs; pigs - 19 pairs; chickens - 39 pairs of chromosomes).
During mitotic cell division chromosomes within each nucleus are replicated so that there is an equal distribution of genetic material when the mature cell divides into two daughter cells. Continuous cell division results in larger tissues (due to an increase in the number of cells) and increased body size of the animals. The rate of cell division in animals is dependent on the availability of important nutrients and healthy environment.

It is said that every animal has a definite growth pattern. In the early stages of life, growth is rapid and animals can use a suitable ration efficiently. After this period of rapid growth, the rate of growth decreases and animals add very little more body tissue, although they have eaten the same amount or more. The three body tissues involved in animal growth are bones, muscles (meat) and fat. Bones grow most rapidly and mature the fastest. Muscles are added during the early stages of the animal’s life. Fat is developed on the body after the animal has matured in age. When animals are not properly fed the rate of growth as well as the tissues they develop would be out of proportion and the animal can become stunted in growth. Once stunted growth is seen, there is very little farmers can do to correct this condition. Regardless of the type of ration fed body size would not increase significantly and there would be deposition of fat beneath the skin instead of between the muscle fibres as is the case when animals are well fed throughout life.

Figure 1-19 (a) Simplified diagram of a pair of chromosomes
REPRODUCTION

Sexual reproduction is the biological process whereby the male sex cell fuses with the female sex cell to produce a zygote which subsequently develops into a young one of the same kind. Sexual reproduction in farm animals is very important, since it determines the output of animal products. By the occurrence of this process, the farmer can obtain the kinds of replacement animals he needs in his herd (or flock.) Mammals on the farm would produce no milk if parturition does not occur, hence the survival of young ones will reduce drastically and there will be no milk for human consumption. Similarly, the reproductive process is vital, if egg production and meat production are to be sustained.

Many times, farmers suffer great economic loss on farms when the reproductive rate is low. The rate at which farm animals reproduce is hindered by problems of sterile and infertile animals existing on the breeding programme. Male animals must produce viable spermatozoa (male sex cells), female animals must produce ova (female sex cells) that are released at the right time to meet with the spermatozoa. Female animals must also provide a proper environment in the uterus for the zygote from conception to
parturition. Because the reproductive process is so critical to livestock production, knowledge of how the process occurs is essential, if farmers are to maximize fertility and minimize abnormal reproduction.

The two main groups of farm animals are mammals and birds. In both groups the reproductive process is similar with just a few differences. Similarities include the following aspects:

- Each group has male and female sexes.
- Fertilization occurs within the female reproductive system located in the abdominal cavity.
- Each takes care of the young ones after birth
- Hormones which stimulate and regulate the reproductive process are the same.

The main differences are:

- Mammals produce their young ones alive, whereas birds lay ova which must be incubated outside of their bodies before the young ones emerge.
- The mammalian young obtain milk from their mothers' udders while young birds obtain nutrients from the yolk of their eggs during the first 48 hours after hatching, they do not take milk

Basically the reproductive systems are the same in mammals. Both the male and the female reproductive systems have organs which are specialised to produce sex cells (also called gametes). Animals begin to produce these cells at puberty when their bodies become sexually mature. Sexual maturity usually occurs before the body is physically mature. It is for this reason that animals should not be mated as soon as they attain puberty, instead their physical growth should be noted until they acquire adequate body weight.

In males, the genital organs seen externally are the scrotal sac which contains the testes and the penile sheath which encloses the penis. In female mammals, only the vulva is visible externally. The other reproductive organs occurring in both sexes occupy posterior positions within the abdominal cavity.
The male reproductive system consists of the following structures:

- two testes with epididymis
- sperm ducts and accessory glands
- the urethra and penis

The functions of these organs are to secrete, store and transport spermatozoa to the female reproductive system. The testes are a pair of ovoid glands which are suspended in the scrotal sac of mammals. The scrotum hangs between the hind legs in most cases. Each testis is separate and just before parturition occurs they descend from inside the abdominal cavity to the scrotum. A male whose testes fail to descend into the scrotum is a cryptorchid and is sterile. Cryptorchid may show normal masculine behaviour and body conformation because of the presence of testosterone but no spermatozoa are produced. It is recommended that these animals should not be used for breeding since some forms of crytorchidism may be inherited.

Testes are responsible for producing spermatozoa and the hormone, testosterone. Spermatozoa contain 50% of the genetic material of offsprings. Spermatozoa is produced when the testes are 4°C to 7°C below normal body temperature. It is for this reason that these organs are located outside of the
body. The scrotum however, has a regulatory function as well as one of protection. The lower temperature required for spermatozoa production is maintained by the contraction and relaxation of muscles in the scrotal wall. In cold environment the scrotal muscles contract so as to draw the testes closer to the abdominal wall to be warmed by body heat. In warm environment, the muscles relax so that the testes extend further away from the abdominal wall and are cooler. These muscular activities are controlled by testosterone.

The epididymis is a very long coiled tubule which surrounds a part of each testis. It connects the testis to the sperm duct. This tubule stores spermatozoa for about 7 days to 9 days where they develop and become mature so that when they reach the tail of the epididymis they are fertile and ready for ejaculation. The time from spermatozoa production to the time they arrive at the tail of the epididymis is very important knowledge for (farmers) breeders. In bulls, this time is 8 weeks. If a bull suddenly becomes sterile, the breeder needs to find out what factors were different 8 weeks earlier.

The sperm duct is a muscular tube which transports spermatozoa from the tail of the epididymis to the urethra at the time of ejaculation. It contracts involuntarily to expel spermatozoa during this time. The tail of each epididymis is connected to a sperm duct which enters the pelvic urethra near the bladder where ducts from accessory glands also empty. The sperm duct, together with blood vessels, lymph vessels, nerve fibres and smooth muscle fibres are all found in the spermatic cord which connects the testes to the pelvis. Male animals can be made sterile by surgically removing the sperm ducts or by cutting and tying them. This process is called vasectomy or castration.

Vasectomized males produce testosterone and spermatozoa normally, but the latter cannot be ejaculated so they are reabsorbed by the epididymis or destroyed by white blood cells and removed from the body. These males however, continue to show normal sex drive and behaviour. They are useful as teasers to detect oestrus in females which are to be inseminated artificially.

The accessory glands include the ampullae of the sperm ducts, seminal vesicles, prostate gland and cowper's gland. Each sperm duct enlarges in the pelvic region into a structure called the ampulla. Ampullae (plural) contain many glands and spermatozoa. The seminal fluid from the accessory glands
together with the spermatozoa is called semen. Semen is an essential medium for transporting spermatozoa to the vagina. It is especially rich in nutrients for the spermatozoa and acts as a buffer against acidity of the female genital tract.

The seminal vesicles and cowper's glands are paired glands. The prostate gland is an unpaired gland. The seminal vesicle supplies citric acid, ascorbic acid, fructose, inositol, enzymes and vitamins to the seminal fluid. The prostate gland produces an alkaline secretion which is rich in electrolytes and helps to give semen its characteristic odour.

The cowper's glands produce secretions which are responsible for clearing away urine from the urethral duct.

*Note:* Urine is toxic to spermatozoa.

The activities of the accessory glands are dependent on the presence of testosterone. These glands produce secretions only when there are muscular contractions during ejaculation. When animals are castrated, the accessory glands degenerate.

The urethra is a membranous tube through which passes semen during copulation and urine during excretion. The urethra is connected to the ampullae in the pelvis and extends through the penis.

The **penis** is the male organ of copulation. Before the male animal can deposit semen into the vagina of the female animal, the penis must become erect. The penis of a bull, ram or boar is always rigid. In the non-erect state (i.e. when they are not mating), the penis of these animals forms an s-shaped curve or sigmoid flexure, beyond the prepuce. The prepuce is an invaginated fold of skin which surrounds the free end of the penis. It is found posterior to the navel. At this time also, urination is inhibited so that there is very little chance for the semen to mix with urine and kill the spermatozoa. After mating, the penis is withdrawn into the penile sheath by the retractor muscle.

Generally, the reproductive system is activated and regulated by chemical substances called hormones. Hormones are secreted by the pituitary gland in the brain and the gonads. They are transported by the blood to the target organs which they activate. They also regulate the activities of these organs. In male animals, the most important hormones for reproduction are the Follicle- Stimulating-Hormone (FSH) and testosterone. FSH is produced by the anterior pituitary gland. It is transported to the seminiferous
tubules in the testes where it stimulates sperm production. Testosterone is produced by the interstitial cells of the testes. This hormone is responsible for maintaining libido (sex drive), body growth, conformation and behaviour, which characterise the male. If there is an insufficient supply of either spermatozoa or testosterone, fertility of male animals is reduced.

THE FEMALE REPRODUCTIVE SYSTEM
The structure of the female reproductive system consists of the following organs:

- the ovaries
- the fallopian tubes and uterus
- the vagina and vulva

The functions of these organs are to produce ova (female sex cells) as well as to provide a protective environment for nourishment of the developing embryo.

The ovaries are a pair of ovoid glands found posterior to the kidneys in the abdominal cavity of each female. Their functions are to produce ova and hormones. All of the ova a female produces during her lifetime are formed in the ovaries before birth, but they remain underdeveloped until puberty when she begins to experience oestrus. Each ovum contains 50% of the genes an offspring will have. In the ovary each ovum is enclosed by a follicle which helps to nourish it. At birth, each ovum occupies most of the space in the follicles and is called a primary follicle. As the animal
approaches oestrus, primary follicles grow much quicker than the ova and the cavities within the follicles become enlarged and filled with liquid. This causes follicles to bulge at the surface of the ovary. Such follicles are Graafian follicles. In monocous animals, e.g., cows, horses, donkeys, it is usual for only one Graafian follicle to develop at a time. In polytocous animals, e.g., sows, ewes, does, several Graafian follicles develop together.

At the beginning of the oestrus cycle, the pituitary gland in the brain secretes Follicle Stimulating Hormone (FSH) and pours it into the circulatory system. The blood transports it to the ovaries where it will stimulate the primary follicles to develop into Graafian follicles. These Graafian follicles secrete estrogen hormone which stimulates a change in behaviour of female animals experiencing oestrus especially that of allowing male animals to mount and mate with them.

Estrogen also conditions the female reproductive tract for the following events:

* sperm transport (i.e. produce secretion in which spermatozoa will swim)
* fertilization of the ovum
* implantation of the embryo (i.e. estrogen causes the uterine lining to thicken with a rich supply of blood vessels);
* secretion of uterine milk to nourish the embryo before it is implanted on the uterine lining.

Simultaneously, Luteinizing Hormone (LH) is produced by the pituitary gland and is released into the blood stream. It is taken to the ovaries and as the level increases, it acts together with FSH to cause ovulation to occur. As Graafian follicles grow, the lining of the follicle becomes thinner and thinner until it ruptures to release the liquid and ovum. Ovulation has just occurred. During follicle development, secretion of FSH reduces. This occurrence prevents other follicles from developing. The resulting high level of LH in the blood promotes ovulation. The cells remaining at the site of ovulation multiply rapidly and become pale yellow in colour. This yellow structure is called corpus luteum or yellow body. If the ovum released is fertilised, the corpus luteum remains on the ovary and produces the hormone progesterone.

This hormone ensures that the favourable environment in the uterus is maintained during pregnancy. It also prevents oestrus and ovulation to occur during this time by suppressing FSH and
LH secretions. If the ovum is not fertilized, the corpus luteum regresses and is reabsorbed into the tissue of the ovary. Similar order of events is now repeated for the next oestrus cycle.

The Fallopian tubes or oviducts are tubules which transport ova from each ovary to the uterus. After the ovum is released from the ovary during ovulation, it is collected by the funnel shaped part of the oviduct called the infundibulum. The infundibulum partly surrounds the ovary during ovulation. The ovum travels through the oviduct to the uterus. Ova are not motile. They are moved along by the movement of hair-like structures on the walls of the infundibulum and oviduct. These structures are called cilia. Fertilization of the ovum usually occurs in the upper 1/3 portion of the oviduct.

Generally, the uterus consists of two long uterine horns and a body where both horns meet. In polytocous animals, the uterine horns are large and contains many folds to provide enough area for embryos to be implanted. The body of the uterus in these animals is relatively small. The uterus is the site of implantation for the embryo. Just before implantation, uterine milk is secreted to nourish the embryo. At implantation, the embryo forms an intimate union with the uterine wall. This wall is lined with mucus, and many blood vessels which serve to circulate blood between the growing foetus and the mother (dam). It is through this wall that nutrients and oxygen are made available to the foetus from the mother's blood. Waste substances and carbon dioxide are removed from the foetus to the excretory system of the mother by way of her blood. This occurs until the foetus is born.

The cervix is a tough muscular structure which separates the uterus from the vagina. It is closed tightly during pregnancy and sealed with a hard mucus plug to prevent micro-organisms and other foreign bodies from entering. In the non-pregnant female, the cervix is closed but not as tightly. It is relaxed during oestrus when spermatozoa must pass into the uterus after mating and just before parturition occurs. During most of the oestrus cycle, the cervix produces viscous (thick) mucus, but at oestrus, especially in the cow, copious amounts of thin watery mucus are secreted. Farmers observe changes in the amount and type of cervical mucus to monitor the oestrus cycle in some animals.

The vagina is a muscular tube which receives the penis during mating and allows the foetus to pass out.
from the uterus at parturition. It is the site of semen placement during natural mating. The elasticity of the vaginal wall allows the necessary expansion while muscular contractions of the abdominal wall move the foetus through the vagina. From the floor of the vagina opens the urethral opening which releases urine from the bladder. The clitoris is also located on the floor of the vagina near to the vulva. The clitoris is the major area of stimulation during mating.

The **vulva** is that part of the female reproductive system which can be seen externally. It protects the vaginal opening from the entry of foreign substances.

**Exercises**

1. What are some key points one should know about morphology?
2. List three (3) dorsal positions of a fish.
3. What are the basic body positions of an animal?
4. a. Describe the position of the kidney.
   b. Identify the components of the abdominal cavity.
5. What are the components of any named excretory organ?
6. Why should farmers be aware of the animal’s body systems?
7. List four (4) joints that can be found in an animal's body.
8. a. To which system of the animal does the brain belong?
   b. Describe how a response action occurs.
9. Why is respiration necessary?
10. Describe the movement of food from the mouth to the rectum in cattle.
11. What are the differences between digestive organs of the fowl and the pig?
12. How many teeth should a rabbit have?
13. Which compartment is the true stomach in ruminants?
14. What is the function of the reticulum?
15. What is the major source of protein for ruminants?
16. What percentage of moisture is reabsorbed in the animal's body?
17. What causes normal addition of body tissues?
18. Why are chromosomes important?
19. With reference to mitosis, explain how farm animals grow?
20. Why is sexual reproduction important?
21. What hinders rate of reproduction?
22. State the groups of farm animals.
23. Differentiate between reproduction in birds and mammals.
24. What are gametes?
25. What is cryptorchism?
26. What produces sperms?
27. a. State the functions of the cowper's gland.
   b. Describe the prepuce.
28. Describe the graafian follicles.
29. Give the functions of the vagina.
2. **ANIMAL NUTRITION**

Farm animals need a regular supply of food to:

- ensure growth
- ensure a supply of energy for all metabolic activities
- repair and maintain body tissues
- maintain good health

Animal nutrition deals with the:

- nature and properties of substances which serve as animal feed
- proportions in which these substances must be made available to farm animals
- mechanisms through which these substances are converted into animal tissues and products.

**THE DIGESTIVE SYSTEM OF FARM ANIMALS**

The variety of foods needed by livestock depends on the physical limitations of their digestive systems. Cattle, sheep and goats, are called ruminants, because they have a complex stomach of four compartments which can digest large amounts of bulky vegetable matter such as grass.

Poultry and pig are non-ruminants or simple stomached animals and require smaller quantities of drier, less fibrous feeds.

**NUTRITIONAL REQUIREMENTS OF LIVESTOCK**

Food is a complex material used by all living organisms for production of energy, growth, repair, and regulation of body functions. In order to understand how food meets these various requirements, it is necessary to study the properties that constitute foods. These properties are called nutrients and can be classified as:
Water: Water is an essential part of any diet and is needed for the chemical reactions and processes such as digestion. The secretion of saliva and other digestive juices, the hormones, the blood, and the excretion of waste products, all need water. Animals that produce milk require more water daily than other animals on the farm.

The bodies of most animals contain 55%-65% water and this is maintained by animals taking it directly or as a component of the food stuff that make up their diet.

In the tropics, beef cattle requires 22 litres - 36 litres of water daily; dairy cattle 36 litres - 46 litres daily; pigs 4.5 litres - 9 litres daily; and sheep and goats 2 litres – 7 litres daily.

The water content of feeds varies considerably. Succulents, such as pasture grasses and young vegetables contain more water than concentrates.

Carbohydrates: These constitute the class of food which contains carbon, hydrogen and oxygen. They are energy yielding foods and can be subdivided into sugars, starches and cellulose.

The bulk of most animal feeds consists of carbohydrates. When oxidized in the body, carbohydrates produce energy and are also the main source of body fat.

Carbohydrates are classified according to the type of sugar which constitutes them. Thus we have:

- Monosaccharides, e.g., glucose, fructose and galactose all of which are called “simple sugar” and are soluble in water.
- Disaccharides, e.g., lactose, sucrose and maltose. These are sometimes called “double sugar” and are broken down to monosaccharides during digestion.
- polysaccharides or "many sugar" from the prefix 'poly', e.g., starch, dextrin, cellulose, pectin and glycogen.

These sugars are complex in nature.

Basal foods such as corn, cassava, potatoes are mainly disaccharides. Roughages such as hay and matured grass, on the other hand, contain a lot of insoluble sugars which are formed when cellulose matures, as plants get older.

Ruminants are able to digest these insoluble sugars. The micro-organisms present in their stomachs, secrete enzymes that break down the cellulose into digestible substances.

Ruminants can live on large quantities of grass and other vegetables high in cellulose which are not useful to other animals.

**Proteins** are essential for young and growing animals but are also required by adults for the repair and replacement of worn out tissues.

Chemically, proteins contain nitrogen, oxygen, carbon, hydrogen and sometimes phosphorus and sulphur. These elements are put together to form amino acids which are the building blocks of protein material.

The protein requirements of animals differ with age and stage of development. Young animals in the late stages of pregnancy, lactating animals and high producing egg birds, require high amounts of protein in their feeds.

Non-producing animals require less protein. Ruminants also require less protein in their feeds than non-ruminants since ruminants can synthesize amino acids from non-protein nitrogen sources. They can do this because of the presence of micro-organisms in their stomach. These micro-organisms synthesize the protein by breaking down the cellulose.
<table>
<thead>
<tr>
<th>Essential amino acids</th>
<th>Non-essential amino acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine</td>
<td>Glycine</td>
</tr>
<tr>
<td>Histidine</td>
<td>Alanine</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>Serine</td>
</tr>
<tr>
<td>Lysine</td>
<td>Cysteine</td>
</tr>
<tr>
<td>Methionine</td>
<td>Tyrosine</td>
</tr>
<tr>
<td>Pheny lalamine</td>
<td>Aspartic acid</td>
</tr>
<tr>
<td>Tryptophane</td>
<td>Glutamic acid</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>Proline</td>
</tr>
<tr>
<td>Leucine valine</td>
<td></td>
</tr>
</tbody>
</table>

**Fats and oils:** Fats are called oils when they are liquid at room temperature. They contain carbon, hydrogen and oxygen. Fats contain less oxygen than both carbohydrates and protein and produce two times the amount of energy produced by the same unit of carbohydrate. Fats are found in both plants and animals. They are specially stored in cotton seeds, palm kernel, ground nut and soya bean. Animal fat is stored in the belly around the intestines and under the skin. If more food is eaten for energy and body building than is required, the body stores the excess as fat. If too little is eaten, the stored fat is utilized for energy.

**Minerals:** When a plant or animal tissue is burnt, the organic matter is destroyed leaving the residue known as ash. This ash represents the salts of minerals or organic elements. Animals, like plants, need minerals. Plants get their minerals from the soil. Animals on the other hand, get their minerals from the food they eat. If their food lacks minerals, then minerals should be given as supplements. Minerals are essential for the formation of teeth, bones, blood and other body fluids.
Minerals are essential for the maintenance of good health. The essential minerals may be grouped into:

**Macro-elements**: Calcium, phosphorus, potassium, sodium, chlorine, sulphur and magnesium.

These are needed in large amounts by livestock.

**Micro-elements**: Iron, copper, cobalt, iodine, zinc, manganese, molybdenum, selenium, florine. These are called trace elements and are required in very small amounts.

**Calcium and Phosphorus**: Together they form over 90% of the total mineral matter of the body. The greatest amounts occur in the bones and teeth.

Calcium salts are necessary for blood clotting and phosphorus forms part of blood protein.

Sources include milk. Grasses are rich in calcium but poor in phosphorus. Cereal grains are poor in calcium but rich in phosphorus. Bone meal is an excellent source of both calcium and phosphorus.

Deficiency of either or both elements leads to the malformation of bones of young mammals, a condition known as **rickets**. The condition may also result from a lack of Vitamin D.

Rickets is very common in pigs and young calves. Severe deficiency in adult stock results in a weakening of the bones, a condition known as **osteomalacia** or soft bone disease.

Inadequate supply of phosphorus to adult animals may lead to a condition known as **depressed appetite** in which the animal chews the walls of its house, stones, etc in an attempt to satisfy its craving for minerals. In cows, a drop in the level of calcium in the blood, leads to milk fever. It can be curbed by injecting soluble calcium and magnesium salts into the blood stream.

**Sodium, potassium and chlorine**: Both sodium and potassium occur as salts of chlorine in the body's soft tissue and in the blood. The gastric juice of animals contains hydrochloric acid. Sweat from animals is very high in sodium salts.

Foods of animal origin are better sources of sodium than those of plant origin. On the other hand, foods of plant origin are richer in potassium.
Chlorine occurs in sufficient quantities in animal products and in many vegetables except cereals. Animals that feed on whole grain feeds need supplements with salt in their diet.

Deficiency in sodium can lead to stunted growth while chlorine deficiency can result in loss of appetite, feather pulling and cannibalism in chickens. The common salt is an excellent source of both sodium and chlorine.

**Magnesium:** This element is closely associated with calcium and phosphorus in the formation of the bones and teeth. It is also part of various enzymes. It is present in grasses, cereal bran, cotton seed and linseed cake.

Deficiency can result in

- Tetanus
- Grass staggers

**Iron and copper:** Very small amounts of these two elements are needed. Iron is a constituent of haemoglobin of the red blood cells. It functions in the transportation of oxygen in the blood stream. Copper is also needed in the formation of haemoglobin. It is also present in the blood and in the liver. Plants are generally poor sources of iron, however, legume seeds and cereals are good sources of iron. Colostrum, the first milk secreted by the animal after the birth of the young, is rich in iron and other nutrients. Iron deficiency may lead to anaemia and death.

**Iodine:** Iodine is present in the body in small amounts. It is part of the hormone called **thyroxine** which is produced in the thyroid gland. Deficiency of iodine may lead to an enlargement of the thyroid gland, a condition known as **goitre.** In farm animals, young animals, may be born dead or very weak. The birth of hairless pigs and the condition, **scouring** are associated with a lack of iodine. Green vegetables are a source of iodine.

**Manganese:** Manganese is present in all the tissues of the body. It is used in the process of reproduction, lactation and growth.
**Zinc:** Zinc is widely distributed in plant and animal tissues. Young animals get their supply from milk. Deficiency results in slow growth and poor development of hair.

**VITAMINS**

**Vitamins** are organic substances present in food in very minute quantities and are vital to the well-being of any organism. In the absence of vitamins, deficiency symptoms appear and may be followed by death.

These substances are grouped into:

- Fat soluble vitamins - Vitamins A, D, E and K
- Water soluble vitamins - Vitamins B and C.

**Vitamin A:** This is vital to normal growth. It is essential in maintaining the resistance of the body to diseases and for good vision. Deficiencies result in retarded growth of young animals, loss of appetite, emaciation and weakness.

In adults, deficiencies lead to weakness in resisting infection of the organs of the body connected with digestion, excretion and reproduction. Acute deficiency can lead to inflammation of the kidney and impaired vision.

Sources include cod-liver oil, animal fats, liver, eggs, butter, milk and cheese. It is also available in palm oil, fresh green vegetables and yellow maize. Vegetables such as pumpkin and carrots which are rich in carotene are also rich sources of Vitamin A.

**Vitamin D:** Vitamin D is present in fish liver oils and milk. It plays an important role in absorption from the intestines and in the formation of strong teeth, bones and egg shell. When the supply of bone forming minerals is inadequate, Vitamin D ensures that the animal makes the best use of what is available.

Plants contain little of this vitamin. However, exposure to sunlight, aids its absorption. Animals have a limited capacity for storing Vitamin D. However, when animals are exposed to sunlight or to artificial radiation of ultra-violet light, Vitamin D is converted and is utilized by the body or stored in the liver. Deficiencies result in a disease known as rickets.

**Vitamin E:** This is the anti-sterility vitamin. It is present in green fodder and cereal grains. Wheat
germ oil is a rich source. Prolonged deficiency of Vitamin E can lead to degeneration of the muscles, a condition known as **muscular dystrophy**. Deficiency in the feed of growing chickens can lead to a nervous disorder in chickens known as "**crazy chick disease**". Vitamin E deficiency is also believed to result in infertility in animals.

**Vitamin K:** This vitamin is found in green plants and fish meal. It is necessary in the process of blood clotting. Ruminants do not normally exhibit this deficiency, since the vitamin can be produced by micro-organisms in the stomach.

**Vitamin B:** Vitamin B is a group of vitamins known as the B-complex. B-complex is made up of:

- **Vitamin B₁ - Thiamin:** protects man against beri-beri, a type of paralysis.
- **Vitamin B₂ - Riboflavin:** is an important growth function, and is of special importance to the young chicks and the laying hen. It influences both the number of eggs laid, and also hatchability.
- **Vitamin B₃ - Niacin:** protects man against pellagra, the symptoms of which are rashes and sores on the skin.
- **Vitamin B₅ - Pantothenic acid:** dried grass is a source of pantothenic acid. Guards against stress and premature aging.
- **Vitamin B₆ - Pyrodoxine:** essential for the processing of amino acids and energy conversion.
- **Vitamin B₇ - Biotin:** promotes healthy skin and hair.
- **Vitamin B₉ - Folic acid:**
- **Vitamin B₁₂ -** protects against anaemia in man, and influences hatchability of eggs. Sources include cereals, beans, yeast, nuts, egg yolk.

**Vitamin C:** This is ascorbic acid and is found in all fruits and vegetables, e.g., citrus, tomatoes, bananas, cherries and onions. Deficiency results in the disease called scurvy in humans. Farm animals seldom suffer from Vitamin C deficiency since they can synthesise this vitamin.
SOURCES OF FOOD

The term feed or feed-stuff refers to any material fed to livestock, whether natural or artificial.

Feed may be classified according to the predominant nutrient or nutrients they contain. The main groups are:

- Basal feeds
- Supplements
- Concentrates
- Forages
- Additives

**Basal feeds:** These are energy feeds and are therefore a source of carbohydrates and/or fats. They are relatively low in crude protein (CP) and crude fibre (CF). These feeds include molasses, cereal grains such as maize, sorghum, barley and oats. Basal feeds make up 60% - 90% of livestock ration.
**Supplements:** These are feeds given to animals in order to supply a deficient nutrient. They are usually rich in protein and may contain vitamins and minerals.

Groundnut cake and cotton seeds supplement the protein needs of livestock, while fishmeal supplements both vitamins and minerals in poultry rations.

Animal products such as fish meal, blood meal, milk and its by-products serve as reliable sources of protein and minerals for livestock. Salt blocks also serve as sources of minerals.

**Concentrates:** These are feeds which supply primary nutrients such as carbohydrates, proteins and fats. Like supplements, these are fed with feeds to improve the nutritive balance of the total mixture.

Concentrates are either energy rich, e.g., paddy, molasses, coconut-meal, rice-bran, cotton seed meal, or they are protein rich, e.g., soya bean meal, fish meal, blood meal, meat meal and groundnut cake.

**Forages:** Forages are crops grown for the purpose of feeding livestock. These crops include pasture grasses, legume crops, cabbages, kale, maize, sugarcane, beetroot and stem tubers.

When forage is cut and dried, as in the case of hay, it is called fodder. Forages comprise of succulents and roughages.

**Succulents:** These comprise of a high percentage of water and very low fibre content. Succulents are green grasses, legumes and green vegetables.

They have a low fibre and high moisture content, approximately 18% crude fibre, and consist of budding grass and vegetables.

**Roughages:** These have a high percentage of fibre and low moisture content. They aid digestion bowel movement.

Grass is a good example of roughage. It can be fed green by allowing animals to graze or can be cut and allowed to dry to form hay. Grass can also be made into silage.

Ruminants can feed on large quantities of roughage because their complex stomach is capable of digesting fibre.
**Additives:** Additives are synthetic materials that are added to feeds to increase the productivity and efficiency of food conversion in farm animals. Although beneficial from the standpoint of increased production, some of these chemical compounds have been found to have undesirable secondary effects on consumers of the products. Feed additives include vitamins, minerals, electrolytes, antibiotics and hormones.

The hormone diethyistibestrol has been used in livestock to stimulate growth and fattening.

Antibiotics on the other hand suppress diseases so that the well-being of the animal is improved. These compounds include penicillin, tetracyclin and aureomycin.

### Table 2.1 Feeding materials

<table>
<thead>
<tr>
<th>Forages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pasture grasses</strong></td>
</tr>
<tr>
<td>pangola</td>
</tr>
<tr>
<td>guinea</td>
</tr>
<tr>
<td>elephant</td>
</tr>
<tr>
<td>antelope</td>
</tr>
<tr>
<td>para</td>
</tr>
<tr>
<td>tanner</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
PLANT PRODUCTS
Cereal grains (e.g., corn, rice, millet, sorghum, wheat, wheat middling, rice bran, and soya bean meal), coconut/copra meal, cotton seed meal and molasses.

ANIMAL PRODUCTS
Fish meal, shrimp meal, blood meal, bone meal and meat meal.

LIVESTOCK RATIONS
A ration may be defined as the feed stuffs making up a 24-hour diet of any livestock.

A pig ration may consist of rice bran mixed with corn meal, soya bean meal, fish meal and some green vegetables. There are different kinds of ration fed to animals. These depend on the stages of growth and production of the animal.

A balanced ration: This contains all the food nutrients required by the animal, in the right proportion.

The relative proportion of the nutrients will depend upon the age and stage of development of the animal. It is also dependent on whether it is lactating or pregnant.

A maintenance ration: This is a balanced ration. It is needed only to supply the energy and protein for the animal’s physiological processes. Such a ration will ensure that there is no loss or gain in weight.

A production ration: This is a balanced ration that is supplied to the animals to meet both the requirements for production and maintenance of young, fattening, laying and lactation.

USES OF PRODUCTION RATION
Flushing: This is a ration that is given to a female animal, prior to mating, to increase fertility.

Steaming up: This is a ration given to an animal during the late stages of pregnancy.
CHARACTERISTICS OF A RATION

There are several principles which should be considered in the preparation of a ration for livestock. Apart from being balanced, there are other qualities that should be considered. These include:

- bulk
- palatability
- familiarity binding
- effect laxative
- effect
- flavours and taint

**Bulk:** Ruminants need more bulky foods than pigs and poultry. Excess bulk can be harmful to young animals. Animals however, need bulk in order to feel satisfied.

**Palatability:** This refers to how tasty or appetizing the food is to the animal. This can be determined by how much of the food the animal consumes.

**Familiarity:** New foods should always be introduced gradually by mixing them with more familiar ones.

**Binding effect:** Foods that are high in crude fibre have a binding effect, e.g., hay, straw. In extreme cases, they can lead to constipation and thus be harmful to health.

**Laxative effect:** This is the opposite to binding. In the extreme, these rations can lead to diarrhoea, causing dehydration and loss of minerals. Ideally, rations should be somewhere between binding and laxative.

**Flavours and taints:** It is possible for some foods to transfer their characteristics, flavours or taint to the fat of the animal being fed. This can be very undesirable.
SOME RATIONS FED TO DIFFERENT CLASSES OF LIVESTOCK

Different classes of livestock are usually fed different kinds of rations. Rations may also vary with development.

The table that follows indicates the class of livestock and the kinds of ration fed at different stages of growth.

**Table 2.3 Rations fed to livestock**

<table>
<thead>
<tr>
<th>Class</th>
<th>Stage of growth</th>
<th>Ration</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig</td>
<td>One (1) day to 9 wks</td>
<td>Starter</td>
<td>20% of Crude Protein(CP) minerals, vitamins</td>
</tr>
<tr>
<td>Pig</td>
<td>Weaners 8 wks 14-23 kg live weight</td>
<td>Starter</td>
<td>18% CP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low in fibre</td>
</tr>
<tr>
<td>Pig</td>
<td>Between 23-25 kg live weight</td>
<td>Fattening ration</td>
<td>14% CP</td>
</tr>
<tr>
<td>Pig</td>
<td>Pregnant/Lactating sow/gilt</td>
<td>Sow ration</td>
<td>16% CP</td>
</tr>
<tr>
<td>Pig</td>
<td>Service boar</td>
<td>Sow ration</td>
<td>16% CP</td>
</tr>
<tr>
<td>Cattle</td>
<td>Calves at 2wks</td>
<td>starter ration</td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td>Calves weaned at 4-6 months</td>
<td>Growing ration</td>
<td>16% CP</td>
</tr>
<tr>
<td>Sheep</td>
<td>Lamb at weaning</td>
<td>Starter ration</td>
<td>16% CP</td>
</tr>
<tr>
<td>Poultry Broiler</td>
<td>Day old to 5 wks</td>
<td>Broiler starter</td>
<td>18%CP</td>
</tr>
<tr>
<td>Poultry Broiler</td>
<td>6-8 wks</td>
<td>Broiler finisher</td>
<td>18%CP</td>
</tr>
<tr>
<td>Layers</td>
<td>1 day to 8 wks</td>
<td>Chick starter</td>
<td>18% C.P</td>
</tr>
<tr>
<td>Layers</td>
<td>9-20 wks</td>
<td>Chick grower</td>
<td>16% C.P</td>
</tr>
<tr>
<td>Layers</td>
<td>20 wks to end of lay</td>
<td>Egg ration</td>
<td>16% CP</td>
</tr>
</tbody>
</table>
PASTURE GRASSES

Grass forms the cheapest and most abundant source of food for ruminants. In Guyana, there are two large expanses of natural grassland vegetation where cattle are reared on an extensive system. These natural grassland areas are found in the Intermediate Savannah and the Rupununi Savannah.

However, there are areas that are specially cultivated with grass and legumes for the purpose of feeding livestock. These areas are called pastures.

There are several species of grasses used in pastures. Some of them respond differently to different soil types and to the dry and wet seasons. Some grasses are short, while some are tall. Others provide more foliage and are better for cutting and feeding livestock.

Table 2.4 Important pasture grasses

<table>
<thead>
<tr>
<th>Local names</th>
<th>Botanical names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermuda or Bahama grass</td>
<td>Cynodon dactylon</td>
</tr>
<tr>
<td>Guinea grass</td>
<td>Panicum maximum</td>
</tr>
<tr>
<td>Water grass</td>
<td>Paspulm rupers</td>
</tr>
<tr>
<td>Razor grass</td>
<td>Paspulm virgatum</td>
</tr>
<tr>
<td>Sour grass</td>
<td>Paspulm conjugatum</td>
</tr>
<tr>
<td>Para grass</td>
<td>Panicum purpurescens</td>
</tr>
<tr>
<td>Antelope grass</td>
<td>Echinochloa pyramidalis</td>
</tr>
<tr>
<td>Pangola grass</td>
<td>Digitaria decumbens</td>
</tr>
<tr>
<td>Tanner grass</td>
<td>Braccharia regulosa</td>
</tr>
<tr>
<td>Elephant grass</td>
<td>Pennisetum purpureum</td>
</tr>
</tbody>
</table>
CHARACTERISTICS OF SOME COMMON GRASSES

**Elephant grass:** This is a tall grass which grows in clumps by tillering abundantly. It is propagated by stem cuttings. It produces very high yields of cut forage and is also suited for grazing.

**Pangola grass:** A medium height grass (30-45 cm) which spreads by surface runners producing a dense mat of vegetation. It is propagated by stem cuttings and grows on a variety of soils in the Caribbean, particularly in the wetter regions. Pangola grass can be cut for use as fodder or it can be grazed.

**Para grass:** This is a medium height grass that grows in a dense mat. Propagation is by stem cuttings. It is well suited to poorly drained soils. It does best as cut forage but is generally grazed.

**Antelope grass:** This grass grows taller than para grass and has a very robust stem. It is a very prolific grass and responds well under wet conditions.

**Tanner grass:** This grass has a relatively short and slender stem. It can be propagated by stem cuttings and it spreads quickly.

PASTURE LEGUMES

Legumes are now widely cultivated as pure stands or mixed with pasture grasses where they help to improve soil fertility by the action of Nitrogen fixing bacteria.

The most common legumes grown in pastures in the Caribbean is the Kudzu. Kudzu however, is not palatable and so it grows with grass in pastures for grazing.

Other legumes in pastures are phasey bean, desmodium, glycine, stylosanthes, river tamarind and some species of pigeon peas.
Table 2.6 Important pasture legumes in Guyana

<table>
<thead>
<tr>
<th>Local name</th>
<th>Scientific name</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centro</td>
<td>Centrosema pubescens</td>
<td>Creeping, climbing, Grows well in wet seasons. Grows in mix stand</td>
</tr>
<tr>
<td>Desmodium</td>
<td>Desmodium sp.</td>
<td></td>
</tr>
<tr>
<td>Stylo</td>
<td>Stylosanthes guyanensis</td>
<td>Drought resistant soil of low fertility, deep rooted, robust</td>
</tr>
</tbody>
</table>

**PASTURE MANAGEMENT**

In the management of the pasture, there are several factors that should be considered. These factors include:

- selection of grasses and legumes
- soil fertility and conservation methods
- land preparation
- planting
- time of planting
- fertilizing
- weed control
- water control
- control of pests and diseases
- harvesting
SELECTION OF GRASSES

When selecting grasses, consideration should be given to the following:

- the type of soil and the pastures
- yield
- method of harvesting
- palatability
- nutritive value
- degree of resistance to pests
- rapidity of establishment
- availability of planting materials
- tolerance to drought

Some grasses do well on dry, shallow soils, while others like the para grass do well on poorly drained soil. Some grasses give high yield for fodder, e.g., elephant and para grass. Pangola and antelope give high yields in pastures that are grazed.

CULTIVATING A PASTURE

A cultivated pasture should be treated as a crop. As such, land preparation should be given priority as in the cultivation of most crops.

The land must be cleared of all vegetation. Some trees should be left to provide shade for the animals. The land must be ploughed, harrowed and drainage and irrigation systems established. Some organic manure can be incorporated into the soil during harrowing.
Planting  Stem cuttings are usually prepared for planting. These are usually selected from mature plants. The stems are cut into pieces with 2-3 nodes and are either laid lengthwise in furrows, or stuck at an angle in the ground, at a distance of 30 cm -38 cm apart. Sometimes these cuttings are broadcast and then harrowed into the soil.

Time of planting: If irrigation is available, planting is possible in the dry season. However, it is best to plant at the beginning of the rainy season.

Fertilizing: Less fertilizing is needed if a legume is mixed with the grass. Table 2.6 is a guide to fertilizer application.

Table 2.6 Fertilizer application

<table>
<thead>
<tr>
<th>Time</th>
<th>Type of fertilizer</th>
<th>Rate of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3 wks after planting</td>
<td>Sulphate of Ammonia</td>
<td>90 kg/acre</td>
</tr>
<tr>
<td>6 wks after planting</td>
<td>Mixed fertilizer (15:10:5)</td>
<td>130 kg/acre</td>
</tr>
<tr>
<td>For established grasses:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• August to September</td>
<td>Sulphate of Ammonia</td>
<td>180 kg/acre</td>
</tr>
<tr>
<td>• November to December</td>
<td>Mixed fertilizer (15:10:5)</td>
<td>180 kg/acre</td>
</tr>
</tbody>
</table>
WEED CONTROL

Weeds can be controlled mechanically or chemically. All weeds are undesirable but some can be more harmful than others. Some cause harm to the animal itself.

Mechanical control involves inter-row cultivation, either by hand tools or by motorised machines. Chemical control involves the use of selective herbicide. A selective herbicide kills the weeds especially broad leaf weeds but has no effect on the grass. In order to control broad leaf weeds, the use of the herbicide 2 – 4D is recommended.

Broad leaf weeds include:

- **Wild leek**: produces unpleasant flavour in milk.
- **Rag weed**: noted for causing hay fever
- **Red head**: poisonous to cattle and horses
- **Cow itch**: causes skin irritation

**Harvesting**: Pastures are generally harvested 8-10 weeks after planting. It is recommended that grazing be done at least 5 months after germination.

**Grazing**: Pastures may be grazed continuously, in rotation, or not at all.

**Continuous grazing**: In this type of grazing, the cattle are set in open pastures and are left there indefinitely. This results in overgrazing in some areas and undergrazing and in other areas, trampling of grass and uneven growth.
**Rotational grazing:** In rotational grazing, the pasture is divided into paddocks which allows for grazing to be completed in 25-28 days. After grazing in one paddock, the cattle are moved to the next, giving the first a rest for 3-4 weeks. This system prevents over grazing.
**Strip grazing**: In this system, the paddocks are sub-divided into strips that can be eaten in 1-2 days before moving to the next strip. This allows for even more efficient consumption of forage. The cattle are returned to each strip after about 3 weeks.

Electric fences are used in the sub-division of the strips. These fences are movable.

*Figure 2-5 Strip grazing*

*Figure 2-6 Zero grazing or stall feeding*
**Zero grazing:** Zero grazing is the system in which the grass is cut and fed to the animals.

This system requires an intensive production from a limited acreage of pasture. The yield is much higher than in the grazed pastures, since there is less wastage due to trampling. There is also a reduction in pests and disease causing organisms. However, the harvesting of grass for fodder results in additional labour and machinery expenses.

![Figure 2-7 Harrowing a pasture](image)

**Silage:** The grass is cut and allowed to wilt for a few hours. It is then chopped and packed into a silage pit. Molasses is added to it to help in the fermentation of the fodder by microbial action. Silage is one form of conservation of grass.

**Exercises**

1. Explain the meaning of each of the following:

   - pasture
   - zero grazing
   - forage
   - rotational grazing
   - fodder
   - concentrates
   - silage
   - roughage
2. Explain the importance of all the food nutrients. Give three examples of feed materials that are sources of each of the nutrients you have named.

3. Explain in your own words, the system of strip grazing.

4. (a) Why must fertilizers be used in the establishment of a pasture?
   (b) How do legumes improve the feeding value of herbage?

5. What are the classifications of starch?

6. Describe the essential amino acids.

7. Name two sources of calcium.

8. How can you determine the presence of manganese in an animal?

9. Why is iodine essential in the diet of animals?

10. Name the sources of food that are required in higher proportion during the fattening of a pig.

11. Define the term ‘fodder’.

12. How are additives beneficial in the diet of animals?

13. How can antibiotics aid in the maintenance of good animal health?

14. Identify the types of livestock ration.

15. What are the classifications of pasture?
3. **CATTLE REARING**

Cattle rearing is very important all over the world. This is so primarily because of the production and utilization of milk. Milk is a perfect food and is mainly fed to children to reduce the incidence of malnutrition.

Apart from milk, cattle provide us with beef, skin, draught power and organic manure.

**BREEDS AND TYPES OF CATTLE**

Farmers should choose the breeds and types of cattle that are best suited for the kind of production they wish to get into, and for the kind of climatic conditions under which the cattle are reared.

All cattle belong to the genus *Bos*, and the family *Bovidae*.

The two major species are the *Bos taurus* which is the European type cattle, and the *Bos indicus* which is the Zebu type cattle. Below are some notable differences between the two species:

**Table 3.1 Notable differences between the two major species of cattle**

<table>
<thead>
<tr>
<th>Focus</th>
<th>Bos taurus (European or Temperate type cattle)</th>
<th>Bos indicus (Asian or Tropical type cattle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hump</td>
<td>none</td>
<td>humped</td>
</tr>
<tr>
<td>Ears</td>
<td>rounded and held upright</td>
<td>long pointed and drooping</td>
</tr>
<tr>
<td>Head</td>
<td>short and wide</td>
<td>long and narrow</td>
</tr>
<tr>
<td>Dewlap, umbilical fold and brisket</td>
<td>small</td>
<td>extremely developed, skin is relatively thin.</td>
</tr>
<tr>
<td>Udder</td>
<td>long and suspended between and behind the hind legs</td>
<td>short, rounded and carried in front of the hind legs.</td>
</tr>
<tr>
<td>Hair</td>
<td>long and rugged coated</td>
<td>short and smooth coated</td>
</tr>
<tr>
<td>Focus</td>
<td>Bos taurus (European or Temperate type cattle)</td>
<td>Bos indicus (Asian or Tropical type cattle)</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Leg</td>
<td>short</td>
<td>long</td>
</tr>
<tr>
<td>Maturity</td>
<td>early</td>
<td>late</td>
</tr>
<tr>
<td>Milk yield</td>
<td>drops with temperature above 24°C (75°F)</td>
<td>drops with temperatures above 35°C (95°F)</td>
</tr>
</tbody>
</table>

**BREEDS OF CATTLE**

**TROPICAL BREEDS**

Zebu          Jamaica Red
Sahiwal       Santa Gertrudis
American Braham Jamaica Hope
Sahiwal

American Brahman

Santa Gertrudis
Jamaica Red

Jamaica Hope

*Figure 3-1 Tropical breeds of cattle*
**TEMPERATE BREEDS**

<table>
<thead>
<tr>
<th>Breed</th>
<th>Breed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein Fresian</td>
<td>Aberdeen Angus</td>
</tr>
<tr>
<td>Jersey</td>
<td>Guernsey</td>
</tr>
<tr>
<td>Ayrshire</td>
<td>Charolais</td>
</tr>
</tbody>
</table>

Holstein Fresian

Aberdeen Angus

Guernsey
Jersey

Ayrshire

Charolais

*Figure 3-2 Temperate breeds of cattle*
CHARACTERISTICS OF BREEDS

Zebu: Originated in India. It is white but the hump, neck and parts of the head of the bull are dark grey. It has a short neck, large hump and long broad hock features that are associated with beef type cattle. The Zebu is also a fair milker by tropical standards and has been used extensively to improve beef breeds in Tropical America.

Sahiwal: This breed has proven to be the best dairy type in the Indian sub-continent and is probably the best tropical dairy breed in the world. The Red Sahiwal which is another tropical breed of cattle, resembles the Sahiwal but is smaller in every respect. This breed originated in Pakistan. Sahiwal are heavily built, short legged animals with a reddish or light brownish red colour. They sometimes bear white markings. The breed has been introduced into Jamaica for cross breeding purposes.

American Brahman: This breed originated in Texas U.S.A from a mixture of the Zebu. It is a beef type animal. It is a large animal. The mature cow weighs 1000 -1500 lb (453.6 - 680.4 kg) and the bull weighs 1600 - 2200 lbs (725.7- 997.8 kg). The calves are born small. The males are usually darker than the females. The calves are born red and quickly turn grey. The skin is loose, soft and pigmented. The ears are pendulous. It is resistant to ticks and biting flies. The animals can become docile when handled continuously.

Jamaica Red: This breed originated in Jamaica by cross breeding Red Poll,Zebu, Devon and the native cattle of Jamaica. This animal adapts well to tropical conditions. It is tolerant to heat stress, resistant to diseases and do well on local forage. It is a beef breed.

The average weight of the cow at maturity is 1000-1600 lbs (454-726 kg) and the bull-1800 lbs. (816 kg).

Santa Gertrudis: This breed was developed in Texas, U.S.A and has 3/8 Zebu and 5/8 Short horn. It is a beef type breed and has a large deep body. The coat is cherry-red, hair short and straight. It is tolerant to cold and hot climates and resistant to ticks. The breed is notable for early maturity, hardiness and is an economic converter of feed. This breed has been successfully introduced in Guyana.

Jamaica Hope: This breed is also known as Montgomery, Jersey and Jersey Zebu. It was developed in Hope near Kingston, Jamaica and it consists of about 80% Jersey,15% Sahiwal and 5% Holstein. The Jamaica Hope is a good dairy type breed of cattle. Females weigh about 900 lbs. (408 kg) and the males about 1300 lbs (453.6 kg). The animal resembles the Jersey, but it is larger.
The colour varies from fawn, brown and grey to black. Production of milk averages, 7000lbs. (3175 kg) with a butterfat of 4% per lactation.

**Holstein Friesian:** The Holstein as it is popularly called, originated in Holland and is the largest of the dairy breeds. The average weight of the cow is 1300 lbs (590 kg) and the bull is 1800 lbs (816 kg). The colour is usually black and white. The legs from the hock down are usually white. There is however, a possibility of red and white markings in pure breeds.

The cow is docile. The calves can have an average weight of 90lbs (40.8 kg) at birth. The animal suffers from heat stress and the hair has to be clipped. It is susceptible to ticks. The milk production per lactation is 9000 lbs (4082 kg) with a 3.7% butter fat.

**Jersey:** This breed originated in Jersey in the British Channel. It is the smallest of the dairy breeds. The cow weighs 800-900 lbs (365-408 kg) and the bull 1200-1400 lbs (544-635 kg). The colour ranges from white to dark grey or black. The tongue and switch are black. The bull is darker than the cow. They are extremely sensitive animals. The average milk yield is 6500 lbs (3484 kg) per year, with a butterfat of 5%. The calves weigh 50-60 lbs (23-27 kg) at birth. The Jersey does better than Holstein on rough pastures.

**Ayrshire:** This breed originated in Scotland. The cow has an average weight of 1000 lbs (454 kg) and the bull, 2000 (907 kg). The colour is spotted red or brown and white. The horns are long and bent upwards and outwards. They are easily handled. The average milk production is 7000 lbs (3175 kg) per year with a 4% butterfat. Calves weigh 60-75 lbs (27-34 kg) at birth.

**Aberdeen Angus:** This is a beef breed that originated in Scotland. The animals mature early and produce high quality carcasses that are well marbled. There are two types of Angus, the Red Angus with the red gene being recessive and the Black Angus with the black gene being dominant. These animals are polled and the hair coat is smooth and black.

**Guernsey:** This breed originated in the British Channel Islands. The colour is reddish-yellow, with white markings on the face, flanks, legs and switch. The nose is cream coloured. The cow weighs 1000 lbs (454 kg). It produces more milk than the Jersey with a 4.8% butterfat.

**Charolais:** This breed originated in France. The animals range from cream to white and the body is rugged, thick and muscular. The horns are similar to those of the Short-Horn. The average weight of the mature cow is (800 kg). It is a beef type breed.
TYPES OF CATTLE

There are basically three types of cattle.

- Milk or dairy type
- Beef type
- Dual Purpose Type

DAIRY TYPE CATTLE

A dairy type animal is reared specifically for the production of milk. The general characteristics are:

- triangular in shape, that is, narrow to the front and broader towards the rear
- the nostrils are wide, strong and well formed
- the barrel is deep
- the udder is large and the teats are well formed
- there is a prominent milk vein underlying the belly
- usually docile.

DAIRY BREEDS

- Holstein Friesian
- Guernsey
- Ayrshire
- Sahiwal
- Jersey
- Jamaica Hope
- Brown Swiss

Figure 3-3 Shape of the dairy type cattle
BEEF TYPE CATTLE

The general characteristics are:-

- rectangular or block shape
- deep and fleshy hind quarters
- the milk yield is low, but the animal gains weight rapidly
- high killing out percentage.

BEEF BREEDS

Drought-master Aberdeen Angus
Jamaica Red Charolais
Santa Gertrudis Hereford
American Brahman Short Horn

![Figure 3-4 Shape of the beef type cattle](image)

DUAL PURPOSE

Milking short horn Red Poll Devon
MANAGING DAIRY CATTLE

Terms used to describe cattle:

**Calf:** Young born to the female animal  
**Cow:** A female that has calved  
**Bull:** Male which is used for breeding  
**Heifer:** A female that has not calved  
**Steer:** A male castrated before mating (usually around 12-18 months)  
**Stag:** Male castrated late in life (usually around 24-36 months)  
**Yearling:** Cattle between one to two years of age

SYSTEMS OF MANAGEMENT

All types of cattle are usually managed under varying systems and conditions which depend on the farmer, the purpose for which the cattle are needed and the location in which they are reared.

There are at least three types of cattle farmers in Guyana, based on the size of land utilized:

- The peasant or subsistence farmer  
- The medium size farmer  
- The large size farmer

Each type of farmer will utilize one of three systems to manage his stock. The systems employed are:

- Intensive  
- Semi-intensive  
- Extensive

INTENSIVE SYSTEM

This is one in which cattle are reared indoors and are hand fed or fed by machines.

This system is used by local farmers who only have a few cows. Much capital is expended to provide a high protein diet and facilities for housing and disease control.
EXTENSIVE SYSTEM

The extensive management is popular among all cattle farmers in Guyana. Cattle are reared on pasture or outdoors all the time. In this system, cattle graze outdoors and some supplementary feeding is done. Most large scale cattle farmers in Guyana utilize this system. A large herd of cattle is given the range of the pasture. This approach to management however, is usually very unscientific since there is little or no record keeping. The pastures for the most period are over-grazed and calf mortality is usually high.
SEMI-INTENSIVE SYSTEM

Most specialized dairy and beef farmers utilize this system. The cattle are reared both indoors and outdoors.

Management, feeding, breeding and disease control practices are more economical and record keeping can be more efficient.

Pasture grazing and/or zero grazing is practised by farmers and yields tend to be very good.

**Figure 3-7 Semi-intensive system of rearing cattle**

BREEDING AND REPRODUCTION

Breeding and reproduction of cattle are done to increase the stock number, and for milk and meat production. Farmers are however, advised to breed for good genetic qualities in order to improve the quality of their stock and production.

A good breeding programme therefore requires a careful selection of both cows and bulls for breeding.

SELECTION OF BREEDING ANIMALS

The cow or bull is selected on three factors:

- conformation
- pedigree
- performance
**Conformation** refers to the physical appearance of the animals. The ideal characteristics are:

- the animal should have a big stomach to hold lots of food
- the cow should have a well-developed udder for storing milk
- the teats should be well formed
- the top line of the animal should be straight, and the pasterns strong
- the bull should have well-developed testicles and be aggressive.

**Pedigree** is used with reference to the parents or ancestors of an animal.

Records must be there to show whose ancestors were good producers of milk, butterfat and calving rate. Records will also show the health of the parents.

**Performance** describes such attributes as growth rate, milk yield, reproduction rate and number of calves weaned by individual animals. Records will give a clear indication of what the offspring are likely to be.

**MATING**

Cows are usually bred naturally by using the bull, or artificially, that is, by the process of artificial insemination.

**Natural breeding:** This method requires that a farmer keeps a bull to serve his/her cows.

Mating is done either in the pasture where the bulls and the cows run freely or it may be done in the pen when the farmer takes the heifer to the bull.

**Artificial Insemination:** The cow or heifer can be artificially bred by inseminating semen into the cervix by artificial means. Artificial insemination involves:

- semen collection
- dilution of semen
- storage of semen
- inserting semen into the cervix of the cow
Collection of semen

Semen is collected from special bulls in a test tube attached to an artificial vagina.

![Figure 3-8 Semen collection](image)

The bull is encouraged to mount a teaser cow and the penis is directed by the technician into the artificial vagina.

**Dilution:** The semen after collection is taken into the laboratory and examined under a microscope for foreign bodies, sperm density i.e. number of sperm in 1 cc of semen, and sperm viability. It is then diluted and extended with egg yolk, pasteurized or homogenized milk, citrate or glycerol up to twenty (20) times the original volume.

**STORAGE OF SEMEN**

Diluted semen is placed in smaller receptacles (straws) and then stored in carbon dioxide cabinets at 173°C. One straw may contain up to 25cc of semen.
INSEMINATING THE COW

The operator carries out the following actions in the process of insemination:

- washes and disinfects his/her hands
- inserts one hand into a plastic glove which covers the arm, up to the shoulder
- lubricates the glove to facilitate easy entry of the hand into the rectum
- collects a straw of semen from the flask
- inserts the gloved hand into the rectum to locate the cervix
- deposits semen into the cervix by the use of the catheter

![Inseminating a cow](image)

*Figure 3-9 Inseminating a cow*

ADVANTAGES OF ARTIFICIAL INSEMINATION

Artificial insemination has many benefits:

- Sperms from selected bulls can be transferred from miles away.
- Semen can be preserved long after the bulls are dead.
- The spread of venereal disease can be minimized.
- The cost of keeping a bull on the farm is not incurred.
- A large number of females can be bred from one ejaculation.
- Desired traits can be obtained for herd improvement.
DISADVANTAGES OF ARTIFICIAL INSEMINATION:

- The operator may not be skilled and can damage the genital tract.
- Insanitary practices can cause infection of the genital tract.
- Non-detection of heat by the farmer can result in bad timing on the part of the inseminator.

INSEMINATION PROCEDURE

The most common artificial insemination method used on cattle is called the rectovaginal technique. With this technique, the technician inserts a disposable catheter containing thawed semen into the vagina and guides it into the cervix with a gloved hand inserted into the cow's rectum. Because the vaginal walls are made up of thin muscle, he can easily feel the catheter through the wall between the rectum and vagina.

He passes the catheter through the cervix into the uterus and slowly deposits part of the semen, then deposits the rest into the cervix as he withdraws the catheter. This process may be repeated later to decrease the chance of conception failure.

EMBRYO TRANSFER

This technique involves the collection of fertilized eggs (embryos) from high producing cows and transferring them to other cows. The donor cow is treated with hormones to induce ovulation. Several eggs are produced and the cows are then bred naturally or by artificial insemination with sperms from superior bulls.

After one week, the fertilized eggs are removed from the donor. They are immediately transferred to other cows (surrogates) or are frozen at -196°C for future use.

REPRODUCTION

A good cow should calve once every year. Sexual reproduction requires that the following conditions are met.

**Puberty** - sexual maturity of both male and female

**Oestrous** or **heat** - readiness of the female for the male
**Oestrous cycle** - interval between two oestrous

**Ovulation** - shedding of eggs by the ovary in the female

**Ejaculation** - shedding of sperms in the vagina by the male

**Fertilization** - union of the sperm and egg in the female reproductive tract

**Conception** - union of the fertilized egg unto the wall of the uterus (placentation)

**Pregnancy or Gestation** - period of development of the foetus in the uterus or womb

**Parturition** – act of giving birth

**TIME OF MATING**

Heifers should be at least 18 months old at the time of first mating. The heifer or cow will accept the bull during the oestrus period or heat. This period lasts for about 12-24 hours. At the time of oestrus, the animal exhibits both physical and behavioural changes.

These changes are:

- restlessness
- bellowing
- mounting other animals and also allowing herself to be mounted
- loss of appetite
- swelling and reddening of the vulva
- milk production in lactating animals decreases.

During the oestrus period, ovulation takes place about 12 hours after standing heat.

The best time for mating the cow is about 10 hours after the end of standing heat i.e. if heat begins in the morning, the farmer should breed in the evening. If it begins in the afternoon, breeding should be done the next morning. It is during this time that conception is likely to take place.

If the animal is not mated during oestrus, or if conception does not take place, the cow will return into heat/oestrus within 18-21 days. This period between one oestrus and the next is the oestrus cycle.
**Pregnancy** or the **gestation** period is the period from conception to birth of the calf. This period lasts between 280-282 days or about 9 months.

If pregnant, there are several changes that the farmer will observe in the cow:

- The cow will settle down and become quieter.
- The cow will not demonstrate any sign of oestrus for that period.
- The cow’s belly will enlarge.
- If the cow is lactating, milk production will decrease.

**REPRODUCTIVE CYCLE OF THE COW**

Oestrus period: 12-24 hours

Oestrus cycle: every 21 days

Time of ovulation: 12 hours after heat

Time of mating: 10 hours after heat

Gestation: 280-282 days

**CARING FOR THE PREGNANT COW**

A pregnant cow requires special care during the time she is bearing the calf.

During the first 6 months, the growth of the foetus is slow, and the cow is treated normally. However, as she progresses, the farmer should ensure that she is provided daily with good quality grass and about 2kg of concentrate along with lots of water, some mineral and vitamin lick.

The cow should be kept away from uneven pastures. By the end of the 7th month, if she is lactating, she should be dried off. “Drying off” means to stop milking the cow. This should be done gradually and is done so that the mammary tissues can rejuvenate for the next lactation period.
The cow that has been dried off should be well fed, not lavishly fed. She will not require large amounts of concentrates. At least one week before calving, the cow can be brought into a clean pen. There should be a bedding of straw in the calving pen. During this time the quantity of grass fed can be reduced and more concentrate provided.

**Calving:** Calving normally takes place without any difficulty. Labour is preceded by several physical and other changes in the cow.

**Signs of calving:**

- nervousness and restlessness
- swollen vulva with a discharge of mucus
- loss of appetite
- udder develops and there is milk present in the teats
- the belly drops
- frequent bellowing and may scratch at the bedding

*Figure 3-10 Calf in the cow's uterus, normal presentation of calf at birth*
During calving, the water bag bursts and the fluid is released. In labour, the cow repeatedly strains and rests until the calf is forced out; front legs first, followed by the head, shoulders and the rest of the body. A veterinarian should be in place at this time.

![Figure 3-11 Abnormal birth positions](image)

The **placenta** (after birth) is expelled within 12-24 hours after calving and should be removed. Wet bedding should also be removed. The mother may not be inclined to eat, but should be given clean fresh water to drink.

**CARING FOR THE CALF**

Immediately after the calf is born, it is cleaned with a dry cloth. The mouth and nostrils are wiped and the umbilical or navel cord is cut to about 4” (10cm) from the body. The cord is then treated with a solution of iodine.
The calf is allowed to stay with the mother in the calving pen, and allowed to suckle the first milk or colostrum.

**Colostrum** is rich in protein, minerals, vitamins and antibodies. Antibodies help to build the immune system of the calf.

If a calf pen is provided, the calf can remain with the cow for 24 hours, and then taken to the calf pen. In the calf pen, the calf is bucket fed with milk.

*Figure 3-12 Calf in calf pen*
Calves should be fed three times daily and according to weight. A 100 lb (45 kg) calf should be fed 10 lb (4.5 kg) of milk per day. The calf should be provided with fresh water daily; after 3-4 days can be fed with whole milk.
Table 3.1 Calf feeding schedule

<table>
<thead>
<tr>
<th>Age. Weeks</th>
<th>Colostrum whole milk/ (litre)</th>
<th>Daily milk Milk substitute (litre)</th>
<th>Daily concentrate (kilogram)</th>
<th>Other daily requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.8</td>
<td>Nil</td>
<td>Nil</td>
<td>Fresh water</td>
</tr>
<tr>
<td>2</td>
<td>4.5</td>
<td>Nil</td>
<td>0.7</td>
<td>Minerals</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
<td>-</td>
<td>0.7</td>
<td>Young grass</td>
</tr>
<tr>
<td>4</td>
<td>1.1</td>
<td>2.3</td>
<td>1.1</td>
<td>Young grass</td>
</tr>
<tr>
<td>5</td>
<td>2.3</td>
<td>-</td>
<td>1.1</td>
<td>Young grass</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>5.5</td>
<td>1.4</td>
<td>Young grass</td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td>5.5</td>
<td>1.6</td>
<td>Young grass</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>4.5</td>
<td>1.8</td>
<td>Introduce to pasture in good weather</td>
</tr>
<tr>
<td>9</td>
<td>-</td>
<td>2.3</td>
<td>1.8</td>
<td>“</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>“</td>
</tr>
<tr>
<td>11</td>
<td>-</td>
<td>0.9</td>
<td>2.0</td>
<td>“</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>2.3</td>
<td>Completely on pasture</td>
<td></td>
</tr>
</tbody>
</table>

The following must be noted by the farmer when feeding the calf:
Calf is to be fed regularly and on time.

Milk and milk substitutes must be heated to body temperature 38.5°C (101.3°F) before they are fed to the calf.

Over feeding must be avoided as this leads to digestive problems.

Change of feed should be gradual.

HOUSING THE CALF

The calf, when kept in a stall, should be provided with a rack for feed, water and mineral lick. The house should be draught free, ventilated and clean. The size of the stall should be 1.5m by 1m, and the floor should be slatted.

OTHER CALF MANAGEMENT PRACTICES

Vaccination: Calves should be vaccinated at 3 - 4 months against diseases such as Rabies and Anthrax.

Tick control: Calves that graze in pastures used by other cattle should be sprayed regularly for ticks.

Deworming: This must be done when the animal is weaned, which is around 3 months old.

Castration: Male calves which will not be used for breeding, must be castrated at 4-6 months.

Several methods can be used in castration:

- **Open** or **bloody castration** in which the scrotum is cut with a scalper blade or a sharp knife and the testes are removed.

- **Closed** or **bloodless castration** in which a burdizzo or clamp is used to crush the spermatic chord.
Disbudding or dehorning: Calves with horns can be dehorned by one of the following methods:

- a caustic stick is rubbed on the horn buds until they bleed. This is done when the calf is two weeks old.
- a cylindrical red hot iron, electric or otherwise is pressed to the buds to destroy them when the calf is 3 - 4 weeks old.

Identification

Calves must be marked early by using one of the following methods: tattooing, tagging, notching or branding.

Management of Heifers

Calves are weaned at about 4-6 months after birth. Weaning means that the calves are taken off milk. Heifers require luscious pastures and an adequate supply of pure, fresh water, concentrates and minerals.

In the management of heifers, farmers should not over feed with concentrates, since this can lead to excessive fat. Management must also include control of internal and external parasites and hair clipping.

Heifers are bred when they are 15-18 mths old, and weigh about 275 kg. Housing should be provided for the animals.
MANAGING THE BULLS

A bull is a male used for breeding. A castrated bull is called a steer.

It is important that bulls be selected from high producing and fast growing parents. The bulls should be healthy, active and masculine in appearance.

Like heifers, bulls must have access to good pastures, some concentrates and minerals.

Some provision should be made for the bull to have regular exercise. Bulls should be separated from the heifers at 4 months. The farmer should not be tempted to use the bull for mating too early. The bull should be about 20 months before he has his first service and should mate at least 12 heifers or young cows in the first 6 months. When fully mature, he can serve about 50 cows.

MANAGING A MILKING COW

Cows can be milked once, twice or thrice daily. It has been proven that milk yield is highest in animals that are milked three times a day.

A cow can produce milk very late into pregnancy. Milk is produced from one calving into another, but this is not recommended. The cow needs a period of rest (drying out) for the mammary tissues to recuperate for the next lactation.

A lactating cow will come into heat 30-60 days after calving, during which time she can be bred.

The cow is usually milked up to the 7th month of the next pregnancy and then "dried off." Drying off is done by gradually desisting from milking the animal and finally removing her from the milking herd. Milk production increases to its peak during the first 3 months of lactation, after which it shows signs of declining.

If the farmer increases the amount of concentrates fed to the cow, the milk production will increase. A good dairy cow can consume between 2.7-6.4 kg of concentrates each day or about 1.6kg of concentrates for every 4.5 litres of milk.

Milk secretion is influenced by the hormone prolactin, while milk let down, is influenced by oxytocin. Milk let down is a conditioned or reflex action that is stimulated by sensations from the teats. These
sensations occur as a result of suckling, wiping the breast with an udder cloth, by gentle pulling at the teat or with any act associated with milking.

Oxytocin, when released, circulates in the blood for some 4 minutes. Milk let down lasts therefore for a relatively short period. Consequently, milking should be done within 5-7 minutes, whether by hand or machine.

**MILKING**

Milking is the extraction of milk from the udder of a lactating cow. The following rules should be observed when milking:

- The cow should not be excited before or during milking.
- Restrain the animal, if necessary.
- Clean the udder.
- Cow should be stimulated to let down milk, one or two minutes before milking begins.
- When hand milking, use dry hands and full hand grasp of the teat.
- In machine milking, see that the machine is thoroughly cleaned and in good working order.
- Stop milking as soon as the milk stops flowing.
- Stripping of the udder is done to avoid mastitis.

**Grazing:** Cows managed outdoors should be rotationally grazed. They should be put on the best pastures. Night grazing has been practised on some farms and has yielded good results.

Dairy cows require 0.68kg of dry matter for every 45.5kg body weight, when they are not in milking, and about 1kg of dry matter for every 45.4kg body weight, when they are producing about 4.5 litres of milk daily.
Table 3.2 Amount of concentrates fed to cows for every extra gallon of milk produced

<table>
<thead>
<tr>
<th>Daily milk production</th>
<th>Amount of concentrate fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4.5</td>
<td>0</td>
</tr>
<tr>
<td>4.6 – 6.8</td>
<td>0.9</td>
</tr>
<tr>
<td>6.9 – 9.1</td>
<td>1.8</td>
</tr>
<tr>
<td>9.2 – 11.4</td>
<td>2.7</td>
</tr>
<tr>
<td>11.5 – 13.6</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Table 3.4 Sources of nutrients

<table>
<thead>
<tr>
<th>Concentrate</th>
<th>Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, molasses, rice bran</td>
<td>Carbohydrates</td>
</tr>
<tr>
<td>Edible fruit pulp, semi-processed vegetables</td>
<td>Vitamins</td>
</tr>
<tr>
<td>Cotton seed meal, soya meal, groundnut meal</td>
<td>Proteins</td>
</tr>
<tr>
<td>Coconut meal, groundnuts</td>
<td>Fats and oils</td>
</tr>
</tbody>
</table>

MANAGING BEEF CATTLE

Local production of beef is obtained primarily from bulls and culls of dairy breeds. At present, beef cattle are crosses of creole and zebu breeds.

Efforts have been made to establish farms with specialized beef breeds. The Santa Gertrudis and the Jamaica Black are specialized beef breeds, used in the Caribbean.

Beef cattle require less intensive management than dairy cattle. Most of the beef cattle reared in Guyana are concentrated in the Rupununi and Intermediate Savannahs. Cattle are allowed the free
range of the pastures.

In some cases the calves are fed concentrates as a supplement.

A few months before the animals are ready for slaughtering, they are put on better pastures and are given concentrates (feed lot).

Zebu are slaughtered when they are about 360-400 kg in weight.

**DRESSING PERCENTAGE**

The percentage weight of the dressed carcass to the live weight of the animal is called the dressing percentage.

The dressing percentage of beef cattle varies between 56%-60%. Prime grade dressing is between 62%-67%.

**DISEASES AND PESTS OF CATTLE**

A disease is a disorder or any condition that deviates from normal health.

Correct feeding, good nutrition, adequate housing and good sanitary practices are all fundamental to the maintenance of good health of all classes of livestock. Some of the most common diseases of cattle are anthrax, foot and mouth, rabies, tick fever, brucellosis, tuberculosis, mastitis and scours.

The common causes of diseases are micro-organisms and macro-organisms. These organisms include:

- viruses
- rickettsia (bacteria-like organisms)
- fungi which cause diseases like ring worm
- bacteria which cause mastitis and anthrax
- protozoa
- ticks
- mites and lice
- worms - round worms and tape worms

Other causal factors include:
- nutritional deficiencies or nutritional disorders, e.g., Milk-fever
- poisoning due to feeding or toxic substances

**DISEASES OF CATTLE**

**Disease: Anthrax**

**Causal Agent: Bacteria**

**Symptoms:**
- sudden death of one of the herd
- in severe out breaks, many animals die within a few hours of one another
- bloody diarrhoea
- staggering, spasm, lack of appetite and fever
- after death, blood oozes from the mouth and anus

**Prevention**
- Vaccination can give an almost complete immunity, but only for a limited time, so immunization should be repeated annually.

**Treatment and control**
- A mild infection can be treated with a dose of penicillin and other antibiotics. Treatment should be done early. Carcasses should be burnt.

*Note:* No treatment will save animals that are in an advanced stage of the disease.
Disease: Black Leg

Causal Agent: Bacteria

Black leg is caused by bacteria which, as in the case of Anthrax, form spores which can live in the soil for years.

The bacteria are contracted mainly through the feed and water. The germs can also enter any skin abrasion or cut.

Symptoms:

Initially

- high temperature
- loss of appetite
- rapid breathing.

Later

- gas filled bubbles which crackle when pressed, all over the body.
- When the animal dies, its body will bloat very quickly and the forelegs will stick straight in front.
- Black tar-like blood oozes from the nostrils, mouth and anus.

Prevention:

- All cattle should be vaccinated annually. In badly affected areas, farmers should vaccinate all animals under one year, every six months.

Note: Usually the disease attacks cattle between the ages of 6 months and 18 months.

Treatment:

The disease can be treated with:

- penicillin
- anti-black-leg serum, when it is recognised in the early stages.
Figure 3-17 A cow that has died from black-leg disease

**Disease: Anaplasmosis (Tick fever)**

**Causal Agent: Protozoan**

This disease is caused by:

- a microscopic protozoan which is transmitted by ticks and other blood sucking animals such as flies and mosquitoes.
- it can also be spread by contaminated instruments- knives and vaccination needles.

**Symptoms:**

- destruction of the red blood cells resulting in anaemia.
- loss of appetite
- the animal isolates itself from the rest of the herd
- the animal is inclined to lie down
- milk production decreases
- high temperature
- rapid breathing and increased pulse rate
- muscular tremors
Prevention:

- Get rid of vectors mainly ticks by dipping or spraying animals regularly
- Use of insecticides such as Lindane and Toxophane.
- Good sanitation
- Sterilization of tools and utensils.

Treatment:

- Antibiotics have been used on sick animals and have resulted in shortening the course of the disease.
- Sick animals should not be exposed to extremely low temperatures.
- They should be given adequate water and some concentrates.

Disease: Mastitis

Casual Agent: Bacteria

Symptoms:

There are two forms of Mastitis:

Acute mastitis

- Hardening of the infected quarter which becomes very hot.
- The animal shows signs of pain when the udder is handled.
- There is a loss of appetite and the temperature of the animal is high.
- Milk from the infected udder will contain flakes (of milk) and blood.

Chronic Mastitis

Chronic mastitis is more difficult to diagnose and is usually found among animals which once had the disease and are now carriers. The milk looks wholesome and only a laboratory test will reveal the germs.
Prevention and Control:

- Good sanitation.
- Surroundings and the cows should be thoroughly washed.
- Milking machines should be disinfected and should be in good working order. Machines should not be left on the udder for too long.
- If milking is done by hand, the milker should wash and disinfect his/her hands before milking. Infected teats should not be milked at the time of milking healthy teats.

The udder should be washed and strip-cup tested before milking is done. Efforts should be made to see that the udder is not injured.

Treatment and Control:

- In severe cases, the cow should be put in a separate stall.
- Infected quarters should be milked and managed frequently.
- Sulphur drugs and antibiotics can be administered both orally and by infusion into the teat canal of the infected quarter. After the injection/infusion, the teat should be massaged upwards to help to spread the medication throughout the udder.
- The udder should be cleaned and the ends of the teats sterilized with alcohol.
Disease: Foot and Mouth

Causal Agent: Virus

This is a highly contagious disease which is caused by a virus. Although the disease is rarely fatal, there are secondary developments that result in mortality.

Symptoms:

- Excessive salivation
- High temperature.
- Blisters on the feet (causing lameness).
- Blisters on the mouth (causing pain when eating).
- Lower food intake.
- Poor performance.

Prevention:

- Vaccination (4 weeks and every 6 months afterwards, in areas where the disease is prevalent).
- Quarantine (enforced in areas where disease is prevalent).

Treatment and Control:

There is no known specific treatment for this disease.

- Antibiotics can help only against secondary infections.

INTERNAL AND EXTERNAL PARASITES

A parasite is a living organism which establishes an association with another living organism called the host. The relationship is not symbiotic it only feeds off the host and provides nothing in return. The parasite establishes itself either externally or internally of the host.

External Parasites are called ectoparasites and internal parasites are called endoparasites

The most common parasites found in and on cattle are found in the table below.
Table 3.5 Common parasites of cattle

<table>
<thead>
<tr>
<th>External Parasites</th>
<th>Internal Parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticks</td>
<td>Roundworms</td>
</tr>
<tr>
<td>Tsetse fly</td>
<td>Liver Flukes</td>
</tr>
<tr>
<td>Biting flies (house flies)</td>
<td>Tapeworms</td>
</tr>
</tbody>
</table>

**Ticks**: The adult tick lives on the body of the animal and sucks the blood from which it derives its nutrition.

The female lays hundreds of eggs in the ground and then dies. The eggs hatch and the larvae climb unto blades of grass and later attach themselves to passing cattle. They can be found under the ears, flanks, on the dewlap, the region between the legs and under the tail. They feed and change into nymphs and finally into adult ticks.

Ticks cause tick fever and anaemia.

*Figure 3-19 The life cycle of a tick*
Tick control: Ticks can be controlled by natural means or by the use of chemicals.

Natural control methods include pasture rotation which minimizes or eradicates infestation by ticks.

Pasture rotation excludes the host from the pasture at the time when the larvae appear. This exclusion results in the death of the larvae.

Extreme temperature changes, may also kill ticks. In moist conditions, some fungi parasitize ticks and kill them.

Ticks can also be controlled artificially by spraying and dipping cattle in an ascaricide solution, e.g., sevin.

Spraying: Cattle can be sprayed individually with a knapsack sprayer or by using the spray race.

When spraying, care should be taken to ensure that the chemical does not get into the eyes. Pregnant cows should not be allowed in a spray race or cattle dip.

(a) Hand spraying cattle
**Round worms**: Round worms are the most common intestinal worms. They live and breed inside of the animal. They lay eggs which are passed out, hatched and developed into the infective little larvae which climb to the blades of grass. The grass is ingested by the cow and the life cycle in the life of the intestinal round worm is repeated.
Round worm in cattle results in scouring. The droppings become softer and is watery, at times soiling the tail and hind quarters.

The cow shows signs of ill-health and is not alert and active. The coat is dull and ruftled, and there is a loss of appetite. In dairy cows, the milk production drops.

Round worms are usually controlled by resting and spraying infected pastures. Deworming is also practised, and it is a preventative measure.

![Round worm](image)

*Figure 3-21 Round worm*
Exercises

1. Explain the meaning of each of the following:
   - mating
   - ovulation
   - embryo
   - oestrus
   - lactation

   parturition
   - milk let down
   - oestrus cycle
   - pregnancy
   - oxytocin

2. List four breeds of cattle suited for the Caribbean and describe each of them.

3. What are some of the new techniques used in breeding cows? Explain the advantages to be derived from the use of each.

4. Write short notes on:
   - Vaccination
   - Castration
   - Dehorning

   - Deworming
   - Milking cow
   - Killing percentage

5. List five diseases of cattle and explain what systems a cattle farmer should put in place to prevent and control diseases on his farm.
4. **SHEEP AND GOATS**

Sheep and goats are reared in Guyana and the Caribbean mainly for their meat. Other products which are not in very high demand in this region are skimmed milk, manure and wool.

In Australia, sheep are reared mainly for their wool, while in Europe, goats are reared primarily for their milk.

*Figure 4-1 External features of a sheep*

*Figure 4-2 External features of a goat*
Table 4.1 External features of a goat

<table>
<thead>
<tr>
<th>1. mouth</th>
<th>8. breast</th>
<th>15. dew claw</th>
<th>22. hind leg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. muzzle</td>
<td>9. shoulder</td>
<td>16. hoof</td>
<td>23. tail</td>
</tr>
<tr>
<td>3. nostril</td>
<td>10. top of shoulder</td>
<td>17. udder</td>
<td>24. hip</td>
</tr>
<tr>
<td>4. forehead</td>
<td>11. back</td>
<td>18. teat</td>
<td>25. loin</td>
</tr>
<tr>
<td>5. ear</td>
<td>12. ribs</td>
<td>19. rump</td>
<td>26. fore flank</td>
</tr>
<tr>
<td>6. eye</td>
<td>13. belly</td>
<td>20. thigh</td>
<td>27. rear flank</td>
</tr>
</tbody>
</table>

These animals feed on a wide range of forage and can survive where little herbage is available. They are therefore ideal for the conditions in this region where lush pastures are not readily available.

**TYPES AND BREEDS**

![Texel](image1)
![Black Head Persian](image2)
![Barbados Blackbelly](image3)

*Figure 4-3 Sheep breeds*
Sheep belong to the group of animals known as **Ovidae**, while goats belong to the group called **Capra**. Like cattle, they are ruminants and can be classified into three basic types:

- Wool
- Meat
- Milk

Some breeds of sheep are:

- Texel
- Barbados Blackbelly
- Black Head Persian

**BREEDS OF SHEEP**

**The Texel**: This is a white faced breed of sheep with no wool on the head or legs. The breed is characterized by a distinctive short, wide face with a black nose and widely placed, short ears with a nearly horizontal carriage. These sheep also have black hooves. The most outstanding feature of the texel breed is its remarkable muscle development and leanness.

**Barbados Blackbelly**: This breed was developed in Barbados. Blackbelly sheep range in colour from light tan to a dark mahogany red, with black stripes on the face and black legs, belly, inguinal region, chin, and chest, which gives this herbivore its name. The ears point forward and are black with white margins.

Both male and female are polled. The rams have a characteristic mane extending from the neck to the brisket. This is a very prolific breed. It can be bred twice a year.

The breed is noted for giving birth to twins.

**The Black Head Persian**: This breed originated in Somalia (Africa) and was introduced into the
Caribbean.

It is a large fat-rumped sheep having a pale coat with a fine woolly under coat. Its colour is white or light brown except for the head, neck and feet which are dark brown to black. It is polled with long legs, semi-lopped ears and a well-developed dewlap. The tip of the tail is thin.

Some breeds of goats are:

- Anglo Nubian
- Toggenburg
- Saanen
- Alpine

**BREEDS OF GOATS**

The **Anglo Nubian**: This breed originated in India, Ethiopia and Egypt, but was perfected in England. It has characteristically long large drooping ears and a convex shaped face. The hair is short and fine with colours ranging between black, dark brown or tan, with or without white markings. It is the largest of all the recommended breeds and gives the best quality milk, which is high in butter fat.

The **Saanen**: This breed originated in Switzerland. The colour ranges from pure to creamy white. The breed is susceptible to skin cancer, under tropical conditions. It is the highest producer of milk among goats.
The Toggenburg: This breed originated in Switzerland. The colour is brown or chocolate, with a light stripe down each side of the face. The legs below the knees and hocks are light grey or white. They are very quiet animals with an extremely pleasing appearance.

The Alpine: There are four main types of Alpines.

The French Alpine which ranges from pure white to pure black, with white spots on the neck, legs and underneath the body, if the animal is not white.

The Swiss Alpine, from Switzerland, has a rich brown colour, with black markings.

The Rock Alpine was developed in America from Swiss goats and pure French Alpine rams. They resemble the French Alpine in colour.

The British Alpine resembles the Toggenburg facially, but is black instead of brown.

MANAGEMENT OF SHEEP AND GOATS

Sheep are easier to control and restrain than goats. The latter are much more active and require freedom of movement to maintain good health. Both classes of livestock can be reared under the semi-intensive system which allows for better development and productivity.

Figure 4-5 A goat foraging
BREEDING AND REPRODUCTION

Male goats may be ready for servicing as early as 5 - 6 months old, but under a semi-intensive system, they are not used for breeding until they are 12 months old. The females also experience very early oestrous (4 - 6 mths) but are not allowed to mate until 9 - 12 months old.

There are great similarities in the stages of the reproductive cycles of both sheep and goats.

Similarities in stages of reproductive cycle

<table>
<thead>
<tr>
<th>Age of puberty</th>
<th>5 – 6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of mating</td>
<td>10 – 12 months</td>
</tr>
<tr>
<td>Duration of Oestrus</td>
<td>24 - 36 hours</td>
</tr>
<tr>
<td>Gestation Period</td>
<td>145 - 153 days</td>
</tr>
</tbody>
</table>

SHEEP BREEDING

Under good management, the male sheep (ram) can service between 20 - 30 ewes.

Two rams should be allowed to run with 50 ewes. For good reproductive performance, older rams should be allowed to mate with young ewes, and young rams with older ewes. Rams should be kept with their ewes for about 50-60 days, so as to ensure that the ewes are pregnant.

Before maturity, the ewes that are not required for mating should be removed from the flock.

Farmers should select only mature, healthy animals. Breeding rams should be vigorous with good hind legs and prominent testicles.

Ewes meant for breeding should show good udder development. They should also have strong legs. About two weeks before breeding, ewes should be put on good pastures or should be provided with high protein concentrate. This practice is called flushing and is practised to ensure a high percentage of twinning and a good crop of lambs.

Pregnant ewes are separated from the rams about 2 - 3 months into pregnancy. After birth, the lambs are allowed to run with their mothers until weaning. Weaning is done around 2 - 3 months of age.
Male lambs not wanted for breeding can be castrated at age 4-6 weeks. The breeding programme is sometimes designed to produce lamb crops in two years. Twinning percentage is a measure of the frequency with which both sheep and goats produce twins. Twinning depends on the breed, the level of nutrition, the age of the ewes and how much the male and female, selected for breeding, conform to the genetic potential of their parents.

![Breeding goat](image)

**Figure 4-6 Breeding goat**

**GOAT BREEDING**

Under semi-intensive management, male goats (bucks) are not used for mating until they are 12 months old. The females should also be mated at the same age even though they would be ready earlier. One buck can serve up to 20 does.

The doe is served after 12 hours from the start of oestrus which lasts for about 24 - 36 hours.

Her feed can be reduced gradually. After giving birth, the kid is allowed to run with the mother. If it is a dairy goat, the kid is separated from the mother after one week and feeding is controlled. It is fed whole milk or milk substitutes at body temperature.

On the other hand, if the mother is not used as a dairy goat, the kid is not weaned until 3-4 months old. At 3 weeks the kid should be introduced to grass or starter rations. Clean fresh water and minerals should also be provided.
MILKING GOATS

Goat’s milk is not widely used by people in the region. The lactation period of the doe lasts for 180 - 230 days with a total yield of up to 400 kg.

Milk production increases to its peak at 6 - 8 weeks after which it declines.

HOUSING SHEEP AND GOATS

Sheep and goats may be reared intensively, semi-intensively or extensively. Usually in these parts, sheep and goats are reared for their meat. Owing to our weather conditions and abundant vegetation, the system most used is the semi-intensive. The animals graze freely in the open pastures during the dry season and are kept indoors at night and during the wet season.
These are very small animals and do not require very elaborate housing. Houses should be covered, well ventilated and have facilities for feeding, watering and mineral licks.

The floor of the pen should be wooden, raised about 0.5 metres from the ground

**FEEDS AND FEEDING**

Generally, sheep and goats maintain themselves by grazing unimproved pastures containing a wide variety of vegetation which include grasses, legumes and shrubs. Goats feed on a wide range of vegetation.

Commercial rations like starter and growing rations, rice bran and soya bean meal are used to supplement the grazing. The feed can be supplemented with about 1kg of a mixture of cereal and soya bean meal in equal parts daily.

![Diagram of feeding goat/sheep](image-url)

*Figure 4-9 Feeding goat/sheep*
**DISEASE AND PEST CONTROL**

Sheep and goats are affected by similar diseases and parasites.

Those diseases include:

- Mastitis
- Foot rot
- Scouring

The pests include:

**Table 4.2 Internal and external pests of sheep and goats**

<table>
<thead>
<tr>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape worms</td>
<td>Screw worms</td>
</tr>
<tr>
<td>Lung worms</td>
<td>Liver flukes</td>
</tr>
<tr>
<td>Round worms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mites</td>
</tr>
<tr>
<td></td>
<td>Lice</td>
</tr>
<tr>
<td></td>
<td>Ticks</td>
</tr>
</tbody>
</table>

**DISEASES**

**Mastitis:** This is a bacterial infection of the udder and teats. The infected quarter or quarters become swollen and painful to touch. The milk is watery with clots of blood. Body temperature rises and the milk yield drops. The same symptoms and signs are observed in cows.

**Prevention and treatment**

- Keep animals and pens clean.
- Use disinfectant to treat all wounds on the udder promptly.
- Milk healthy animals before milking infected ones.
- Use warm application and gently milk non-infected quarters.
- Inject infected teats with antibiotics.
• Get rid of infected milk.

• Use clean equipment for milking.

**Foot Rot**: This disease is prevalent among sheep and goats that are reared in damp pastures. It is a fungal infection which causes the animal to have difficulty in walking. This results in the animal being unable to feed itself well.

**Prevention and treatment:**

• Provide dry housing and pastures

• Keep the feet in good condition - infected feet should be washed, cleaned and the diseased tissue cut away.

• The area should be treated with a 10% formalin or 30% copper sulphate solution.

• Treated animals should be kept indoors until the condition is over.

*Figure 4-10 Mastitis*

*Figure 4-11 Attending to foot rot*
**Scours or Diarrhoea**: Scours or diarrhoea in goats often results from heavy infestation of the stomach and intestines with harmful bacteria, coccidia and/or worms. These organisms damage the walls of the digestive tract and cause bleeding and digestive disorders.

Scours or diarrhoea also results from the eating of stale mouldy food or very young grass.

**Prevention and treatment**

- Frequent deworming
- Keep stock away from food that is stale or mouldy and grass that is too young and succulent

**INTERNAL PARASITES**

These are parasites living inside the body of the animals. Tapeworms, roundworms, lung worms and liver-flukes infest different internal organs of the animals. These organs include the stomach, intestines, liver and lungs.

Internal damage is done and the animal suffers from diarrhoea, anaemia, loss of hair, loss of condition and general weakness.

**Prevention and treatment:**

- Good sanitation and feeding prevent the animals from becoming susceptible to these parasites.
- Rotational grazing reduces the build-up of any infestation in the pastures.
- Regular deworming with drugs such as Miliven, being administered in the feed, should be carried out.
EXTERNAL PARASITES

These parasites live on the outside of the animals.

**Ticks:** These suck the blood of the animals and cause anaemia. When ticks bite an animal, they cause irritation which results in an itch. Itching causes restlessness and damage to the skin of the animal. These lesions are openings for other external parasites.

**Prevention and treatment:**

- Ticks can be treated with tickicide, e.g., Bercotox.
- Rotational grazing also controls the infection by ticks in pastures.

**Lice:** These can be spread by contact and infected animals become itchy and restless. They rub themselves against trees and fences causing damage that can lead to secondary infection.

**Prevention and treatment:**

Lice can be treated in the same way as ticks by:

- Dipping, spraying or dusting with an appropriate chemical.
**Screw worm:** These are common among most classes of livestock. The larvae are derived from eggs laid by the screw worm fly. These eggs are laid at the edge of fresh wounds or sores (lesions). The maggots then enter the wounds, where they feed on the tissues of the animals causing the wound to become more severe and to give off a foul odour.

**Prevention and treatment:**

The maggot must be picked out and the wound should be thoroughly cleaned and disinfected.

A screw worm spray can be sprayed into the wound to control any further attack.

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**Figure 4-13 Life cycle of a louse**

**Figure 4-14 External parasites**
Exercises

1. List the characteristics of any three breeds of sheep and goat.

2. List three advantages of rearing sheep and goats in Guyana.

3. Describe how you will manage sheep or goats under the headings:
   - Housing
   - Breeding
   - Feeding

4. (a) Name two diseases of sheep and goats. Explain in detail how the named diseases can be controlled.
   (b) Identify one example of an internal and external parasite. State how each can be controlled.
This chapter deals with the preparation and marketing of meat, milk and eggs. These foods have a relatively high protein content. The demand for them on the market is increasing. Livestock farmers are increasing the production of these commodities to satisfy this high demand. In so doing, they must know what consumers need if their produce are to meet these requirements. Preparation therefore, must start on the farms where farmers strive to produce healthy animals of the right type. Animals for meat production are expected to gain the desired weight in the shortest possible time, since older animals produce tougher meat and, in some cases, the meat has too much fat. Dairy animals must produce a large quantity of milk with an acceptable level of butterfat. Hens must produce eggs of standard size daily. The main objective of preparation of livestock produce is to offer consumers commodities which are clean, wholesome, disease free and unadulterated. To achieve this, other preparational processes must be done in hygienic environments.

**PREPARATION OF MEAT**

Preparation of meat for marketing may be done by the farmer. He or she may sell the animals alive to butchers who will take care of the slaughtering, dressing, cutting and marketing processes. Butchers purchase healthy animals on the basis of their expected dressed weight.
Table 5.1 Popular meats on the market

<table>
<thead>
<tr>
<th>Name of animal</th>
<th>Name of meat</th>
<th>Approximate age at slaughter</th>
<th>Approximate weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>cattle</td>
<td>beef</td>
<td>16 to 24 months</td>
<td>500-600 kg</td>
</tr>
<tr>
<td>Pig</td>
<td>pork</td>
<td>to 8 months</td>
<td>54 to 60 kg</td>
</tr>
<tr>
<td>Sheep</td>
<td>mutton</td>
<td>to 8 months</td>
<td>40 to 60 kg</td>
</tr>
<tr>
<td>Goat</td>
<td>chevon</td>
<td>6 to 8 months</td>
<td>40 to 60 kg</td>
</tr>
<tr>
<td>Fowl</td>
<td>chicken</td>
<td>2 months</td>
<td>1.75 to 2 kg</td>
</tr>
<tr>
<td>Duck</td>
<td>duck</td>
<td>2 months</td>
<td>3 to 5 kg</td>
</tr>
<tr>
<td>Rabbit</td>
<td>rabbit</td>
<td>2 months</td>
<td>2 to 2.5 kg</td>
</tr>
</tbody>
</table>

Before slaughtering, animals are taken to holding pens at an abattoir where they will be provided with much water to drink, but no food for 18 - 24 hours, before the time of slaughter. This practice does not reduce the carcass weight significantly and carcasses are easier to dress since the stomach will be empty. During this period of quarantine, animals for slaughter are examined by a qualified Animal Health Inspector, Livestock Assistant or Veterinary Surgeon to ensure that they are healthy and non-pregnant. When sick animals are recognized, they are removed, so as to avoid unnecessary contamination of workers and their equipment in the slaughter room. Such an examination is called an ante-mortem examination after which a permit to slaughter will be issued to the butcher. This exercise has legal implications since charges can be brought against butchers who do not comply with the regulations.

At the time of slaughter, proper slaughtering procedures must be used, if meat presented for sale is to be free from bloody tissues, damaged tissues and foreign particles. The meat preparation process involves restraining the animals, slaughtering, dressing and chilling. The importance of proper control of animals cannot be over emphasized since animals are subject to severe injury on their way to the
killing room.

The popular method of slaughtering meat animals is by "sticking". During this process, large animals are shackled with the hind legs attached to overhead rails and the ventral part of the body facing the worker. Pigs are positioned on their sides on large concrete tables. In both cases, the slaughterer sticks a knife into the hollow portion of the neck just above the chest bone. He/she then, severs the main arteries and veins in the neck and allows the animal to bleed out. "Sticking" should be done so quickly that animals must be unaware and unconscious of the entire process.

Birds to be slaughtered are placed in killing cones which restrain them and expose the necks which are rapidly cut off, allowing their carcasses to bleed out.

The trend of slaughtering today is towards humane methods where animals are made unconscious immediately before slaughter. Several stunning devices are used to render animals unconscious. The electrical knife is used on birds. Enough current passes through the brain to stun the animal in a very short period of time. The head is then cut off and bleeding occurs.

Carbon dioxide gas has an anesthetic effect on animals. Pigs for slaughter are driven on to a moving floor which takes the animals into a tunnel-like room which has about 65% to 85% of the gas. The speed at which the floor travels exposes pigs to the gas for about 50 - 90 seconds so that they emerge from the room relaxed, unconscious and ready for bleeding. Bleeding must be done immediately since animals can regain consciousness in only a few minutes.

The captive bolt method has been used on larger animals. The bolt is pushed forward by the discharge of a blank cartridge. The animal is stunned by the blow on the head. The bolt should not penetrate the skull because the brain will be contaminated with bones, hair, dust and other foreign particles.

After slaughter, ruminants and rabbits are skinned. Pigs are scalded in a scalding vat which contains water at 65°C-71°C. They are then scraped immediately. Birds are scalded in water at 64°C to loosen the feathers which are later plucked by hand or machine.
The next stage of preparation is dressing the carcass. With the exception of poultry, a long cut is made ventrally (along the belly) from chest to hind legs to expose the internal organs.

Care must be taken not to cut the intestine. All the internal organs and other structures are removed from the chest and abdominal cavities.

The shanks, head and tail are removed from the carcass which is halved by splitting the vertebrae (back bone). Carcasses, at this stage, are displayed for post-mortem inspection by the Public Health Inspectors. Meat acceptable for human consumption is stamped after inspection. Diseased or unfit carcasses and/or parts are condemned by the Public Health Inspector and in whose presence they are destroyed.

The Public Health Inspectors also ensure cleanliness of the environment and presence of facilities for hygienic meat preparation, e.g., a reliable supply of potable water, electricity and good drainage system. In dressing birds after slaughter, the carcass is washed, feet are removed and a cut is made down the skin at the back of the neck. The neck is cut off at the point where it meets the back. The crop is then removed.

A horizontal cut is made below the tip of the keel bone to expose the intestines. Two fingers are used to remove the internal organs from the body cavity. Care is taken not to spill the contents from the intestines into the body cavity. The carcass is flushed clean with water and is displayed for inspection.

Chilling is the cooling of carcasses to a temperature of about 2.2°C - 4.5°C (37 °F - 40°F). Carcasses are usually hung up at room temperature for about 2 hours before chilling. Quick chilling of carcasses is done to check and prevent the growth of spoilage organisms on the meat. The actions of enzymes in the meat also slow down during chilling and this prevents sour meat. Chilling should be done for about 24 hours before the carcass is cut up.
Figure 5-1 (a) Dressed birds ready for refrigeration

(b) Birds packaged and ready for sale in a chilled cabinet
MARKETING MEAT

Meat is marketed according to consumer demand. Consumers require cuts of meat from specific areas of the carcass for different purposes. Butchers must know the parts of each type of carcass and must be able to make definite cuts, if they are to market meat in the right shape and size.

CUTS OF BEEF
The halved carcasses are quartered by cutting through between the 12\textsuperscript{th} and 13\textsuperscript{th} ribs. Butchers, according to consumer requirements, cut up the quarters into wholesale cuts and retail cuts. Study Fig 5.1

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{beef_cuts.png}
\caption{(a) Beef carcass halved \hspace{1cm} (b) Wholesale and retail cuts of beef}
\end{figure}
The main wholesale cuts with the corresponding retail cuts are given in the table below:

**Table 5.2 Cuts of beef**

<table>
<thead>
<tr>
<th>Wholesale cuts</th>
<th>Retail cuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>round steak</td>
<td>round steak, top round steak, bottom round steak, heel of round, ground beef, hind shank</td>
</tr>
<tr>
<td>rump</td>
<td>rolled rump, rump roast</td>
</tr>
<tr>
<td>loin end</td>
<td>sirloin rump, rump roast</td>
</tr>
<tr>
<td>short loin</td>
<td>porter house steak, T-bone steak, club steak</td>
</tr>
<tr>
<td>flank</td>
<td>flank steak, rolled flank, flank stew, flank stew, flank steak fillet</td>
</tr>
<tr>
<td>rib</td>
<td>standing rib roast, rolled rib roast, rib steak</td>
</tr>
<tr>
<td>plate</td>
<td>plate boiling beef, rolled plate, short ribs</td>
</tr>
<tr>
<td>brisket</td>
<td>beef brisket, corned beef</td>
</tr>
<tr>
<td>shank</td>
<td>knuckle soup bone, cross cut foreshank</td>
</tr>
<tr>
<td>chunk</td>
<td>blade steak, blade pot roast, triangle pot roast, shoulder fillet, rolled neck, boneless neck, arm steak, arm pot roast</td>
</tr>
</tbody>
</table>
CUTS OF PORK

Butchers place the half carcass on its side on the table with the bone side up and feet towards them. The bold lines in Fig 5.3 (a) show the positions of the cuts in producing wholesale cuts. The order of cuts is as follows:

- shoulder
- clear plate
- loin and back fat
- neck bone
- fore shank
- spare ribs and belly
- jowl
- ham
The main wholesale cuts are the loin, ham, side and spare ribs, butt, picnic and jowl.
CUTS OF CHICKEN

The main cuts of chicken are legs, breast and back. The most expensive of these are the legs and breast. Chicken may also be marketed alive or as whole dressed and frozen in which case the following classes of market chicken may be established:

- **Fryers and broilers** - young chickens which are below 12 weeks of age; the meat is tender with soft, pliable smooth-textured skin and flexible breast bone cartilage.

- **Roasters** - young chickens under 8 months of age; the meat is tender with soft, pliable, smooth-textured skin but the breast bone cartilage is not as flexible as that of broilers.

- **Stags** - male chickens under 10 months of age with toughened, dark flesh, coarse skin and hard breast bone cartilage.

- **Capon** - castrated male chickens under 10 months of age which have tender meat with soft pliable smooth - textured skin.

- **Hen** - stewing chicken or fowl is a mature female chicken, more than 10 months of age, with toughened meat and hard breast bone.

- **Cock or old roaster** - a mature male chicken with coarse skin, toughened and darkened meat and hardened breast bone.

Generally, there is a high demand for cuts from the loin and hind quarters of the larger carcasses. These cuts are more expensive than the other cuts. Cuts taken from muscle tissues, that do relatively little work for the animal when it is alive, are tender and understandably the most expensive. Examples of very expensive cuts are fillet, sirloin and loin. Round steak and chuck are cheaper cuts while flank, plate and side are some of the cheapest cuts of meat.

Other factors which cause the price of meat to lower are:

- too much of fat (in pig and chicken). In beef when fat is spread uniformly through the meat, it is known as marbling and the cuts are costlier.

- dark colour of meat (sticky and labby),

- too many connective tissues (stringy)

- old animals (tough muscle fibres).

After cutting, meat is packaged for storage at a temperature of 9.4°F
PRESERVATION OF MEAT

Methods of preserving meat are curing, drying, smoking, canning and refrigeration. Meat is preserved to weaken or destroy the undesirable micro-organisms and enzymes so that spoilage is reduced considerably.

CURING

There are two main methods of curing - pickle cure (or wet cure) and dry cure. The main ingredient is common salt. When salt petre (sodium nitrate) is used, it preserves the meat as well as improves it colour and flavour. Vinegar and spices are usually added to enhance the flavour of the meat. In wet cure, a concentrated salt solution (called pickle or brine) is made and the meat is immersed in it.

In dry cure, the pickle is pumped into the arteries of the meat or it is spray pumped onto the meat. This method is used in ham production.

DRIYING

This process is used to reduce most of the moisture in the meat tissues. It creates an unfavourable environment for the growth of spoilage organisms. Salt can be rubbed on the surface of the meat which is later allowed to dry in the shade.

SMOKING

Meat is exposed to wood smoke. The smoke kills bacteria and prevents the growth of other spoilage organisms. It also slows up the action of fat becoming rancid and adds flavour to the meat. Smoking sometimes is used together with drying and curing.

CANNING

By this method, meat previously processed by curing, smoking or cooking may be packed with salt solution into specially designed aluminium cans which are then heated to remove the air therein before they are sealed. The vacuum created in the tin slows up growth of micro-organisms. Tins labelled "Perishable" must be kept under refrigeration.
REFRIGERATION

Meat frozen quickly to a temperature of -26.1°C can be kept in storage for a long time, if the supply of electricity is continuous. At this temperature, the meat appears to retain its colour after thawing. Refrigeration at this temperature freezes meat and bacterial growth is suppressed so that spoilage is delayed. It is advisable to start this process as soon as possible after slaughter. Frozen meat should not be placed on racks in a warm room to be defrosted since the surface meat can begin to spoil before the interior parts of the cut are fully defrosted. Frozen meat should be placed in a large container of circulating water with temperature up to 32.2°C.

PREPARATION OF MILK

Milk is the fluid produced by the secretory cells of mammary glands. For consumers, it is the white emulsion which contains proteins, carbohydrates, fats, minerals and vitamins. It should be free from colostrum flakes, blood and other abnormalities. Milk is withdrawn from dairy animals during the process of milking, whereby it is removed from the gland and teat cisterns after successful milk let down. Consumers require milk of high quality so it must be clean, of good flavour and must contain very low levels of bacteria.

In order to achieve and maintain this quality, the milking process is highly organised and done in an environment that is hygienic. Farmers have to ensure that dairy animals are healthy (that is, free of brucellosis, tuberculosis, mastitis and other diseases). Healthy cows produce milk with very low levels of bacteria. The objective is to prevent contamination of milk and to inhibit the growth of bacteria present so that spoilage does not occur. The bacteria present in the milk feeds on lactose (milk sugar). Lactose is changed to lactic acid which curdles milk.

Before milking the animals, equipment and the milking parlour must be thoroughly washed so as to reduce the level of contamination with foreign particles, e.g., dirt, faeces or hair. These particles provide a very good medium for bacterial growth which results in spoilt milk. Milking equipment should be sterilized to get rid of micro-organisms. Seamless containers are easier to keep clean. The milker should be spotlessly clean, free from contagious diseases and suitably dressed in white overalls, cap and clean boots. Hands should always be clean. Nails should be kept short and clean.
After milking, milk should be strained and cooled to about 4°C or less. It should be held at this temperature. Low temperatures of milk stop the growth of bacteria so lactic acid is not produced to curdle the milk. Alternatively, milk may be heated to increase its ability to be kept for a limited period of time which will allow for processing or distribution and sale to consumers. By heating, some bacteria are destroyed. Milk must now be transported quickly and under ideal conditions to prevent recontamination.

MARKETING MILK

Before milk is marketed, tests can be done to ensure that it is of very high quality. Popular tests are the Methylene Blue Test for the level of bacteria and the solid Non Fat test which indicates how dense the milk is. These tests are carried out on farmers' milk before it is sold for processing. However it is not usually done when farmers sell their milk on the farm or retailed to customers at their homes. Milk of poor quality is rejected by the buyers and farmers suffer great loss. Processed milk such as pasteurised milk is more expensive than fresh milk sold by farmers on the farms.

PROCESSED MILK

The main purpose of processing milk is to destroy harmful bacteria. Table 5.3 shows grades of milk and the method of processing.
### Table 5.3 Milk and methods of processing

<table>
<thead>
<tr>
<th>Grades of Milk</th>
<th>Definition</th>
<th>Method of Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated milk</td>
<td>Milk which has not undergone any form of heat treatment.</td>
<td>Milk is strained and may be cooled on the farm. Sold as fresh milk.</td>
</tr>
<tr>
<td>Homogenized milk</td>
<td>Milk processed to break up fat globules and scatter them evenly throughout the milk so that they do not float on top.</td>
<td>Warm milk is forced through very tiny valves so that the fat globules break up into tiny globules and are evenly scattered in the milk. Fat does not float to the top.</td>
</tr>
<tr>
<td>Pasteurised milk</td>
<td>Milk which has been mildly heated to destroy disease causing bacteria.</td>
<td>Milk heated to 72 °C for 15 seconds, then rapidly cooled to 10°C or below. It is then bottled and sealed.</td>
</tr>
<tr>
<td>Ultra Heat treated milk (UHT)</td>
<td>Homogenized milk which has been subjected to a very high temperature.</td>
<td>Milk heated to 132°C for 1 second, destroying microorganisms without producing undesirable chemical changes that would affect flavour</td>
</tr>
<tr>
<td>Sterilized milk</td>
<td>Homogenized milk which has been treated in the bottle and vacuum sealed. The taste of the milk is expected to change and most of the Vitamin B and C destroyed but the milk can be kept for several months.</td>
<td>Pre-heated, homogenized, bottled and sealed. The filled sealed bottles are then heated to 104°C for 20 - 30 minutes and allowed to cool.</td>
</tr>
</tbody>
</table>

Other forms of milk products marketed:

- Skimmed milk - milk with butter fat removed, it is sold in the liquid or powdered form
- Evaporated milk - fluid milk with the water level reduced
• Condensed milk - evaporated milk, sugar added
• Dried powdered milk - full cream or skimmed milk with the water removed

Some products made from milk are ice-cream, butter, cheese, ghee, health beverages and cakes

PREPARATION OF EGGS

Generally, consumers require fresh eggs of a very high quality. Eggs are of best quality soon after they are laid by the hens. To ensure that the best quality eggs are marketed, the following measures should be practised:

• Feed suitable rations with minerals and grit to laying hens.
• Provide clean nesting materials.
• Gather eggs from the nesting boxes frequently.
• Clean dirty eggs and keep them in a cool place with a temperature of 18°C to 21°C and a relative humidity of 18.3% - 21.1%.
• Candle eggs, to check for meat and blood spots.
• Separate eggs into small, medium and large sizes.
• Pack eggs carefully and market immediately.

On the large markets, the external and internal qualities of table eggs are of great importance. The external qualities are measured by shell quality, cleanliness, shape, colour, size and weight.

SHELL QUALITY

Eggs should have strong sound shells which must be attractive and even. Cracked, hair-line cracked or broken eggs are rejected. Eggs with chalk heads and sand heads are disqualified.

CLEANLINESS

Egg shells should be clean. Dirty and contaminated egg shells are rejected.

SHAPE AND COLOUR

A normal egg is oval shaped. Very round or very long eggs must not be selected because of
transportation problems. Abnormal shaped eggs are also rejected. They do not fit well into the egg flats and are easily broken. An even shell colour adds to the attractiveness of the egg. Some consumers have special preferences for either white shell or brown shell eggs.

SIZE AND WEIGHT

Eggs must be uniform in size. Double yolk and extremely large eggs are rejected because of transportation problems. Egg weight is important in grading eggs by weight. This system allows eggs of similar weight to be put in a particular class for market.

INTERNAL QUALITIES

The internal qualities of eggs are measured by the (i) size and condition of the air space, (ii) condition of the yolk and egg white (albumen) and the (iii) presence of blood and meat spots or other abnormalities in the egg white. These qualities can be assessed by the use of a candler which is used to see the egg against a light in a darkened room. The following checks are made during candling:

Table 5.4 Quality check of eggs

<table>
<thead>
<tr>
<th>Quality Checked</th>
<th>Accepted eggs</th>
<th>Rejected eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>egg shell</td>
<td>whole</td>
<td>hair crack, thin</td>
</tr>
<tr>
<td>air space</td>
<td>1 cm - 1.5 cm, fixed</td>
<td>1.5 cm or more, loose</td>
</tr>
<tr>
<td>yolk</td>
<td>firm, well centred, free from blood and meat spots</td>
<td>loose at the side</td>
</tr>
<tr>
<td>egg white</td>
<td>clear, thick, firm</td>
<td>blood and meat spots</td>
</tr>
</tbody>
</table>
Table 5.5 Grading of eggs

<table>
<thead>
<tr>
<th>European</th>
<th>American</th>
<th>African</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>Weight</td>
<td>Size</td>
</tr>
<tr>
<td>1</td>
<td>70g and above</td>
<td>jumbo</td>
</tr>
<tr>
<td>2</td>
<td>60g to 70g</td>
<td>extra large</td>
</tr>
<tr>
<td>3</td>
<td>60g to 65g</td>
<td>large</td>
</tr>
<tr>
<td>4</td>
<td>55g to 60g</td>
<td>medium</td>
</tr>
<tr>
<td>5</td>
<td>50g to 55g</td>
<td>small</td>
</tr>
<tr>
<td>6</td>
<td>45g to 50g</td>
<td>pee wee</td>
</tr>
<tr>
<td>7</td>
<td>45g and below</td>
<td></td>
</tr>
</tbody>
</table>

**PRESERVATION, STORAGE AND MARKETING OF EGGS**

Treatment to egg shells prevents the evaporation of moisture from the egg content, during hot weather conditions. Eggs may be dipped or sprayed with light mineral oil which is colourless, odourless and tasteless.

Eggs may be marketed in the liquid form as frozen eggs. Machines have been designed to break eggs and separate the albumen from the yolk, so that consumers may purchase liquid eggs as whole eggs or either the albumen or the yolk to suit their specific purpose. Before freezing, eggs should be pasteurized. This is done by raising the temperature to 60°C for 3.5 minutes. This process destroys micro-organisms which would have multiplied and spoiled the eggs.

Eggs may also be purchased in the dry state for making cake mixes, sweets and meringue powders. The liquid egg is first clarified of bits of egg shell, then pasteurized and preheated. It is then pumped...
under pressure through nozzles and released into a large room where it is exposed to a stream of hot air. The moisture evaporates from the liquid egg causing the fine powder to fall to the floor. It is cooled, packed and sealed in containers.

Exercises

1. Study Figure 5.3 b and list the retail cuts from each wholesale cut.

2. Name and describe any method used in meat preservation.

3. Explain the process of pasturisation in cow’s milk

4. What is:
   (a) untreated milk
   (b) homogenised milk
   (c) sterilized milk
   (d) ultra-heat treated milk?

5. Explain the process of candling.

6. What factors must be considered when eggs are being graded?
6. AGRICULTURAL INSTITUTIONS

AGRICULTURAL INSTITUTIONS IN GUYANA

There are institutions / agencies in Guyana that support the development of agriculture. The institutions are as follows:

- Developmental
- Training
- Research and Extension
- Financial

DEVELOPMENTAL INSTITUTIONS

The Ministry of Agriculture has five main areas of operation. These areas are:

- Crops
- Guyana Livestock Development Authority
- Fisheries
- Hydraulic Section
- Land and Surveys

CROPS

National Agriculture Research Extension Institution (NAREI) is governed by a board but is under the Ministry of Agriculture.

This section of the Ministry helps in extending to farmers new and improved planting techniques and materials that are obtained from research institutes.
GUYANA LIVESTOCK DEVELOPMENT AUTHORITY (GLDA)

This section collects information on improved techniques and extends these modern methods to farmers. It also provides services on Animal Health and Artificial Insemination. Under the GLDA falls the Government Veterinary Diagnostic Laboratory.

HYDRAULIC SECTION/ NATIONAL DRAINAGE AND IRRIGATION AGENCY

The Hydraulic Section takes care of all the sea defences, water conservancies, and drainage and irrigation schemes.

LANDS AND SURVEYS

The Lands and Surveys section is concerned with the distribution of land for agricultural purposes, among other activities. These lands are surveyed and classified before distribution.

FORESTRY

This area involves conservation of soil, the protection of the rain forest, maintenance of the eco-system, preservation of wildlife and the management of a reforestation programme.

FISHERIES

This department deals with the supervision of marine and inland fishing. It also deals with the issuing of license for off-shore and deep sea fishing.

The Ministry of Agriculture is also responsible for a number of developmental projects that are autonomous. These are:

- Drainage Rehabilitation Project.
- Mahaica-Mahaicony-Abary Agriculture Development Association (MMA/ADA).
The University of Guyana located at Turkeyen and Tain offers programmes in Agricultural Science and Forestry (currently Tain does not offer Forestry). Degree programmes are offered in:

- Agronomy
- Forestry
- General Agricultural Science
- Animal Science

These are four year programmes offered to persons who are suitably qualified. Persons who would have completed the Diploma in Agricultural Science at the Guyana School of Agriculture are given exemption of some courses.

These programmes consist of theoretical and practical work. The latter is often done in the field.

The Guyana School of Agriculture (GSA) is located at Mon Repos, East Coast Demerara. This Institution was opened on the 9th of September, 1963. In 1964, the institution became a corporation with the following objectives:

- to train persons in the theory and practice of Agriculture,
- to manage, develop and operate farms and undertakings of an agricultural nature to operate commercial farms and undertakings in accordance with good farming practices.

The school is operated by a Board appointed by the Minister of Agriculture to formulate policy and direct operations. It comprises a chairman and fifteen members.

The Guyana School of Agriculture offers two courses:

- Diploma in Agricultural Science; Animal Health
THE DIPLOMA COURSE

This is a course designed for graduates of secondary schools and trained teachers who, on graduating, will be expected to serve their country, either as agriculture field assistants or teachers of agriculture in schools. These graduates may also proceed on degree and other programmes at University level.

THE CERTIFICATE COURSE

This is a two year practice-biased course and is intended for youths with a full primary school education, who have attained the age of seventeen years. It is intended to equip young people for successful farming careers.

The Curricula for both courses include subjects in Pure Science and Social Science undertaken mainly in the first year.

In the second year students engage in Animal Science, Crop Science, Food Science, Microbiology, Plant Protection, Agricultural Mechanization and Extension Education.

SUBSIDIARY COURSES

Short vacation courses are also mounted to assist farm families in all the areas of production. The programme also provides for attachment of students on Work-study assignments.

PROGRAMME OF PRACTICAL WORK

Farm Activities

The School operates three (3) semi commercial farms at three different locations. The emphasis is on livestock, market garden, field and orchard crops.

The students engage in all aspects of production in each area and are expected to complete a minimum of eight (8) hours of practice work per week on the farms. This is done with adequate supervision and training.

LIVESTOCK FARM

Located about 0.8km from the main campus, the livestock farm occupies about 12 hectares and consists
of modern structures. It houses three main classes of livestock

- poultry
- swine
- dairy cattle

It is a viable enterprise and the most profitable aspect of the institution.

THE POULTRY SECTION

This has the capacity to accommodate 10,000 broilers and 10,000 layers. It is equipped with a mechanical egg-grader, a plucking machine and additional cold storage facilities.

THE SWINE SECTION

This section has adequate facilities for housing, farrowing and fattening pigs. The housing area is equipped with automatic waterers.

THE DAIRY SECTION

The animals are predominantly Holstein breed bulls and calves. There are well equipped calf pens and Stanchion type milk parlour.

BIO GAS UNIT

This unit utilizes some of the waste from the farm and provides energy for plucking and brooding by conversion of the waste to methane gas. The slurry from this process will be used as a fertilizer for the pasture and other farms.

MARKET GARDEN

This area of activities comprises the growing of green vegetables, mainly legumes and cherries.

FIELD AND ORCHARD CROPS
A carambola orchard was established by students in 1980. The produce is processed in the commercial fruit storage and processing facilities.

**SCIENCE LABORATORIES**

The laboratories are well equipped to meet the needs of all students and on-going expansion programmes. The Biology, Physics and Chemistry Laboratories are used mainly by first year students while the new plant and soil science sections are utilized mainly by final year students.

**MANAGEMENT AND FUNDING**

The Principal, who is also Deputy Chairman of the Board, Heads the Management Team in the day to day Administration of resources. The funds for the institution accrue from four sources.

- An annual government subvention fund for recurrent and capital expenditure
- Charges for boarding
- Revenue from farms and Food Processing Unit
- An Endowment Fund

Guyana School of Agriculture plays an active role in training students from overseas territories including Antigua, the Bahamas, Belize, Dominica, Grenada, Montserrat, St Kitts Nevis, St Vincent in the Caribbean area and Zimbabwe and Nigeria in Africa.

**RESEARCH INSTITUTIONS**

The National Agricultural Research Extension Institute (N.A.R.E.I) was established in 1985. The mission statement of this Institute is: "To advise on and develop technologies and systems for sustained Agriculture Development. This institution is governed by a committee of ten members who are under the direction of the Ministry of Agriculture. N.A.R.I was recently renamed N.A.R.E.I- National Agricultural Research and Extension Institute and takes on the same role as N.A.R.I with the inclusion of the extension component of the Ministry of Agriculture.

The main objective of this institute is to educate the farmers on the best methods of propagation and
systems of eradication of pests and diseases in crops.

Specially trained Extension Field Officers are engaged in field and laboratory experiments in the effort of gaining new techniques for improved varieties.

There are several stations or outstations with plant nurseries in all ten administrative regions.

Table 6.1 Below are the names and locations of N.A.R.E.I stations and outstations

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<thead>
<tr>
<th>ADMINISTRATIVE REGION</th>
<th>LOCATION</th>
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<tr>
<td>1</td>
<td>Santa Rosa</td>
<td>Nursery</td>
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<td>2</td>
<td>Charity Anna Regina</td>
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<td>N.A.R.E.I Timehri Kairuni</td>
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<td>Kato Paramakatoi Monkey Mountain</td>
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<td>St. Ignatius Annai</td>
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<td>nursery/outstation nursery/outstation nursery/ outstation</td>
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At Mon Repos there is a field research unit with the following sections:

- The Library
- The Plant Tissue Culture Laboratory The Weed Herbarium Laboratory The Soil Chemistry Laboratory
- The Plant Pathology Laboratory
- The Seed Technology Laboratory Entomology Laboratory
- Soil Survey Laboratory
- Field Equipment Maintenance Laboratory

**Burma Branch**

This is basically the research on rice for the production of improved and resistant varieties.

**LOCAL FINANCIAL INSTITUTION**

The Guyana Agricultural and Industrial Development Bank commenced operations on the 26th of May 1973. Its name was then the Guyana Co-operative Agricultural Development Bank. In 1978 the bank included an industrial section.

In 1994 the bank was merged with the then Guyana National Cooperative Bank, which became non-existent sometime later.

There is no specific bank that provides credit for agriculture, this task is now undertaken by commercial banks, Institute of Private Enterprise Development (I.P.E.D) and small business enterprise.

**SOME OBJECTIVES OF LENDING AGENCIES**

- To satisfy the demand for credit and related advisory services to producers in agriculture and other industries.
- To promote investment in development projects in agriculture and other industries to that aid in the economic development of Guyana.
• To assist in the development of Co-operative enterprises involved with agricultural and in industrial production of goods and services.

The banks have a special department that deals with the administration of loans to farmers. This department is referred to as the Agricultural and Industrial Credit Department.

THE AGRICULTURAL PROJECT UNIT

This department provides high level support to the Ministry of Agriculture in a number of areas, including policy analysis, sectorial and sub-sectorial monitoring, project cycle development, project monitoring, coordination of technical assistance and budget preparation.

REGIONAL INSTITUTIONS

REGIONAL FINANCIAL INSTITUTION

THE CARIBBEAN DEVELOPMENT BANK

This bank was established on November 18th, 1969 with an initial share capital of $100,000 T.T which was made up of contributions from the United States, Canada and some countries of the Caribbean.

The Objectives of the Bank

• To contribute to the harmonious growth and development of the member countries of the Caribbean.

• To promote economic cooperation and integration among those member countries having special and urgent regard for the needs of the less developed members of the region.

The Bank intends to achieve the above by pursuing the following tasks:

• assisting regional members in the coordination of their development

• mobilising within and outside the region additional financial resources for the development of the region

• financing projects and programmes contributing to the development of the region by providing appropriate technical assistance to its regional members, particularly by undertaking or
commissioning pre-investment surveys and by assisting in the identification and preparation of project proposals.

**REGIONAL RESEARCH INSTITUTION**

Caribbean Agricultural Research and Development Institute, (CARDI)

This organization is autonomous. It was established by the Governments of the Caribbean Community in 1975 to serve CARICOM member states. The Governing body is comprises of Ministers of Agriculture in all member countries.

The objectives of the institution are as follows:

1. to provide for the research and development needs of Agriculture for the region as identified in national plans and policies

2. to provide an appropriate research and development service to the agricultural sector of member states

3. to provide and extend the application of new technologies in production processing, storage and distribution of agricultural products of member states

4. to pursue for specified periods long term research in pertinent areas

5. to provide for the co-ordination and integration of the research and development efforts of member states where this is possible and desirable

6. to undertake teaching functions normally at the post-graduate level, limited to the development of the relevant research by any member state

7. to seek to achieve the optimum decentralisation of facilities.

**REGIONAL TRAINING INSTITUTION**

The University of the West Indies

In this University is a Faculty of Agriculture which offers graduate and under graduate training courses in Agriculture. It also conducts research, in collaboration with other local or regional institutions. It operates out-reach stations in several countries, and provides specific training for extension officers.
CARIBBEAN AGRICULTURE EXTENSION PROJECT

The goal of the Caribbean Agriculture Extension Project (C.A.E.P) is to improve the economic and social standards of small farms in the region.

This is done in a two-fold way:

- it increases the effectiveness of national, public and private sector extension systems in bringing about the adoption of improved practices and appropriate technologies by farmers in the Eastern Caribbean States
- it also improves the long term effectiveness of regional institutions to support national extension services as they become more farm oriented and market responsive.

REGIONAL MARKETING AND ADMINISTRATIVE INSTITUTION

CARIBBEAN COMMUNITY

The Caribbean Community was established on May 1, 1973 to replace the then existing Caribbean Free Trade Association (CARIFTA).

One of the major aims of the community is to create the conditions under which member states can increase their output of agricultural and manufacturing products and trade with each other. To implement this, a common trade policy has been adopted by the area.

Members of the community do not charge duty on imported goods which originate from other CARICOM countries. The same duty is charged by all members on all goods imported from outside of the community.

INTERNATIONAL AGRICULTURAL INSTITUTION

The Inter-American Institute for Co-operation on Agriculture (I.I.C.A) is the specialized Agency for Agriculture of the Inter-American System. This Institute was founded on October 7, 1942, when the Council of Directors of Pan American Union approved the creation of the Inter-American Institute for
Agricultural Sciences.

I.I.C.A was formerly intended to be an institution for Agriculture Research and Graduate Training in Tropical Agriculture. However, the institute gradually changed to an Institution for Technical Co-operation and Institutional strengthening in the field of Agriculture.

The main objective of the institute is to promote and support co-operation among the 29 member states and, to bring about agricultural development and rural well-being.

- Agrarian Policy
- Analysis and Planning
- Organization and Management for Rural Development
- Marketing and Agro-industry
- Animal Health and Plant Protection

The history of I.I.C.A in the Caribbean began with the first member country, Haiti in 1972. Guyana became a member in 1975 and Dominica in 1984.

**Exercises**

1. List the different categories of agricultural institutions.
2. Discuss two ways how the agricultural sector is supported by NAREI.
3. (a) Name the category in which the Guyana School of Agriculture falls
   (b) State the programmes that are offered at the institution.
4. (a) What does the abbreviation GLDA mean?
   (b) What services does this agency offer farmers?
5. State how financial institutions have impacted on the agricultural sector.
6. Explain the importance of mangrove in Guyana.
7. **CROP PROTECTION**

Weeds, insects and other pests, plant diseases and mineral deficiencies frequently limit the development of crop plants, causing reduction in yield and quality of the produce.

The losses due to pests and diseases are very substantial mostly in tropical and sub-tropical countries. High temperature and humidity facilitate the rapid and constant multiplication of the pests and diseases more than in temperate countries. To reduce these pests and diseases to a low level of population, crop protection has now become one of the key aspects of crop cultivation. Cultural, biological, quarantine and chemical measures are used to keep pests and diseases under control.

Weed and its control have been dealt with in Agricultural Science Book 2. In this chapter, crop protection will be considered in four parts:

- Insects and other pests of crop plants
- Diseases of crop plants
- Methods of control
- Disorders in plants

**INSECTS AND OTHER PESTS OF CROP PLANTS**

Common agricultural pests include insects, mites, nematodes (eel worm), slugs, snails, rodents and birds. Insects form the largest group, (about two thirds of known animals) and are the most destructive of all the pests. They are recognised by the following features:

- the body is divided into head, thorax and abdomen
- a single pair of antennae (feelers)
- three pairs of legs, one pair to each thoracic segment
- the wings, when present, arise from the second and third thoracic segments.
Based on the type of mouth parts and their feeding habits, insect pests are classified into two main groups:

- **Biting and chewing insects**: The mouth parts are adapted for biting and chewing solid food from the plants or its products, e.g., grasshoppers, termites, cockroaches, larvae of moths and butterflies.

- **Piercing and sucking insects**: The mouth parts are modified to pierce the plant tissues and suck the sap from cells of leaves, buds and fruits.

Crop plants are attacked by insects at all stages of their growth. Insects also attack all parts of the plant—roots, stems, leaves, fruits and even the seeds. Very often, it is the larvae that cause damage to crops, but in some cases, both the young and the adult (e.g., grain weevil) attack crops. The insects cause damage either in their attempt to feed or lay eggs on host plants.

- They feed on leaves and reduce the leaf area. As a result, photosynthesis in plant is reduced. This arrests plant growth and, as a consequence, the final yield of the plants is reduced. Some examples of these insects are grasshoppers, leaf beetles, caterpillars or butterflies and moths.
Some insects bore through stems of plants and weaken them. In some cases, this results in the death of plant parts, distal to the point of attack, e.g., stem borers in rice and sugarcane.

Few insects tunnel through roots and tubers resulting in the destruction of the transport system and spoiling the appearance and storage qualities of the tubers, e.g., sweet potato weevil.

Some insects bore fruits and seeds and destroy them- coffee berry borer, fruit flies and pea pod borer. Sometimes, infested fruits fall pre-maturely.
Some insects suck the juices from the cell sap of leaves, stems and fruits resulting in leaf curling and deformation, crinkling of fruits, and stunting of plants. Those include aphids, bugs and scale insects. Some of these sucking insects transmit diseases in crop plants, e.g., cassava mosaic disease by the white fly and tobacco mosaic virus disease by aphids.

In stored grains, insect infestation results in contamination and loss of quality, which results in the reduction in nutritional and market value. Wounds resulting from insect damage provide entrance for other harmful organisms such as fungi, bacteria and viruses.

**Mites**

These organisms belong to a separate class different from insects and are called Arachnida. They are very minute in size and differ from insects in having four pairs of legs, in the adult stage, instead of three. They lack wings and antennae. The mouth parts are adapted for piercing and sucking plant sap from leaves, flowers and stems. The mites are usually found on the underside of the leaves. The attacked leaves turn yellow, then brown. Under severe attack, the plant may be completely defoliated. Mites multiply rapidly and build large numbers on plants very quickly.
Some crops that are attacked by mites are citrus, cotton, cucurbits, tomato, potato and bean.

**NEMATODE (EELWORM)**

Nematodes are usually too small to be seen with the naked eye. The body is long, slender, smooth and unsegmented. They are more prevalent in warm climates and light soils. Most of them are specific to their host plants, each species attacking a particular crop or small group of crops. Some of the nematodes are parasitic on crops and cause economic damage to plants. Some of the crops attacked by nematodes are beet, potato, banana, pineapple, citrus and pea.

Most of the nematodes live in the soil and attack the roots of plants. However, some species live on leaves, stems and flowers. Root nematodes live only in the roots and never appear above ground. They disorganise the root system and form abnormal cell growth in vascular tissues of roots. They also form knots on the roots of many vegetable crops. Species of Meloidogyne (potato root nematode) form root knots on the roots of potato. These root knots block the xylem vessels and severely restrict water supply and mineral nutrients to the shoot. They also cause root rot in perennial crops such as banana and citrus.

Few species attack above-ground parts which cause the plant to become stunted and sickly or cause yield reduction. Stem nematodes live and breed in stems and leaves causing twisting and decaying of the plant tissue. Eggs of some nematodes can remain viable in the soil in cysts for up to 7-10 years. Nematodes are extremely difficult to control and preventive measures are the best. Some of these measures are the practise of crop rotation (e.g., potatoes), planting resistant varieties (e.g., oat – Avena sterilis), using soil fumigants (e.g., in nursery beds), Dichloropropene - dichloropropene mixture (D-D), methyl bromide etc and the use of nematicide like nemagon (e.g., to pineapple suckers) all of which help to reduce nematode population in an area.
SLUGS AND SNAILS

They are generally more common on heavy soils, particularly where drainage is poor and where there is a high level of organic matter and humid weather. They devour the leaves of many kinds of vegetables, e.g., cabbage, lettuce and tomato. They spoil potato crop by boring holes in the tubers. They feed mainly at nights. Hand picking and destroying or using poison baits containing either metaldehyde or methiocarb can control them.
RODENTS

Rats and mice are the most important rodents that cause considerable damage to young rice plants, to newly transplanted oil palms, sugarcane and tuber crops. They also cause damage to stored food by consuming them or contaminating the grain with their faeces and urine. Field hygiene and use of rat poisons such as Zinc phosphide, Thallium sulphate and Arsenical compounds keep them in check in the fields.

BIRDS

Birds are important pests of cereal crops (rice, sorghum and millets) and fruit trees (papaw, mango, jak). They could be controlled by using scare crows, using children to scare them away, using explosives to scare them and harvesting the crops promptly to reduce losses.

DISEASES OF PLANTS

An abnormal condition in the growth and development of a crop plant is called disease. It appears at any stage of plant growth and affects any part of the plant. Plants affected by diseases can be identified by the symptoms they produce on the plants.

Some of these symptoms are discoloration, necrosis, dwarfing of plants or plant parts, swelling of plant parts, dropping of leaves, blossoms or fruits, roughening of fruits or stem surfaces, deformed fruits, complete distortion of some of the plant organs and, in severe cases, death of infected plants before maturity.

Diseases such as powdery mildew, rust, necrotic spots and blight which attack the leaves of plants will reduce photosynthetic activities. Those which attack roots and stems, such as rot and damping off, tend to destroy the whole plant.

Diseases that attack the fruits and seeds will reduce the market value of the produce and lower the viability and germination capacity of seeds.

Infectious diseases such as rust, wilt and necrosis are produced by living organisms-fungi, bacteria
and viruses.

Non-infectious diseases are produced by environmental factors like extreme weather, deficiency or excess of plant nutrients, excess acidity or alkalinity, water logging or poor aeration in the soil.

**Fungi**

These are plants completely devoid of chlorophyll and lacking roots, stems and leaves present in higher plants. The body is made up of a number of fine delicate branching threads or *hyphae* which are collectively known as the *mycelium*.

In some fungi, the hyphae are segmented (septate) by cross walls, while in others they are unsegmented. Since the hyphae do not possess chlorophyll, they cannot synthesise their own food as green plants. They live as parasites on living organisms or as saprophytes on dead organic matter. Many of the fungi grow on living plants as parasites. Some specialised hyphae in the mycelium grow vertically and terminate in a swollen sac called sporangium in which spores are produced.

It is by means of these spores that most fungi are dispersed from one host to another, either by wind, water (irrigation water or rain splash), infected seeds, or insects. When these spores fall on suitable hosts, under favourable conditions, they develop into new fungal growth, penetrating the host tissue and absorbing food from those tissues. High humidity, fairly high temperature and adequate food supply help in their rapid multiplication and development. The majority of plant diseases are caused by various parasitic fungi. They attack the leaves, stems, roots, fruits and seeds. Some common fungal diseases are:

- **damping off** of young seedlings in the nursery, e.g., tomato and tobacco seedlings
- **rust** in cowpea, yard long bean, black gram, mung, etc
- **blast** in rice
- **moulds** in moist stored grains
- **brown** spots on leaves of rice, groundnut, etc.
BACTERIA

These are microscopic, one celled, colourless organisms which can only be seen with the aid of a microscope. They vary in shape and size being either spherical (c cocci), rod shaped (bacilli), curved or spiral (spirilli).

A single bacterium consists of a mass of protoplasm surrounded by a thin cell wall made up of protein material; not of cellulose. There is no definite nucleus, but nuclear materials are distributed throughout the cytoplasm. Like fungi, bacteria also do not have chlorophyll. They thrive on or in living or decaying organic host from which they obtain food.
Under favourable conditions bacteria reproduce by splitting their cells into halves (binary fission). During the dry or unfavourable season they reproduce by forming spores (sporulation). At sporulation, thick walled resting spores are produced to help the bacteria to adapt themselves for survival under unfavourable conditions. The bacteria that cause bacterial wilt in tomatoes can live in the soil for as long as 7-10 years, even in the absence of its host. The spores are spread by irrigation water, rain splash, budwoods, seeds, insects, soil and mechanical equipment (pruning knives, cultivation implements).

In comparison with fungi and viruses, very few plant diseases are caused by bacteria. Most bacterial diseases are specific, that is, they are capable of attacking only one type of crop or family of plants. Infection may be localised rotting of plant parts or the whole plant may be affected.

- **Bacterial wilt in potatoes**: The affected plant wilts even when water supply is adequate. Wilting may also be due to nematode attack which is characterised by root knots. In the absence of root knots, when you squeeze the roots or stems of affected plants, a white milky sap exudates. This confirms bacterial infection.

- **Bacterial leaf blight in paddy**: The early symptoms of the disease are the yellow undulating lesions along the margins of the upper portion of leaf blades. Eventually, a large portion of the leaf blade turns yellow or dirty white and dies.

Apart from few harmful effects of bacteria, they are in many ways beneficial to man. They bring about decay of plant and animal residues forming useful plant nutrients, e.g., making compost, silage, butter, cheese, nitrogen fixation in legumes and in brewing.

**VIRUSES**

Viruses can be regarded as a kind of link between 'non-living' chemical substances and 'living' organisms. They possess certain properties of both chemicals and living organisms. Most species of virus can withstand boiling and freezing temperatures that would normally kill all other living organisms. These suggest that viruses are not living organisms. On the other hand, they grow and reproduce like living organisms. They contain Deoxyridonucleic acid (DNA) and Ridonucleic acid (RNA), the carriers of heredity.
Viruses are extremely small organisms which could only be seen under a very powerful microscope. They consist of protein molecules arranged symmetrically round a centrally located very long coiled thread of nucleoproteins. This arrangement gives them a definite crystalline shape. Viruses are able to multiply only inside living tissues of hosts. They cannot be cultivated in an artificial nutrient medium such as agar.

Unlike fungi and bacteria, viruses do not produce spores. Therefore, they require some other means to spread themselves. Since viruses are found in the sap of plants, most of the virus diseases of plants are spread by sucking insects (vectors) which, as they feed, transmit the virus from diseased plants to healthy plants. Examples of such insects are aphids, whiteflies, thrips, leafhoppers and flea beetles. Virus diseases in fruit crops are spread largely by budding and grafting.

Although viruses are often more concentrated in one part of the infected plant or another, they are generalised in distribution. Thus, every part of the infected plant is a source of infection. The effects of virus infection in the plant are usually rather generalized, consisting of general loss of vigour. One of the common symptoms of virus infection is leaf chlorosis due to the impairment of the plants ability to synthesise chlorophyll. Other symptoms include curling of foliage, rosetting, distortion, vein clearing, stunting and die back. Among the virus diseases causing great concern in the Caribbean are mosaic in peas, beans, tobacco, papaw, ochro, etc., panama disease in banana, lethal yellowing in coconut in Jamaica and rosette in groundnut.

METHODS OF CONTROL

Insects and disease producing organisms are usually kept under control by natural factors such as unfavourable weather, natural enemies (parasites, predators and pathogens) and shortage of food supply. Cultivation of large acres of land under a single crop may reduce the effectiveness of natural control. This leads to increase in pest population. The application of other measures of control becomes necessary. More or less, the same principle underlies the control of all plant pests, be they insects, nematodes or disease-causing organisms such as fungi, bacteria and viruses. Each control method has its merits and limitations on different pests.
In order to control pests successfully it is necessary to recognise the various types of pests, their habit and habitats, body structure, method of feeding, mode of reproduction, dispersal and likely time of attack. For most diseases, prevention is better than cure. Good cultural practices - attention to hygiene and quarantine measures - should form the basis of any general programme aimed at disease prevention.

When disease symptoms appear on a crop plant, the organism has already penetrated the host tissue, established itself and cause damage. At this point, it will be very difficult or impossible to cure the infected plants. The earlier a disease can be recognized, the sooner can control measures be started and less will be the losses caused. Application of chemicals at the early stage of disease outbreak, may control its establishment and spread. Preventive measures for controlling insects are the same as those for controlling plant diseases. Here the application of chemicals is advocated 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 crops. In attempting to control pests and diseases, one must consider the value of the likely damage against the cost of the control measure.

The control measures commonly practised have been divided into the following groups:

- cultural
- use of resistant varieties
- quarantine
- biological
- chemical
- integrated pest management

CULTURAL CONTROL

It is the modification of ordinary farm operations to enable the crop to escape pest attack. Efforts could also be made to reduce or destroy the buildup of pest population. Those methods are inexpensive and can be carried out as part of the routine operations in crop production. These include the following:

- **Early or late ploughing or planting** to ensure that the crops are not at a susceptible stage of
growth when a particular pest or disease is wide spread.

- **Deep ploughing** may bury some insects so deeply in the soil that they cannot emerge, e.g., corn borer. Ploughing may also bring insects that are in the soil to the surface where they are eaten by birds and rodents or killed by desiccation, e.g., white grub, crickets. Ploughing also buries stubbles and weeds that may provide food and breeding site for certain pests that could infect or infest newly planted crops.

- **Field hygiene** or **farm sanitation** involves the destruction of breeding sites of pests and diseases either by burying or burning. This method is effective in the control of rhinoceros beetle of coconut, banana weevil, sweet potato weevil, cutworms and many others. Cutting off and burning of diseased or damaged branches will also assist to arrest the spread of pests and disease.

- **Weed removal** helps to eliminate alternate host of some pests and disease causing organisms of crop plants. Regular weeding also improves aeration around crop plants and prevents humidity build up which promotes fungal development, e.g., black pod disease of cocoa.

- **Crop rotation**: Crop rotation is one of the recommended methods of control against root nematodes. Crop rotation is effective against insects with a restricted host range. Those possessing limited power of movement are unable to survive for long in the absence of a suitable host plant. It is also effective against soil borne diseases.

  When a farmer grows one crop or related crops on a piece of land, season after season, it tends to permit the buildup of insect and disease causing organisms peculiar to those crops. If this system is broken by a succession of botanically unrelated crops, in 2-5 year rotation, it will help to reduce the pest and disease causing organisms by starvation and death.

**RESISTANT VARIETIES**

Some varieties of crop plants pose difficulty to pests and diseases. They prevent the organisms from attacking them. The resistance may be due to inherited characteristics (genetic) or physical ones such as the presence of thick cuticle, hairy foliage or the presence of toxic substances in the plant that may harm the attacker. This method has been successful in eliminating the damage caused by some insect
pests. Some varieties of squash and pumpkins are resistant to squash bug, similarly, some varieties of rice are found to be resistant to stem borer and leaf hopper attack. Some of the inherited characteristics of resistance are used in breeding to evolve new resistant varieties with other desirable characteristics.

**QUARANTINE**

Most countries have laws which permit the importation and distribution of pest-free plants or plant parts only. This aims at preventing the introduction of new pests into a country or area or preventing the spread of already existing pests to other areas in the country which have been free of the pest. The inspectors at the port of entry examine plants for insect pests as well as evidence of disease. Before plants or plant parts are released into a country, they must be treated (fumigated) and observed for a certain period of time. If found to be free of pest, they are released to the importer, otherwise the material is confiscated and destroyed. It is desirable to obtain a certificate of health, which states that the plant is free of pests and/or diseases, from the originating country before entry is permitted into another country. Some of the pests that are prohibited from entering countries are Colorado beetle, fruit flies, grape phylloxera (aphid).

**BIOLOGICAL CONTROL**

This measure utilizes natural enemies of pests, e.g., predators (lady bird beetle, lacewing), parasites (wasps, Amazon fly), and pathogens (some fungi, bacteria and viruses). These natural enemies may be either locally present and need to be increased by creating an environment conducive to their multiplication and spread, or deliberately introduced from countries of their origin and multiplied and released in pest infested areas. It is a promising method to keep some insect pest population at a low level. It has been successful in the control of many pests introduced into a country unaccompanied by their natural enemies. Around 1890, the citrus plantations in California were heavily infested by the scale insect (Icerya purchasi). This pest was controlled by a lady bird beetle (Rodolia cardinalis) introduced from Australia (the country of origin of the pest).

The larvae of Braconid wasps are used to control pests belonging to the class Lepidoptera (butterflies and moths). The Japanese beetle, a pest that gained entry to the United States from Japan, was successfully controlled by the bacteria causing milky disease in Japanese beetle. The bacteria Bacillus thuringiensis is widely used to control larvae of Lepidoptera and Diptera. Biological method of pest
control is practiced in sugar plantations in Guyana to control pests like stem borers.

CHEMICAL CONTROL

Pests may be killed by exposing them to toxic substances. For centuries, the chemicals that have been used to control pests were usually inorganic compounds like arsenic, salts of copper, sulphur, Bordeaux mixture (lime + sulphur) and plant derivatives like nicotine, pyrethrum and derris. Since 1942, many synthetic organic compounds were widely used in pest control. These chemicals are generally called pesticides. They include insecticides and ascaricides used against insect and mite pests, fungicides and bacteriocides against fungal and bacterial diseases, nematicides against nematodes, rodenticides against rats and mice and herbicides (weedicides) against weeds. The different pesticides can be grouped according to their mode of action.

- **Stomach pesticides**: These chemicals are sprayed or dusted on the crop or mixed with baits which must be eaten by insect pests. Biting and chewing insects are killed in this way. Examples of chemicals that come under this group are lead arsenate, gamma BHC and dieldrin.

- **Contact pesticides**: These chemicals are sprayed directly on the pest or plant. When they are directed on the pest, they penetrate the exoskeleton and kill the insect pests that come into contact with them. If the chemicals are applied on the plant, or other surfaces, the insects that walk over the deposit of insecticide are killed. Examples of chemicals that come under this group are DDT, lindane, malathion and nicotine.

- **Systemic pesticides**: When they are sprayed or applied to crop plants, or soil, they are absorbed by leaves, stems and roots and translocated to most of the other parts of the plant. When this sap is sucked by insect pests, while feeding on it, they die. Insects with sucking mouth parts (aphids, mealy bugs, etc) are controlled by this method. Systemic fungicides, like benlate, are effective in killing fungi by penetration. Examples of chemicals that come under systemic insecticides are furadan, roger and phorate.

- **Fumigants**: These are chemicals that will enter the body of pests through breathing holes (spiracles in insects) as gas or vapour and interfere with respiration and kill the pests. They also kill nematodes and fungi that live in the soil. They are used as granules or injected into the soil to form vapour, e.g., methylbromide and vapam.
FORMULATION OF PESTICIDES

With the exception of fumigants, few pesticides in their raw chemical state are suitable for direct use on crops. The toxic substance (active ingredient) that is used in very small amount (less than one pound/0.5kg per acre) would be difficult to spray or dust evenly over a field of crop. Most organic pesticides are insoluble in water. They are either crystalline solid or oily liquids. Mixing them in raw state with water in a spray tank will be difficult as they will settle at the bottom of the spray tank and clog up the nozzles of the sprayer. To use them effectively, conveniently and economically, the raw chemical must be formulated. **Formulation** involves grinding, mixing, impregnating or dissolving the raw pesticide with inert carriers (clay, talc) to facilitate effective handling and mechanical distribution. They may also improve storage and handling of pesticides. Pesticides may be applied in dry state, in such a case they are formulated as dust or granules. They may also be applied mixed with liquid then they are formulated as wettable powders, emulsifiable concentrates or concentrated solutions. Many different formulations can be made from a single pesticide and used for several distinct purposes. For example, malathion can be formulated as emulsifiable concentrates, wettable powders or as dusts.

DUST OR POWDER

Dust is prepared by mixing or impregnating the raw pesticide with a finely powdered inert carrier such as clay or silica and later diluting it with a large bulk of the powdered inert substance. The active ingredient in dust is low, that is, between 0.1% to 5%. They could be applied to leaves, soil or as seed dressing to protect stored grains. Dusts are best applied on leaves either when the crop is wet (either by dew, rain fall or watering) so that the dust will easily stick to the leaves or plant. Some examples of dust formulations are gamma BHC 5% or 10% dust, malathion 4% dust, aldrin 5% dust.

GRANULES

These are large sized particles (2-5mm in diameter), made by impregnating the toxicant onto an inert material like clay. The granules have enough bulk and weight for even distribution. The active ingredient of granules ranges from 2%-25%. In the soil, the granules disintegrate to release the toxicant slowly. Granules are highly suitable against soil dwelling pests. Granules have now replaced dust and are widely used for the treatment of seedling crops. Some examples of granules are furadan, diazinon and aldicar.
WETTABLE POWDERS (WP)

Many solid pesticides that will not dissolve in water in their raw form can be finely ground and mixed with an inert substance like powdered clay and formulated as wettable powder. To promote dispersion of these powders in water (without aggregating together) when they are mixed with it, a dispersing agent is added to the mixture. Similarly, to enable the pesticides to have contact between spray and sprayed surface, a wetting agent is added to wettable powders.

The wettable powders are mixable with water and readily form a suspension. Most fungicides are formulated as wettable powders. Wettable powders contain a high proportion of active ingredients. Sevin 85%WP, for example, contain 85% of the active ingredient carbaryl. Wettable powders are one of the most widely used sprays for crawling insects. They are relatively cheaper than emulsifiable concentrates. Some examples of wettable powders are lannate 25% WP, Sevin 85% WP, malathion 50% WP (insecticides), kocide 80% WP (fungicide).

EMULSIFIABLE CONCENTRATES (EC)

Pesticides that are insoluble in water may be dissolved in organic solvents such as xylene or naphtha and treated with an emulsifier to form an emulsifiable concentrate. In the field, they can be diluted with water to an appropriate spray strength. They form a milky emulsion with water. With gentle agitation, they remain uniformly dispersed throughout the spraying period. The proportion of active ingredient is higher than that found in dust, but lower than that of wettable powder. Some examples of emulsifiable concentrates are endrin 20% EC, fenetrothion 50% EC and metasystox 50% EC.

CONCENTRATE SOLUTION (CS)

If the raw chemical is soluble in water, the pesticide can be prepared as a very concentrated solution which only needs dilution with water to the appropriate spray strength at spraying. The solution remains clear when diluted with water. Some examples of concentrate solutions are azodrin and metasystox.

METHODS OF APPLICATION OF PESTICIDES

Pesticides are applied to the soil, crops, targeted pests, seeds or planting materials.
APPLICATION TO SOIL

Many insects and disease causing organisms live in the soil. They attack and destroy the germinating seeds, growing seedlings and even adult plants. It is important to control them in nurseries, seed beds in small scale intensive cultivations by treating the soil with general sterilants before sowing or planting crops. These sterilants are usually applied to the soil either as drenches or injections. The injections are applied at a specific depth and specific intervals, depending upon the amount and the type of chemical being used. Sterilants applied to the soil have fumigant action. They penetrate minute spaces in the soil and kill pests that live in it.

Covering the soil with tarpaulin or plastic sheetings, helps to prevent the fumigant vapour escaping from the treated soil. Hand operated injectors are used to apply these chemicals in small areas. Time must be allowed to lapse for all the toxic vapours to be expelled from the soil before sowing or planting a crop in the treated soil. This method is economical only on few high value crops. Some selective pesticides are now available in dust or granular forms. These can be applied and incorporated into the soil during normal land preparation or applied as a band on the side of sown seeds.

APPLICATION TO THE SEED (SEED DRESSING)

This method is used to eradicate several seed borne pests and disease organisms which may attack the growing seedlings. Examples of such diseases are blast and brown spots in rice. These could be controlled by treating the seeds with organa-mercuric compounds like Cerasan before sowing.

Seed dressings with less toxic fungicides (Thiram) are applied to seeds of most other farm crops. Seed dressings are also used to combat insect and other pests such as wireworms, shoot tiles, etc. In this method, only a small quantity of pesticide is needed to treat a relatively large amount of seeds. Pesticides must be thoroughly mixed in a revolving drum to ensure even distribution of the chemical.

Recently, the seeds are coated with a mixture of pesticide and a cementing substance. When the seed is planted, the coat gradually dissolves in the soil moisture and releases the toxic substance into the rooting zone of the developing seedlings and kills the pests surrounding it.

Fumigation is used for the protection of stored grains or pulses.
APPLICATION TO CROPS

Pesticides are usually applied to growing crops in the form of spray or dust. Dusting is used to a limited extent in Guyana but spraying is widely practised. The choice of the equipment for the application of pesticides depends upon the physical nature of the formulation of the pesticide to be used. It includes sprayers, dusters and other application equipment.

A small scale farmer, cultivating less than 15-20 acres, uses the hand operated knapsack sprayers or dusters. A large scale farmer uses motorized or power driven sprayers or dusters to treat large acres of land. The spraying could be done by mounting large sprayers to carts, trailers drawn by animals, tractors or by use of aeroplanes. Emulsifiable concentrates, wettable powders and concentrated solutions are applied as sprays.

Different types of sprayers are used to deliver different droplet sizes of the pesticide solution on the target pest or crops. Hand operated knapsack sprayers are used to deliver high volume pesticide solution, that is, more than 40 gallons per acre.

Figure 7-11 Parts of a knapsack sprayer
Most knapsack sprayers, while differing in many ways, have the following essential parts:

- 9 - 14 litre capacity container to hold the pesticide spray liquid
- a gauze filter to keep dirt out of the tank
- a pump for creating pressure inside the container to force the pesticide spray out
- a flexible hose to receive the pesticide forced by the pump
- a lance or boom to carry the nozzle
- one or two nozzles which create the spray

Some sprayers have a small piston which is operated by a handle with which the operator pumps continuously to maintain pressure while spraying. Whereas pressurized sprayers do not have to be pumped during spraying.

The spray solution is placed in the container which is then pressurized by compressing air into the tank, using a hand operated pump.

When the hand control at the lance is released, the pressure forces the spray through the nozzle. The hand operated knapsack sprayer can be carried on a farmer’s back and sprayed by a single person in small farms. They are simple to use and maintain.

**Disadvantages of hand operated knapsack sprayers are:**

- they need large quantity of water as diluent
- the cost of spraying equipment is high
- the time required for application is long
- it is a tiresome exercise.

Dusting machines basically consist of a container to hold dust which must be fed at a constant rate into the air stream, produced by manual or power operated fan. In

- Control of pests by pesticides has its advantages. Pesticides are:
  - highly effective
• effective immediately
• used to rapidly bring under control any outbreak of large pest population.
• employed as needed

There are however, many problems associated with haphazard and intensive use of Non-selective/broad spectrum and persistent pesticides.

These include:

• disruption of the environment
• retention of residual chemicals on plants or seeds
• contamination of soil and water ways such as rivers, creeks, ponds, trenches, ground water
• the development of immunity (resistance) to particular pesticides by pest population
• reappearance of treated pest population
• outbreak of less serious pests to major pest status
• adverse effects on beneficial insects like predators, parasites and pollinators.

As a result of the problems listed above, the recent trend in pest control is not to fully rely on chemical control but to combine all other control measures such as physical, cultural, biological and quarantine with minimal and careful use of selective, less persistent pesticides. This type of pest control is termed integrated pest control or integrated pest management.

The aim is to control pest with little adverse effect on the crop environment and limited use of pesticides.

No chemical has yet been developed that has given encouraging results in controlling viruses. Since most viruses are spread by sucking insects such as aphids and thrips, (vectors) an indirect control measure is to get rid of the vectors and to plant disease resistant varieties. Once the disease is observed on a crop, the affected plants should be pulled out and burnt.
PLANT DISORDERS

Crops sometimes look diseased without an attack by pests or pathogens. This may be caused by mineral deficiencies, extremes of temperature, soil acidity or alkalinity, drought or temporary flooding. Such disorders may sometimes be confused with disease attack.

If the essential plant nutrients are not available or lacking in the soil, deficiency symptoms may appear. These symptoms are usually referred to as **deficiency diseases**.

When a crop suffers from nitrogen deficiency, there will be general yellowing of the leaves and stunted growth of the plant. Plant nutrient disorders are associated usually with soil type.

For example, manganese and copper deficiency will occur more frequently on peat soils, while potassium shortage may be common on chalky soils. Nutrient deficiency disorders can be corrected by applying adequate amounts of appropriate fertilizers.

**Exercises**

1. (a) List ten common pests of agricultural crops found in your locality.
   (b) Classify the pests listed in 1(a) as to whether they belong to
      i. the insects with biting and chewing mouth parts
      ii. the insects with piercing and sucking mouth

2. (a) Why is the mite not included in the class Insecta?
   (b) Briefly discuss the damage it causes to the crop plants.

3. (a) List three common symptoms of disease attack in plants.
   (b) Name two common plant diseases caused by each of the following:
      i. bacteria
      ii. fungi
      iii. viruses

4. Outline the general methods that can be employed to prevent or control insect pests in crops.

5. (a) List three reasons for discouraging the use of chemicals in combating pests in crop plants.
   (b) How could the ill effects of chemicals in crops or plant products be overcome?
8. CROPS

BANANA

Botanical name: *Musa acuminata*

Family: Musaceae

Figure 8-1 Bananas

**ORIGIN AND DISTRIBUTION**

A banana is an edible fruit produced by several kinds of large herbaceous flowering plants in the genus Musa. (In some countries, bananas used for cooking may be called plantains.) The fruit is variable in size, color and firmness, but is usually elongated and curved, with soft flesh rich in starch and covered with a rind which may be green, yellow, red, purple, or brown when ripe. The fruits grow in clusters hanging from the top of the plant. Almost all modern edible parthenocarpic (seedless) bananas come from two wild species – *Musa acuminata* and *Musa balbisiana.*

Bananas are thought to have originated in Malaysia around 4,000 years ago. One of the first documentations of bananas was by Alexander the Great’s army in 327 BC. Banana fruit grows in clusters of 50-150 pieces, which are then broken into 10-25 bunches, referred to as “hands.” There are approximately 50 species in the Musa genus, which includes the edible forms of bananas and plantains.
Bananas (Musa spp.) are a tropical crop, and a staple in the wet tropic areas of Africa, the Americas
main land and island, South and Southeast Asia, Melanesia and the Pacific Islands. Perhaps 87% of the
total bananas consumed worldwide today are locally consumed; the rest is distributed outside of the wet
tropical regions in which they are grown.

Bananas have been cultivated and hybridized a number of times over several thousand years. All edible
bananas today are hybridized from Musa acuminata (diploid) or M. acuminata crossed with M.
balbisiana (triploid).

Today, M. acuminata is found throughout the mainland and islands of Southeast Asia, including the
eastern half of the Indian subcontinent; M. balbisiana is mostly found in mainland Southeast Asia.
Genetic changes from M. acuminata created by the domestication process include the suppression of
seeds and the development of parthenocarpy, that is, the ability of humans to create a new crop without
the need for fertilization.

**ECONOMIC IMPORTANCE**

Bananas are one of the most consumed fruits in America. They are often eaten raw, but can also come
in the form of chips, on an ice cream sundae, or on a breakfast oatmeal, pancake, or cereal. Bananas are
a component of the Bananas Rice Applesauce Toast (BRAT) Diet recommended to people who have
diarrhea or are experiencing an upset stomach. The potassium in bananas helps to regulate the fluid
balance in the body, and the fiber aids in digestion.

Plantains, a type of banana that is green and larger in size, are typically prepared fried, mashed, or
boiled, and found often in Latin American cuisine.

**VARIETIES**

**Gros Michel** – The fruit of this variety are of good flavour and high quality, but due to its
susceptibility to the Panama disease and to leaf spot, it has now being replaced by varieties which,
although not so well flavoured are more resistant to this disease.

Various species of the Cavendish banana, a hardier group, have been crossed with Gros Michel to
produce commercial varieties.
Other varieties include the Cavendish, Valery, Lacatan and Robusta. The Valery, Lacatan and Robusta are the three most important. Locally we have Sweet Fig, Sour Fig and Apple.

**PLANTING AND CULTIVATION**

The banana is propagated exclusively by vegetative methods. The pseudo stem produces three main types of suckers: Maiden, water and sword. The water sucker is one in which the stem is the same width from top to bottom. These are usually produced by the remote or grandparent corm and must never be used for planting. Sword sucker are very vigorous and are produced by the main stem; such suckers are relatively large from the bottom and taper towards the top; they also have long, thin blade – like leaves. These are the best suckers for planting. Between the sword and the water sucker is the maiden sucker which has narrower leaves than the sucker leaves. The stem tapers somewhat from bottom to top, but not to the same degree as in the sword sucker. Maiden suckers also make good planting materials. The best plants are obtained from the corms of old stems which have one or two buds on them.

![Water sucker, Sword sucker, Maiden sucker](image)

*Figure 8.2 Three main types of sucker*

Bananas keep growing for several years. There are many alluvial valleys and plains where they remain in production for 10 – 20 years without being replanted. However, the average period of productive growth, without replanting, is about 5 years. This is particularly true of crops planted on clayey soils commonly found in the region.
All new planting materials for banana should be free from pests and diseases. Whether old corms or suckers are being planted, they should be inspected for plant borers and nematodes. All other roots and trash are removed and decaying portion of stem should be cut away. The stem should be dipped in Nemagon to which a sticker such as Triton has been added. Suckers or corms, sometimes referred to as heads, are planted in holes about 45cm wide and 45cm deep at a spacing of about 2.4m × 2.1m or closer, depending on the fertility of the soil, the slope of the land and the banana variety. Bananas were previously sold by the stem or bunch and the emphasis was on the number of hands per bunch, but they are now sold by weight. The farmer’s aim therefore is to produce a high tonnage per hectare, although individual fruits may be smaller. This means that if the spacing between plants is reduced, more plants can be planted per hectare and higher yield can be obtained.

APPLICATION OF FERTILISERS

Bananas require fertilizer, if a high level of production is to be maintained year after year. At least two applications per year are recommended, but the rate of application and type of fertilizer used have to be determined by soil testing. A mixed fertilizer is generally recommended since bananas do not appear to show any major mineral deficiency.

PRUNING

The attitude towards cutting out suckers has changed considerably since the introduction of the practice of selling bananas by weight. In fertile soils, as many as four or five suckers may be allowed to develop from the parent plant; whereas, in less fertile soils, it is advisable to allow only two suckers to be produced at different stages of development. In short, the farmer has to decide whether sucker removal is necessary and to what extent it should be done. Where a sucker needs to be removed from the parent plant, this should be done using a sharp cutlass or machete, by inserting it between the sucker and the parent. If a choice has to be made between a number of suckers, the one furthest removed from the parent plant or one growing on a lower slope should be removed since these are not so firmly established as others which are closer to the parent plant. A smooth, clean cut is essential since it discourages possible infection of the plant.

HARVESTING
The top portion of the pseudo stem is cut off and allowed to remain at the base of the plant. This serves
as a source of mulch; alternatively it can be fed to cattle and some farmers use it as supplementary feed
in times of scarcity. Most losses occur during harvesting. Rejection of bunches is usually based on the
maturity of the fruit which is often harvested when immature. Some rejection takes place because the
fruits are bruised. In some plantations, the young fruits are wrapped in polythene bags to prevent
graazing of the fruits. The bananas are transported from the field to boxing plants. They are cut into
hands, washed and boxed for shipment to foreign markets. Hands of bananas may be dipped in growth
regulators substances gibberlins to improve post-harvest storage. Keeping at temperatures of 13°C -
15°C and 85% relative humidity also prolongs the storage time.

PESTS AND DISEASES

Banana bunches are sometimes encased in plastic bags for protection. The bags may be coated with
pesticides.

While in no danger of outright extinction, the most common edible banana cultivar Cavendish
(extremely popular in Europe and the Americas) could become unviable for large scale cultivation in
the next 10 –20 years. Its predecessor 'Gros Michel', discovered in the 1820s, suffered this fate. Like
almost all bananas, Cavendish lacks genetic diversity, which makes it vulnerable to diseases,
threatening both commercial cultivation and small- scale subsistence farming.
PANAMA DISEASE

Panama disease is caused by a fusarium soil fungus (Race 1), which enters the plants through the roots and travels with water into the trunk and leaves, producing gels and gums that cut off the flow of water and nutrients, causing the plant to wilt, and exposing the rest of the plant to lethal amounts of sunlight.

Prior to 1960, almost all commercial banana production centred on "Gros Michel", but it was highly susceptible to that disease. Cavendish was chosen as the replacement of Gros Michel because among resistant cultivars, it produces the highest quality fruit. However, more care is required for shipping the Cavendish, and its quality compared to Gros Michel is debatable.

TROPICAL RACE 4

Tropical Race 4 (TR4) is a reinvigorated strain of Panama disease first discovered in 1993. This virulent form of fusarium wilt has wiped out Cavendish in several Southeast Asian countries. It has yet to reach the Americas; however, soil fungi can easily be carried on foot wear, clothing or tools. This is how TR4 travels and is its most likely route into Latin America. Cavendish is highly susceptible to TR4, and over time, Cavendish is almost certain to disappear from commercial production by this disease. The only known defense to TR4 is genetic resistance.

BLACK SIGATOKA

Black Sigatoka is a fungal leaf spot disease first observed in Fiji in 1963 or 1964. Black Sigatoka (also known as black leaf streak) has spread to banana plantations throughout the tropics from infected banana leaves that were used as packing material. It affects all main cultivars of bananas and plantains (including the Cavendish cultivars), impeding photosynthesis by blackening parts of the leaves, eventually killing the entire leaf. Starved for energy, fruit production falls by 50% or more, and the bananas that do grow ripen prematurely, making them unsuitable for export. The fungus has shown ever increasing resistance to treatment, with the current expense for treating 1 hectare (2.5 acres) very costly. In addition to the expense, there is the question of how long intensive spraying can be environmentally justified. Several resistant cultivars of banana have been developed, but none has yet received commercial acceptance due to taste and texture issues.
BANANA BUNCHY TOP VIRUS (BBTV)

Banana Bunchy Top Virus (BBTV) moves from plant to plant by aphids. It stunts leaves, resulting in a "bunched" appearance. Generally, an infected plant does not produce fruit, although mild strains exist which allow for some production. These mild strains are often mistaken for malnourishment, or a disease other than BBTV. There is no cure. However, its effect can be minimized by planting only tissue-cultured plants (in vitro propagation), controlling aphids, and immediately removing and destroying infected plants.

BANANA BACTERIAL WILT

Banana Bacterial Wilt (BBW) is a bacterial disease caused by Xanthomonas campestris pv. musacearum. After being originally identified on a close relative of bananas, Ensete ventricosum, in Ethiopia in the 1960s, BBW occurred in Uganda in 2001 affecting all banana cultivars. Since then, BBW has been diagnosed in Central and East Africa, including the banana growing regions of Rwanda, the Democratic Republic of the Congo, Tanzania, Kenya, Burundi and Uganda.
SUGARCANE

Botanical name – Saccharum officinarum- noble cane

Family: Poaceae

ORIGIN AND DISTRIBUTION

The Sugarcane plant is indigenous to India, China, Indonesia, Phillipines, Java, and New Guinea. It is grown commercially in many tropical and subtropical countries where it contributes to a significant portion of the world’s sugar production.

The plant is propagated sexually by seeds, and more commercially, by cuttings. From the early species, new hybrid type varieties have been developed. The first variety bred was POJ2878 at Java from which CO 205 was developed.

The breeding system is intensified to produce varieties with particular characteristics such as juice quality, pest/disease resistance, flowering, stalk length and recumbence.

In Guyana, sugarcane is grown on narrow strips of land along the coast and bordering the mouths of the Demerara, Bebice and Corentyne rivers. The whole of the cultivated area lies within 13 km of the Atlantic Ocean and much is below the sea level. In 2013 sugarcane was cultivated on 49,003 hectares on seven (7) estates in Guyana- Skeldon, Albion, Rose Hall, Blairmont, East Demerara, Uitvlugt, and Wales.
Table 8.1 Estates and hectares cultivated

<table>
<thead>
<tr>
<th>Estates</th>
<th>Hectare (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeldon</td>
<td>10,026</td>
</tr>
<tr>
<td>Albion</td>
<td>10,134</td>
</tr>
<tr>
<td>Rose Hall</td>
<td>7,440</td>
</tr>
<tr>
<td>Blairmont</td>
<td>6,138</td>
</tr>
<tr>
<td>East Demerara</td>
<td>5,820</td>
</tr>
<tr>
<td>Wales</td>
<td>4,388</td>
</tr>
<tr>
<td>Uitvlugt</td>
<td>5,057</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49,003</strong></td>
</tr>
</tbody>
</table>

**ECONOMIC IMPORTANCE**

- Sugarcane is a major crop in many countries. It is one of the plants with the highest bioconversion efficiency. Sugarcane crop is able to efficiently fix solar energy, yielding some 55 tonnes of dry matter per hectare of land annually. After harvest, the crop produces sugar juice and bagasse, the fibrous dry matter. This dry matter is biomass with potential as fuel for energy production.

  Sugarcane bagasse is a potentially abundant source of energy for large producers of sugarcane, such as Brazil, India and China. According to one report, with the use of the latest technologies, bagasse produced annually in Brazil has the potential of meeting 20% of Brazil’s energy consumption by 2020.

  Bagasse is used as a fuel in sugar mills. It is also used for paper making and as an ingredient of fiber board.

- A lot of sugar is used in the manufacture of alcoholic beverages, soft drinks, ice-creams, chocolates, canning industry.
• **Falernum**: a sweet, and lightly alcoholic drink made from sugarcane juice.

• **Cachaça**: the most popular distilled alcoholic beverage in Brazil; a liquor made of the distillation of sugarcane juice.

• **Rum**: is a liquor made from sugarcane products, typically molasses but sometimes also cane juice. It is most commonly produced in the Caribbean and environs.

• **Basi**: is a fermented alcoholic beverage made from sugarcane juice produced in the Philippines and Guyana.

• **Sugarcane juice**: a combination of fresh juice, extracted by hand or small mills, with a touch of lemon and ice to make a popular drink.

• **Syrup**: a traditional sweetener in soft drinks.

• **Molasses** is an important by-products of sugarcane industry which is used as a livestock feed and for preparation of rum, industrial alcohol, vinegar, glycerol, lactic acid and mono sodium glutamate. Molasses is used as a sweetener and a syrup accompanying other foods, such as cheese or cookies. The molasses is used in cooking and candy making, and sometimes it is used as manure.

Sugar is one of the most valuable products of the plant world obtained from Saccharum species.

**CLIMATE AND SOIL REQUIREMENTS**

Sugarcane is typically a crop of the tropics and sub-tropics. Most commercial sugarcane is grown between 35°N and 35°S. It requires high temperatures, plenty of sunlight and large quantities of water. For growth, a long warm season that is fairly dry and sunny is necessary. Cool weather is required during the ripening and harvesting season. The optimum temperature for sprouting is 32°C - 35°C. Below 21°C growth is hindered.

**CROPPING SYSTEMS**

Sugarcane is a crop which is grown for many years on the same land. Sugarcane grows well on a wide variety of soils ranging from sandy to heavy, but heavy soils are usually preferred. The soil should be fertile; otherwise heavy fertilisation will have to be undertaken. Sugarcane has no special demands regarding soil pH, but it does not normally tolerate salinity.

Flood fallowing of sugarcane field has been practiced in Guyana for many years. This consists
essentially of the total submergence of the land at the end of the crop cycle by fresh water to a depth of approximately 12 inch or 30 cm.

The sugar belt front land clays are mainly of marine origin. In Berbice, it is predominantly montmorillonitic clay and in Demerara it is a mixture of mica, vermiculite, some kaolin and some amount of chloride. All these soils (particularly the Berbice clays) swell when wet and shrink and harden into large clods when dry. When adequate water is supplied for cane growth, oxygen may be lacking as a result of the swelling. Organic matter from sugarcane root systems and decomposing trash is present in the top soil. It is due to this that a reasonable surface tilth is maintained. Below this, the texture deteriorates, and a few feet down, a structureless clay in which root development is limited, is encountered. In dry weather, salt moves upwards and may often be seen as a whitish deposit on the surface as water evaporates from the soil surface.

A large proportion of the Berbice heavy clays and some of the Demerara clays, particularly those nearest the coast, are saline. Flood fallowing provides one means of leaching salts since with the final removal of the water, it carries substantial quantities of dissolved salts.

On certain types of soil, the operation may be neither desirable nor feasible. For example, on an excellent structured pegasse (tropical highly acid peat) and on some silty clay where there is an abundance of fine sand and silt, may be poor in suitable substrates for micro-organisms. The latter are dominantly riverain sediments and the benefits from flood fallowing are not only small, but are only achieved when cultivation follows, rather than precedes flood fallowing.

This is because re-oxidation is slow and drainage alone may not be adequate to complete the re-oxidation, particularly when the end of flood fallowing coincides with one of the two wet seasons.
THE STRUCTURE OF THE PLANT

The main parts of the sugarcane plant are the stalk, leaf and root system.

![Image of sugarcane plant](image)

Figure 8-4 The sugarcane plant

THE STALK

![Image of stalk](image)

Figure 8-5 Parts of the stalk (stripped of leaves)

The stalk consists of segments called joints. Each joint is made up of two **nodes** and an **internode**. The node is where the leaves are attached to the stalk and where the buds and root primordia are found. A leaf scar can be found at the node when the leaf drops off the plant. The length and diameter of the joints vary widely with different varieties and growing conditions. In general, the joints at the base are short and internodal length gradually increases.
THE LEAF

The leaf of the sugarcane plant is divided into two parts: sheath and blade, they are separated by a blade joint. The sheath, as its name implies, completely covers the stalk and extends over at least one internode. The leaves are usually attached alternately to the nodes, thus forming two ranks on opposite sides. The mature sugarcane plant has an average total upper leaf surface of about 0.5 metre$^2$ and the number of green leaves per stalk is around ten, depending on variety and growing conditions.

THE ROOT SYSTEM

The function of the root system is two-fold: first, it enables the intake of water and nutrients from the soil; and second, it serves to anchor the plant. Two kinds of roots will develop from a planted seed piece. The set roots, which arise from the root band, are thin and highly branched; the shoot roots, originating from the lower root bands of the shoots, are thick, fleshy and less branched.
THE INFLORESCENCE

When a sugarcane plant has reached a relatively mature stage of development, its growing point, under certain photoperiod and soil moisture conditions, change from the vegetative to reproductive stage. This means the growing point ceases forming leaf primordia and starts the production of an inflorescence. The inflorescence, or tassle of sugarcane, is an open-branched panicle. Each tassle consists of several thousand tiny flowers, each capable of producing one seed.

Generally, a day length close to 12.5 hours and night temperatures between 20\(^{0}\)C - 25\(^{0}\)C will induce floral initiation. Temperatures that are too low and/or water stress inhibit inflorescence development.

VARIETIES

Presently, in Guysuco two main breeding programmes prevail: The 'D' (Demerara) programme and the 'DB' (Demerara-Barbados) programme. In the 'D' programme, parental cross and clonal selection are conducted at the Guysuco Agricultural Research Unit (GARU) at La Bonne Intention (LBI). Choice of parents and parental combinations, crossing, fuzz management and the germination of seedlings are conducted according to various criteria as decided by the Breeding and Selection Department of that Unit. Varieties generated through this programme are 'D' varieties, for example, D-8415, D-15841 and D-14146. In the 'DB' programme, crosses are made in Barbados for testing throughout the West Indies and affiliated member countries.
Clones generated from fuzz imported to Guyana from Barbados (subsequent to testing and selection) are labelled 'DB' varieties and issued numerics according to the year and selection number as detailed above.

The commercial varieties recommended to be grown in Guyana are:

- DB-75159
- DB-9314
- D-9017
- DB-66113
- D-93222
- D-7661
- DB-7869
- D-89138
- DB-9633
- D-15841

**FIELD LAYOUTS**

- Traditional fields comprise raised cambered beds of width 8 m to 11 m and the length extends to 380 m.
- English beds and Dutch beds have a width of 11.5 m. However, the English bed extends longitudinally and the Dutch bed, horizontally.
- Beds are separated by drains 7.3 m apart and 0.8 m deep, which empty into collector drains sited in the centre (for Dutch beds) or at the drainage canal end (for English beds).

**Dutch beds** - run across the field, with centre drain
**English beds** - run lengthwise along the field

**Traditional ridge and furrow** - short rows across the field

**Wide English beds**, Skeldon - 500 metres long
PLANTING

Since the cultivars of sugarcane are highly heterozygous, they do not “come true” from seed produced in their tassels, so sugarcane is propagated vegetatively by stem cuttings of young canes, known as setts.

WEED CONTROL

Proper weed control is critically important in sugar cane cultivation, as significant losses in crop yield result from inadequate, weed control. Losses as high as 65% have been reported where cane is left to grow along with aggressive weeds such as Rottboellia cochinchinensis (Itch grass). Even comparatively 'soft' weeds growing uncontrolled for six weeks during the establishment phase of the crop have been shown to result in 10-15% yield loss. This, in a 30-ton per acre crop, equals 3 tonnes of cane which, in value, far exceeds the cost of the weed control operation needed to control such a weed infestation.

Weeds are best managed by integrated control methods. These include:

- Cultural
- Ecological/biological
- Manual
- Mechanical
- Chemical methods.

The objective of the weed control policy is to move towards Integrated Weed Management thereby reducing the amount of chemical weed control required. With more timely and improved methods of application, it is anticipated that the quantities of herbicides used will be reduced.

However, we cannot do without herbicides. They form the mainstay of the GuySuCo weed control programmes but with safer and more effective treatments, using newer products coupled with state-of-the art application equipment, the target can be reached with greater efficiency.
IRRIGATION

The current irrigation policy for GuySuCo is:

1. Flood (or basin) irrigation will continue to be the method of choice until further research and development work on field layouts and irrigation technique demonstrate another method to be more practical.

2. Dam beds will continue to be irrigated using dam bed pumps mounted in punts as per the design developed at Central Workshop where the dam bed irrigation unit will also be built.

3. The method of determining the timing of irrigation will continue to be through use of the moisture deficit method. Studies are now in progress to determine the optimum moisture deficit. Unless, and until, the results of these studies indicate a need to adjust the soil moisture deficit action level, the 5 inches/12 cm deficit level will continue to be used.

4. Irrigation is to be managed on a block basis and when a block of fields is calculated to be approaching a deficit of 5 inches/12 cm then 5 soil samples will be taken with an auger diagonally across each of every other field in the block. The samples are to be sealed immediately into moisture cans and returned to the field laboratory for measurement of moisture content by oven drying. The values are to be compared with those at which the various soils are to be irrigated. If the soil moisture content is equal to, or lower than, the value shown in the table for the particular soil series, then the block is to be irrigated. If the soil moisture content is higher than this value, then irrigation will be delayed and the fields subjected to further sampling and analysis.

It is important to note that preparations for irrigation should commence when the accumulated deficit reaches 76 mm/7.6 cm but that the operations do not begin until the 127 mm/12.7 cm deficit has been confirmed.

FERTILIZATION APPLICATION

Sugarcane plants that are in a favorable environment, have large dark green leaves, long internodes of good-sized diameter, and healthy well-developed root systems. Plants which are not making satisfactory growth are stunted and frequently show symptoms of distress. The poor cane growth may be due to deficiencies of one or more of the essential elements or it may be due to toxicities. The rate at which nutrients are absorbed varies considerably with the conditions under which the cane was grown. Fertilisers are generally applied when deficiencies exist in a soil, so it is not surprising to find that the application of fertilizers affects the chemical composition of sugarcane. Balanced feeding results in vigorous healthy growth. Plants with deficiencies first show a retarded rate of growth and are characterized by “Hidden Hunger”. As the deficiency becomes more acute, growth is further reduced,
the plant becomes stunted, and frequently develops deficiency symptoms. Growth rate remains low and varies with the supply of the limiting elements. Fertilisers are added to supplement the soil’s supply of nutrients to produce profitable yields.

The determination of the quantity of fertiliser is dependent on the soil type and the nutrient requirement of the plant. Other factors, such as flood fallow and plough and plant would influence the rates of application. Rates of application and types of fertilisers are determined by soil testing and testing leaf samples. Current standard fertilisers used in sugarcane are Urea, Ammonium Sulphate, Di-ammonium Phosphate and Muriate of Potash.

INSECT PESTS

SMALL MOTH BORERS

Stem borers (Diatraea species) are a major problem of sugarcane throughout the world. Several species have been identified as major pests of sugarcane in different countries, with several others being minor pests. In Guyana, Diatraea centrella and saccharalis have been identified from sugarcane.

DIATRAEA CENTRELLA

Eggs are laid on the underside of green cane leaves. The newly emerged larvae move up or down the leaf feeding on the surface tissues of the leaf. Later, they move behind the leaf sheath where they feed upon the tender leaf tissues. As the larva becomes older, it bores into the stalk and forms a tunnel. Older larvae may abandon their tunnels and move down the stalk into harder, more mature internodes but usually, most of the feeding occurs in the top internodes. The mature larva hallows a population chamber near the edge of the stalk and chews a hole large enough for an adult to escape. Adults are short lived with few living more than three days after emergence. Mating occurs shortly after emergence and egg laying from one to three days after that.
Damage

The tunneling of D. Centrella (fig.30) is usually parallel to the length of the stalk and only in very severe attacks does sufficient weakening occur for stalk to break. The losses thus are chiefly in the form of sucrose loss, either through tunneling (very minor) or the activity of Red Rot (sometimes very serious). No detailed study has been carried out on the sucrose losses due to D. Centrella.

Control

Natural – The eggs of D. centrella are attacked by egg parasites, principally Trichogramma fasciatum. They are also fed upon by a range of small predators. The first instar larvae are very prone to predator attack with ants likely being a key control factor. As the larvae become larger, they are in more protected habitats and are more difficult to attack. A few species, such as earwigs, are capable of killing large D. centrella larvae. While several parasites are recorded for D. centrella, none kills a significant number of larvae. In fact, field parasitism is quite rare. A search for an exotic parasite to attack D. centrella has been unsuccessful.

Cultural – The major cultural control is planting of clean seed material as infested setts provide a large population of moths to oviposite on the very young shoots. This provides a population base for a very heavy attack later. One method used regularly years ago, and occasionally used now, was the rouging of deadhearts and destruction of the larvae. There is little evidence that such a programme actually reduces subsequent damage. Rouging for Diatraea control requires abundant, very cheap labour and cannot be justified under present day conditions.

DIATRAEA SACCHARALIS DAMAGE

D. saccharalis tunnels tend to be circular around the outside edge of the pith, just above the node. Some longitudinal tunneling occurs. This tunneling weakens the cane and results in breakage or growth retardation. Sucrose losses are similar to that incurred by D. centrella. Stalk breakage can result in heavy losses due to lower tonnage, poorer juice and increased reaping cost. Heavily attacked fields may also be subject to secondary attacks by rodents or rotten stalk weevils. Losses due to deadhearts by D. saccharalis are similar to those by D. centrella. Heavily attacked fields in early growth are rare.

Control

Natural - D. saccharalis have several important parasites which are capable of substantially reducing
population size. Amazon fly, Metagonistylum minense, kills a large portion of the D. saccharalis larvae in Guyana. Before the introduction of Amazon fly from Brazil, D. saccharalis was a major problem (see Amazon fly section). Trichogramma fasciatum parasitizes D. saccharalis eggs and has been used for its biological control in several countries including Guyana. It is now thought to be uneconomic to mass rear and release this parasite.

Deadhearts or stalks with the central leaves dead are a common result of D. centrella attack, particularly cane in the pre-boom growth phase. The presence of a large number of deadhearts in young cane often arouses great concern, but this is of little consequence because of the surplus of tillers and the ability of cane to compensate for early losses. More serious is the occasional heavy attack in cane in the boom growth period resulting in deadhearts. These stalks are likely to side shoot heavily producing a lower yielding stalk. Fortunately, such damage by D. centrella is uncommon.

GIANT MOTH BORER (CASTNIA LICOIDES)

Eggs are laid on or near the base of the cane stool where the newly hatched larvae have easy access to the cane stalk. Initially, feeding occurs on the outer layers of the stalk tissues, particularly on suckers. Small larvae penetrate the rind and establish small convoluted tunnels in the pith, whereas the later instars form a single, large tunnel (15 - 17 mm.) along the centre of the cane. Larvae move from stalk to stalk through the root stalk and are never found outside the plant. There is evidence that pre-harvest burning drives the larvae down the stalks into the root where they are protected from harvesting operations. Up to seven larvae have been removed from a single stool but one or two larvae are much more common. Before pupation, the larva establishes a pupal case of cane fibre in a rotten stump or in a stalk near soil level. If pupation occurs in a stalk, an emergence hole is cut. Pre-pupal and pupal periods are about 6 and 35 days respectively.

Damage

The primary damage by Castnia is done by tunneling in the stalks with bored portions, yielding virtually no sugar. Boring into the root stalk weakens the stool and in small stools, can result in death and hence heavy Castnia attack has been implicated in poor ratooning. Secondary losses occur when pests and diseases enter the stalk through the Castnia tunnel. Post-harvest feeding results in the death of new tillers when the bottoms are cut through. Occasionally, such damage can cause severe losses and
even force ploughing of the fields.

**Control**

**Biological** – There appears to be no potential for biological control of Castnia. The only known parasite, *Palpozenillia palpalis*, is found only from Castnia attacking wild plantain and its life history renders it unsuitable for use in sugar cane. The larvae are much too robust to be fed upon by conventional predators, besides which the cane provides adequate protection.

**OTHER PESTS**

The Sugarcane rat *Holochilus brasiliensis* - Species responsible for majority of damage to sugarcane cultivation in Guyana. The species is indigenous to low lying Coastal savannah areas. Colonization of better drained sugarcane lands (subject to environmental variations extreme wet and dry periods). Rats cause considerable damage to growing and mature sugarcane by eating the cane at the internodes. As a result, the shoot collapses through lack of support. Deterioration in juice quality also occurs. The damage also results in the entry of pathogens causing diseases such as red rot.

**Control**

- Baiting
- Hunting
- Circle burning and hunting
- Varietal tolerance
Table 8.2 The table below shows common diseases that affect sugarcane.

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>CAUSATIVE AGENT</th>
<th>TYPE OF PATHOGEN</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smut</td>
<td><em>Ustilago scitaminea</em></td>
<td>Fungus</td>
<td>• Rouging diseased shoots/stool</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Disinfecting setts prior to planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Do not ratoon an affected field</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Plant resistant varieties</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Surveys</td>
</tr>
<tr>
<td>Common Rust</td>
<td><em>Puccinia melanocephala</em></td>
<td>Fungus</td>
<td>• Plant resistant varieties</td>
</tr>
<tr>
<td>Yellow Spot</td>
<td><em>Mycovellosiella koepkei</em></td>
<td>Fungus</td>
<td>• Plant resistant varieties</td>
</tr>
<tr>
<td>Leaf Scald</td>
<td><em>Xanthomonas albilineans</em></td>
<td>Bacteria</td>
<td>• Plant resistant varieties</td>
</tr>
</tbody>
</table>

**HARVESTING**

Different varieties have different maturity periods, which vary from 12 - 18 months, the ripe cane has a smooth brittle skin and the leaves begin to yellow. Experience, visual observation and field history will also assist in assessing ripening. To determine the optimum harvest time, random samples of cane juice are taken at intervals of 7 – 10 days across the field as cane reaches maturity. This juice is analysed in a laboratory for its sugar content and total soluble solids. Harvesting of cane should be done while the sucrose content is at its highest.

Irrigation is stopped 6 weeks before harvesting, so that the soil condition could be as dry as possible, at harvesting time. The cane is usually burnt before harvesting to get rid of trash, rodents, snakes and other...
harmful animals. This is done early in the morning or late in the evening when there is little wind. Harvesting is done mechanically and manually.

Currently 60% of the fields across the industry are harvested mechanically while the remaining 40% are harvested manually.

SUGARCANE HARVESTER

MANUAL CUTTING AND LOADING
RATOONS

After harvesting a newly planted cane crop, the new shoots will grow from the old stumps. These are usually referred to as ratoons. These ratoons take about forty-eight weeks to mature after sprouting. Three ratoons are normally used after which replanting is done.
HELICONIA

Scientific Name: *Belicoma ladspatha*

Family: Helccmiaceae

DESCRIPTION

Heliconia, derived from the Greek word helilwnios, is a genus of about 100 to 200 species of flowering plants native to the tropical Americas and the Pacific Ocean islands West to Indonesia. Many species of Heliconia are found in rainforests or tropical wet forest of these regions. Common names for the genus include lobster-claws, wild plantains or false bird-of-paradise. The last term refers to their close similarity to the bird-of-paradise flowers (Strelitzia). Collectively, these plants are also simply referred to as heliconias.

The Heliconia are a monophyletic genus in the family Heliconiaceae, but was formerly included in the family Musaceae, which includes the bananas. However, this was later placed in the order Zingibreales, in the commelinid clade of monocots.

These herbaceous plants range from 0.5 to nearly 4.5 meters tall depending on the species. The simple leaves of these plants are 15-300 cm. They are characteristically long, oblong, alternate, or growing opposite one another on non-woody petioles often longer than the leaf funning large clumps with age. Their flowers are produced on long, erect or drooping panicles, and consist of brightly coloured waxy bracts, with small true flowers peeping out from the bracts. The growth habit of heliconias is similar to Conna, Strelitzia, and bananas, to which they are related. The flowers can be hues of reds, oranges, yellows, and greens, and are subtended by brightly colored bracts. The plants typically flower during the wet season. Theses bracts protect the flowers. Floral shape often limits pollination to a subset of the hummingbirds in the region.
ECONOMIC IMPORTANCE

They are widely used as ornamentals. Heliconias are grown for their beautiful, brilliant colorful flowering bracts. Breathtaking and unusual flower heads (bracts) rise from clumps of banana like leaves, sometimes very large or slender.

Heliconia flowers are actually highly modified leaves and bracts. The flowering stems are mostly pendulous. A bract is a leaf structure at the base of a flower. Heliconia flowers are produced on long, erect or drooping panicles, and consist of brightly coloured waxy bracts, with small true flowers inside the bracts. Bracts which can be orange, purple, red, yellow, pink, green, or their combinations

SOWING HELICONIA

Preparing your potting mixture: Select a suitable potting mix and add 1/3 peat moss and 1/3 sand. You then fill the container with the prepared mixture. If you are planting your heliconia outdoors, dig a hole slightly larger than the rootball. Add sand and peat moss.

Place the plant in the pot or hole you have dug, making certain that the tip of the rhizome will stick out the top of the soil.

Fill your pot or hole with the potting mix you have prepared with peat moss and sand.

Water thoroughly and keep the soil moist but not soggy. Heliconias need an abundance of water.

Fertilize at least once a month with an all-purpose fertilizer. If you are growing your heliconia indoors, or in a low humidity climate outdoors, it is helpful if you mist your plant every day.
Heliconias should be planted in a draining soil with the top sticking out of the ground. Heliconias flourish well in loamy soils rich in humus.

- Heliconias need sunlight, with temperatures that do not go below 4.4°C.
- Plant rhizomes which may or may not have a young shoot.
- Cut back the old shoot to about 15.3 cm before planting.
- The eyes or buds, present in the Heliconia rhizome help to grow new shoots in about 4 weeks, while roots grow from the rhizome.
- Since Heliconias are heavy feeders, a soluble balanced or granular time-release fertilizer can be used.
- Heliconias bloom once or several times a year.

**GROWING HELICONIAS**

Typically, heliconias grow naturally in lowland to mid-elevation humid tropical areas. Many, if not most, occur in light gap areas, along water ways. Some are even found along road cuts. Moisture is always available even for those species, which are native to seasonally dry areas. They are fast growing plants, which easily take advantage of soil fertility. These factors should help in the understanding of Heliconia cultivation.

In cultivation, a plant is often started from a rhizome division, which includes at least one erect pseudostem. We start our plants in a sterile potting medium, in a pot just large enough to accommodate the plant. All leaf blades are removed or at least reduced to slow water loss through transportation. The pot is then put in a warm, lightly shaded spot and watered regularly to keep it moist but not perpetually soggy. Some growers, find it useful to place a paper cup or other shield over the cut end of the pseudostem to prevent excess water from entering and accelerating decay. Once new sprouts are seen at the base of the plant, it is considered strong enough to be planted directly into the garden. If the season is cool or dry, the plant will be held until hot/wet weather condition is expected.
FERTILISING

Plant Heliconias 4-6 inches deeper than they are in their sprouting container. Place a slow releasing fertiliser directly into the planting hole. Planting tablets 13-5-13 give a practical boost to the newly planted Heliconia. This fertiliser was formulated to be used by rice farmers in wet conditions and is very slow release. Since heliconias are fast growing plants, they are heavy feeders. In addition to the fertiliser placed in the planting hole, the plants should be heavily fertilised 4 times per year.

MULCHING

Maintaining a layer of organic mulch around Heliconia plants serves several purposes:

- Mulch helps to retain moisture around root zone.
- The mulch also helps to hold fertilisers for slower release to the plants.
- There is evidence that organic mulches help to reduce infestations of nematodes.
- Nematodes are often a serious problem for plants growing in rock or sandy soils.
- Mulches help to control weeds and maintain a tidier appearance around plants.

HELICONIA DISEASE

Diseases Foliage

Causal Agent: Fungi

*Calonectria spathiphylli*

**Disease and symptoms:** The most pronounced foliar symptoms on heliconia caused by *Calonectria spathiphylli* are leaf yellowing, "firing" or drying of leaf margins, sheath spots and petiole blights. Rots of the sheath and petiole interfere with water movement to the leaf, causing water stress and producing dry leaf edges. As rots of the sheath expand, less water moves up to the leaf blade, and leaves become yellow. Eventually the leaves die, resulting in premature loss of older leaves. Less frequently, the fungus causes brown, oval spots of varying sizes up to 9.5 by 19mm (3/8 by 3/4 inches). The photosynthetic or food-producing capacity of the diseased plants is reduced by multiple sheath and
petiole infections followed by leaf loss. Foliage loss and root rots cause large, vigorous plants with the high productivity to decline in a few years and become small, weak plants with the poor flower production. Severely diseased plants of susceptible cultivars are killed.

*Bipolaris incurvata* and other *Bipolaris* species

**Disease** and **symptoms**: Bipolaris causes leaf spots and large rots of the leaf (referred to as blights). The disease begins as small, water-soaked flecks and spots. The fungus continues to grow in the leaf tissue, and the spots enlarge. After two weeks, many spots are 9.5 to 35 mm (3/8 to 13/8 inches) in diameter, oval or irregular in shape, and are yellowed around the spot. The spots are light brown with a darker edge. Holes form on the leaf as diseased tissue falls out. Leaf blisters an unusual symptom, also are formed on the under-surface of the leaf in wet weather. The petiole, sheath and floral bracts also are spotted with faint brown to purplish-red spots. Spotting of floral bracts makes flowers unmarketable.

Infections of young leaves result in deformed, blighted mature leaves. In advanced stages of the disease, leaves become tattered and brown.

*Exserohilum rostratum*

**Disease** and **symptoms**: leaf spots caused by Exserohilum rostratum are similar to those caused by Biplaris. Typical spots are oval and brown with slightly yellow borders. The spots expand into larger blights that kill part of the leaves.

**RHIZOME AND ROOT DISEASES CAUSED BY FUNGI**

*Calonectria spathiphylli*

**Disease** and **symptoms**: This fungus is presently the most widely spread pathogen attacking roots and rhizomes of heliconia in Hawaii. Severe root and rhizome rot kill plants or cause rapid plant decline. Root and rhizome rots of field heliconia start at the center of clumps with old diseased stalks, which are dry and collapsed, and develop outward. New growth is the healthiest and diseased clumps of heliconia have empty circles within the older diseased growth. Root rots prevent proper anchorage, and taller diseased heliconia cultivars are prone to toppling. Biology and spread: Calonectria infects roots and
rhizomes of heliconia and can be found deep within the rhizomes in infected root traces that originate from severe root rots. Fungal spores and microsclerotia move into a field with water (e.g run-off). The pathogen also moves in infested or contaminated soil, especially in mud adhering to trucks, plows other field equipment, tools, boots, etc. the fungus is also transported when infested rhizomes are moved to new fields.

**Phytophthora nicotianae**

**Disease and symptoms:** *Phytophthora nicotianae* has been isolated from rotted roots and rhizomes of *Caribaea*. Healthy, vigorous plants gradually decline over one to three years and then produce few flowers. The disease has been found on Kauai and Oahu. *Heliconia mutisiana* appears to be highly tolerant of *P. nicotianae*. Diseased stems have brown rots at the collar and are surrounded by rotted roots. Within the stem, the rot is blackish-brown.

Phytophthora species produce specialized spores called sporangia which release 20 or more swimming spores when water is abundant. These motile spores aid pathogen movement from one part of the plant to another or over longer distances through irrigation ditches, run-off, and streams. Spherical chlamydospores with thickened walls are formed in diseased tissue. These specialized spores allow the fungus to survive without the host for many months. Contact with spores on diseased plants or movement of infected tissues also transport the pathogen.

**Pythium species**

**Disease and symptoms:** Several pythium species have been isolated from diseased heliconia roots and rhizomes. These include *P. splendens*, *P. aphanidermatum*, *P. myriotylum*, and others. The role of these organisms needs to be investigated further. To date, *P. splendens* appears to be pathogenic, with disease developing slowly over a three-to four-month period. Root rot and slow decline of the plants are primary symptoms.

Moisture and poor drainage greatly favor diseases caused by pythium. Like Phytophthora, most Pythium species produce motile spores which distribute the fungi over greater distances. Other spores, such as oospores, have thickened walls which enable the fungus to survive long periods within the dead plant tissue or in the soil. The pathogen is transported to new locations by the movement of contaminated soil and water or infected plants.
DISEASE CAUSES BY BACTERIA

Pseudomonas solanacearum

Disease and symptoms: The bacterial wilt pathogen Pseudomonas solanacearum causes foliar symptoms that include leaf rolling and wilting, leaf margin firing (browning of edges), and eventual dieback of the shoot. Leaves curl initially due to water stress caused by vascular plugging following infection of roots and rhizomes. As the disease advances in the rhizome, drying and browning of leaf edges occurs, followed by formation of large patches of necrotic tissue towards the midrib. Usually, these symptoms are more pronounced on older leaves. Eventually, the entire leaf turns dark brown with an oily appearance, resulting in leaf loss. Within the rhizome, a dark brown discoloration of the vascular tissue runs longitudinally down the center. Often, a milky ooze is associated with this brown vascular discoloration.

ROOT DISEASE CAUSED BY NEMATODES

Nematodes are microscopic roundworms that inhabit the soil and feed on plants and animals. Nematodes differ from segmented worms (such as earthworms) in morphology, anatomy, and life cycle. Plant- parasitic nematodes cause diseases such as leaf rots, root or rhizome rots, flower or bulb rots, and seed damage.

Disease and symptoms: the major disease symptoms are brown, rotted roots, swollen roots or root knots, and root lesions. Nematode infections of roots may occur alone but sometimes are accompanied by pathogenic fungi such as Calonectria spathiphylli, Rhizoctonia spp., and Pythium spp. Although the relationship between nematodes and fungi on heliconia roots is not well understood, nematode- fungus relationships are known to cause diseases in other crops.

Plants with roots infected by nematodes exhibit symptoms similar to those caused by water stress and nutrient deficiency. These symptoms include yellow leaves, excessive leaf curling and waiting, and poor growth rate. With severe nematode infections accompanied by Calonectria spathiphylli, plants will topple over or fall with minor wind movement because of insufficient anchorage.

Most nematodes complete their life cycle from egg to larvae to adult in about three to four weeks given proper soil temperature, moisture, and aeration. If environmental conditions are not suitable for development, egg can remain dormant for years, and larvae of some species can remain quiescent for long periods.
Nematodes are not very mobile in soil and move slowly within the soil solution that surrounds soil solution that surrounds soil particles. They are spread greater distances by movement of soil on farm equipment and tools, surface water run-off, and infected plant propagation materials.

**Fungal Disease Cycle and Control**

In a typical fungal disease cycle, the pathogen produces spores or other propagules that are spread by various means to healthy plants. These spores germinate, producing fungal hyphae (strands or threads) which then infect the plant. In a susceptible plant, the fungus grows and feeds on the plant by releasing enzymes and absorbing nutrients released from damaged plant cells. The growth of the fungus and the plant damage it causes by its metabolic processes are seen as disease symptoms, i.e., spots, rots etc. The pathogen continues to grow and produce new spores which repeat this cycle. This may occur as soon as a few weeks after infection or many months later. The sexual stage frequently increases the range if disease spread, since ascospores are forcibly discharged into the air, becoming wind-borne. Asexual spores formed early in the disease cycle may also be wind-borne but are primarily spread by splashing water.

All effective disease control methods interfere with one or more elements of this disease cycle. Some of the objectives of disease control are to prevent infection, to prevent pathogen growth after infection, to reduce pathogen movement in the plant, to reduce or eliminate sporulation, and to reduce pathogen level in the environment. These control measures are discussed below:

- Prevention. Clean seed and clean rhizomes will prevent the introduction of pathogens to commercial nurseries. Few heliconias are propagated by seed, but for those for which seed is available, even in very small quantities, a unique opportunity exists for the establishment of clean stock. Seeds collected fresh from the field are generally free of pathogens. The fruits should be washed, rinsed, and dipped in a dilute household bleach solution (10-20% bleach in water) for one minute. Set aside all blemished or rotted fruit. Inspect the seeds for signs of rot, and keep only healthy seeds. Remove the pulp from clean fruits, rinse the seeds, and plant them in moist pasteurized sphagnum moss. Procedures for producing clean rhizomes are as follows; Wash rhizomes well, remove all brown sheath tissue and all roots, and trim the outer layer of the rhizome. Dip in 10-20% household bleach for 1 minute. Plant the cleaned rhizome in clean
Moisture control: In general, moisture is needed for fungal sporulation, spore dispersal, spore germination, and penetration of the fungus into the leaf. For most tropical diseases, the rate at which the fungus grows in the plant (or the rate at which the disease develops) depends on moisture. In general, high moisture favors pathogen growth, especially for those diseases, the rate at which the fungus grows in the plant (or the rate at which the disease develops) depends on moisture. In general, high moisture favors pathogen growth, especially for those diseases caused by Pythium, Phytophthora, Bipolaris and some Cercospora species. Because moisture is so critical to the establishment and progress of disease, controlling moisture will decrease disease levels. Some moisture control suggested are as follows:

- **Grow seedlings and clean rhizomes under solid cover** (Polyethylene film, fiberglass, solid plastic, etc).

- **Increase air movement within the field**: Adjust row direction to produce the best air flow based on wind direction and terrain. Remove dead plants and old leaves to eliminate damp areas. Keep weed low.

- **Prepare the field along contour lines** that will provide good Drainage, avoiding patterns which pond or pool water. Areas with poor drainage are highly conducive to **Pythium** or **Phytophthora** rots.

- **Sanitation**: Keeping the greenhouse or field free of diseased plants will reduce or eliminate pathogens. Severely diseased leaves in the field harbor pathogens and are a source of pathogen spores. Fungi survive in diseased plant tissue and persist in the environment for many months. Removal of pathogen sources will reduce possibilities of continuing the disease cycle.

- **All field equipment should be washed** before moving to a clean field to minimize transporting of pathogens through soil movement. This includes bulldozers, jeeps, and trucks and all tools such as shovels, hoes, picks and sickles. Soil from fields with diseased heliconia may contain pathogen spores or plant tissue containing the pathogen.

- **Adding organic matter**: Adding organic matter to the field generally reduces the severity of root rots. Organic matter provides nutrients and aeration, promotes good drainage, and increases microbial competition. All of these factors can reduce pathogen growth. In some cases, microorganisms inhibit each other, either by micro-parasitism or through competition for
nutrients. Incorporating organic matter before the field is first planted, or adding organic matter to established fields, may reduce root rots in heliconia, especially if the established field is declining severely from root and rhizome rots.

- **Host resistance**: Host resistance uses the ability of the host plant to prevent disease. It is therefore the most economical and best method to control disease, but it usually takes a long time to develop. For many commercially important crops that have been in cultivation for a long time, researchers have identified sources of disease resistance and have added these genes to the plants. Today, biotechnological techniques that allow the transfer of genes from one plant species to another may hasten the development of new crops resistant to serious diseases.

- **Chemical control**: Many chemical pesticides that inhibit or reduce the growth of fungal pathogens have been developed for agricultural crops. Broad-spectrum fungicides such as mancozeb are effective against Bipolaris, Pseudocercospora, Exserobilum, Phytophthora, and others. Metalaxyl is effective against phytophthora and Pytibium.

- **Insect and pest control**: Snail, slugs, insect, rodents and other animals such as pigs will transport spores of fungal pathogens. Large animals such as pigs easily track soil-borne spores from diseased to clean fields. Insects and slugs also carry pathogens because of the microscopic size of fungal spores, thus, populations of these pests in field and on plants should be kept to a minimum.

**BACTERIAL DISEASE CONTROL**

Control measures described in the fungal disease control section also pertain to control of bacterial diseases, with the exception of chemical control. Unlike fungal diseases, bacterial diseases are seldom adequately controlled by chemicals. Prevention and sanitation are the keys to controlling bacterial diseases.

Although heliconia is affected by the bacterium *Pseudomonas solanacearum*, it is helpful to understand the specific bacterial control procedures used for anthurium blight caused by *Xanthomonas campestris* dieffenbacbiae. The general prevention and sanitation control procedures are similar for both heliconia and anthurium, regardless of the bacterial organism.
NEMATODE CONTROL

Innate, endemic vegetation, serious pathogens such as the burrowing nematode are not likely to be present. Thus, the establishment of new heliconia fields with clean rhizomes is crucial. Some guidelines for heat treatment of diseased heliconia rhizomes can be adopted from those for the control of burrowing nematode in banana. For banana, corms are trimmed and all discolored areas are removed. These cleaned corms are placed in hot water held at $50^\circ$C for 10-15 minutes and immediate dipping into cold water to stop the treatment has been suggested. The cleaning process used for banana corms may be used for heliconia rhizomes prior to hot water treatment. In certain tropical countries, some banana fields are flooded for 5-6 months to destroy nematodes and other pathogens. This procedure would have little applicability in volcanic soils but may help in heavy clay soils. Traditionally, soil fumigation has been used to control many types of nematode diseases. These chemicals are becoming increasingly difficult to register for use and many are now unavailable for agricultural uses. Development of bio control strategies is being intensely pursued. Parasites that attack the eggs, larvae, or adults of pathogenic nematodes are being tested in many laboratories, along with new technologies developed to manipulate the complex host-pathogen relationships in ways that reduce susceptibility to disease.

Table 8.1 Disorders, diseases and treatment

<table>
<thead>
<tr>
<th>DISORDERS</th>
<th>DISEASES</th>
<th>TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aerial Disorders</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf spots</td>
<td>Bipolaris and Alternaria</td>
<td></td>
</tr>
<tr>
<td><strong>Shoot Rots</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emerging shoots</td>
<td>Pythium myriotylum</td>
<td>Preicur and fongarid. Avoid water-logging</td>
</tr>
<tr>
<td><strong>Basal Rots</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudostem at ground level</td>
<td>Cyclindrocladium floridanum</td>
<td>No chemical control available. Usually attacks weakened plants, so avoid water-logging which can cause other root</td>
</tr>
</tbody>
</table>
**Soilborne Plants Disorder**

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Cause</th>
<th>Control Advice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilt syndrome</td>
<td>A form species of Fusarium oxysporum</td>
<td>No chemical control available. Clean knives when harvesting flowers, clean planting materials. Never re-plant on diseased ground.</td>
</tr>
<tr>
<td>Rhizome Rot</td>
<td>Cyclindrocladium floridanum</td>
<td>No chemical control currently available. Avoid water-logging</td>
</tr>
<tr>
<td>Root knot Nematode</td>
<td>Meloidogyne</td>
<td>Nematicides not recommended due to cost and toxicity. Organic mulches, e.g., green manures, forage hay incorporated into beds at planting.</td>
</tr>
</tbody>
</table>

**Root Rots caused by poor soil drainage**

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Cause</th>
<th>Control Advice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine-feeder roots</td>
<td>Phytophthora and Pythium</td>
<td>Recommended fungicidal grench, e.g., cropper oxychlorride, fongarid. Avoid planting in wet season. Incorporate gypsum in clay soils to aid in water dispersal. Do not plant rhizomes too deep in beds.</td>
</tr>
</tbody>
</table>

**Factors affecting Flower Quality**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cause</th>
<th>Control Advice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Abrasion due to wind causes brown superficial lesions on peduncles and bracts.</td>
<td>Incorporate wind breaks, e.g., native timber, palms and/or bama grass.</td>
</tr>
<tr>
<td>Biological</td>
<td>Spray-damage due to herbicide drift can</td>
<td>Do not spray on windy days; choose calm weather</td>
</tr>
<tr>
<td>Condition</td>
<td>Recommended Action</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Causendiscolouration of bracts. Poor spraying practices can cause scorch marks and reduce bloom quality</td>
<td>Spray in early morning or late evening, cooler parts of the day. Use correct formulation, concentrations recommended on the label.</td>
<td></td>
</tr>
<tr>
<td>Flower attacked by ants and rodents are not salable.</td>
<td>Aim to reduce pest populations through appropriate trash management.</td>
<td></td>
</tr>
<tr>
<td>Curvularia and Alternaria can cause severe spotting on bracts.</td>
<td>Regular spray program of bravo. Improve aeration during wet season to avoid water build-up on leaves.</td>
<td></td>
</tr>
<tr>
<td>Bipolaris incurvata can cause flower bract spots.</td>
<td>Regular spray of Mancozeb, Rovral and Tilt. Improve aeration during wet season to avoid water build-up</td>
<td></td>
</tr>
</tbody>
</table>
Figure 8-9 Leaf spot in *Heliconia psittacorum* flower caused by *Curvularia*

Figure 8-10 View of *Fusarium* wilt infected *Heliconia psittacorum* plants caused by *Fusarium Oxysporum* spp.

Figure 8-11 Internal vascular discolouration caused by *Fusarium Oxysporium* spp.

Figure 8-12 Base an rhizome rot caused by *Floridanum*
PADDY

Botanical name: *Oryza sativa*

Family: Gramineae

ORIGIN AND DISTRIBUTION

Rice has been cultivated in Southeastern Asia since ancient times. It is believed that it originated in China, but spread very early to India. It is now grown throughout Asia, Southern Europe, Africa, some parts of Australia, North and Central America and South America. Guyana is the greatest producer of rice in the Caribbean and it is one of the chief export crops in Guyana. At first rice was grown on sugar plantations as food for the working force, but became a business in the early part of the twentieth century, largely by East Indians. Guyana started exporting rice to other countries since 1903. In 2013 it produced tonnes and exported tonnes. Venezuela, Barbados and Trinidad are the major importers of rice from Guyana.

ECONOMIC IMPORTANCE

The rice industry has become one of the economic cornerstones of Guyana. It is second to sugar as the most important agricultural industry, contributing approximately 20% of the agricultural GDP and 12% of export earnings. In addition, in excess of 12,000 farmers are involved in rice production and the industry benefits approximately 20% of the population. Rice production has increased from 171,000 metric tonnes (rice equivalent) in 1992 to an all-time high of over 500,000 metric tonnes in 2013. In addition, a wide range of by-products are attained from this agricultural industry, such as in the use of fuel, food for man and animals, fertilizer (potash) and craft.

GROWTH PHASES AND STAGES OF THE RICE PLANT

The life cycle of rice plant may be divided into the following phases:

1. **Vegetative phase**: From germination to panicle initiation.
2. **Reproductive phase**: From panicle initiation of flowering.
3. **Ripening phase**: From flowering to maturity.
These phases may be subsequently divided into different growth stages.

**VEGETATIVE PHASE:**

This phase begins with the seed germination, which is signified by the emergence of radicle or coleoptile in the germinating embryo. During the vegetative phase, the plant undergoes the following stages:

1. **Seedling stage:** This stage follows seed germination and the seedling develops germinal and lateral roots. Seedling stage is generally considered from germination until the plants develop the fifth leaf. During this stage, the seedling absorbs food from the endosperm.

2. **Transplanting stage:** Only the transplanted rice plants undergo this stage. It covers the period of uprooting of the seedling to full recovery.

3. **Tillering stage:** This stage starts with the appearance of the first tiller from the auxiliary bud in one of the lower most nodes. The number of tillers increases, at a point more rapidly (active tillering stage), until the maximum tiller number (maximum tillering stage) is reached. Then some tillers die, the number of tillers declines and level off. The plant stops tillering after the tertiary tillers have been produced.

**REPRODUCTIVE PHASE**

During the reproductive phase, the plant undergoes the following stages:

1. **Panicle initiation stage:** The reproductive phase begins before reaching the stage of producing maximum number of tillers, at about the time of the highest tillering activity or thereafter. This phase is marked by the initiation of the panicle primordial of microscopic dimension on the growing shoot.

2. **Booting and internode elongation stage:** As the young panicle develops, it becomes visible to the naked eye in a few days. This marks the beginning of the booting stage. The time of occurrence of internode elongation stage differs among varieties.

3. **Heading stage:** This stage is marked by the emergence of panicle tip out of the flag leaf sheath. Emergence continues until 90% of the panicles are out of the sheaths.

4. **Flowering stage:** Flowering or blooming begins with the protrusion of the first dehiscing anthers in the terminal spikelet on the panicle branches. Flowering continues successfully until
all spikelet in the panicle bloom. Pollination and fertilization then follow.

**RIPENING PHASE:**

The rice grain develops after pollination and fertilization. Grain development is a continuous process and the grain undergoes distinct changes before it fully matures:

- **Milk stage:** The contents of the caryopsis are first watery, but later turn milky in consistency.
- **Dough stage:** The milky caryopsis turns into soft dough and subsequently into hard dough.
- **Maturity stage:** The individual grain is mature when the caryopsis fully developed in size and is hard, clear and free from greenish tint. This stage is completed when more than 90% of the grains are fully ripened.

**STRUCTURE OF THE RICE PLANT**

Rice is a monocotyledonous annual grass with a fibrous root system. The culm (stem) is rounded and jointed with a series of solid nodes and hollow internodes. The node bears a leaf and a bud. Buds in the axils of leaves at lower nodes grow out to produce tillers. The leaves are borne at an angle on the culm in two rows, one at each node. The blade is attached to the node by the leaf sheath. On either side of the base of the leaf blade are small, paired, ear-like appendages known as auricles. Just above the auricles is a papery triangular structure called the **ligule**. Rice plant has both auricles and ligule, while a common grass weed like Echinochola species found on most rice fields normally has neither auricles nor ligule. This characteristic is often helpful in differentiating between the two plants when they are young.

The **panicle** is a group of flowers borne on the uppermost node of the culm above the flag leaf. The rice grain develops after pollination and fertilization are completed. In paddy 99% of the flowers are self-fertilized. The mature grain is covered by the husk or hull. When the hull is removed, the rice grain becomes visible, which consists of the embryonic shoot (plumule) and the embryonic root (radicle). The plumule is enclosed by a sheath, the **coleoptile**, and the radicle by the **coleorhiza**. The rest of the grain is occupied by the starchy endosperm.
CLIMATE AND SOIL REQUIREMENT

Rice grows over a wide range of climatic conditions extending from 45°N - 40°S. The crop is regarded as one suitable for the wet tropics although it grows in other parts as well. It is generally grown under flooded culture, and sown with the early rains and harvested at the end of the monsoon when dry weather sets in. It needs abundant sunlight particularly during the last 45 days in the field. High yields are usually obtained when there is greater solar radiation at this time, provided there is sufficient water, e.g. warm temperate countries. Low yields are obtained during the wet, cloudy monsoon. Heavy rain at flowering interferes with pollination and excess rain also causes lodging at maturity. The average temperature during the growth season varies from 20°C - 38°C. Lower temperatures during early growth retard seedling development and tillering.

Rice can be grown on many types of soil from sandy loam to heavy clays, provided there is adequate water from rain or irrigation. However, clay and clayey loams, silty clay loams or silt loams are considered more desirable. Clayey soils help to retain water and mineral nutrients better, as there is less percolation and leaching from the soil. Yield is not affected in the pH range 4 - 7.
VARIETIES

During the long period in which rice has been cultivated adaptation has taken place to a diversity of climate, latitude and soils. This has resulted in the evolution of geographical races. There are about twenty four (24) species in the genus *Oryza* of which twenty two (22) grows wild and two (2) species are cultivated. The cultivated species are *Oryza sativa* grown in Asia, Europe and America and the *Oryza glaberrima* grown in Western African countries.

*Oryza sativa* has three (3) sub species. They are the *indica* grown in India, Burma and Sri Lanka; the *japonica* grown in Japan, China, South Korea, Southern Europe, USA and South America and the *javanica* grown mainly in Indonesia.

The *indica* rice is generally adapted to areas with a tropical monsoon climate, where the day length is short. The plant is hardy, tall, with vigorous vegetative growth and high tillering habit. It is susceptible to lodging. The period of vegetative growth is also long. The leaves are broad and pale green in color. The flag leaf is long, narrow and drooping after flowering. It is sensitive to long day length, but resistant to pest and disease attack. It responds poorly to the application of fertilizers, but can grow well under unfavorable conditions. It matures late. The grain is narrow, long and flattened. The cooked rice is non-cohesive.

The *japonica* rice is grown in temperate areas. It is less vegetative, short, with sturdy culms and moderate tillering. It is sensitive to long day length. The leaves are narrow and dark green in color, but the flag leaf is short, fairly broad and remains erect even after flowering. The plant respond well to fertilizers, that is, with additional amount of fertilizers it gives higher yields. It is moderately tolerant to unfavorable conditions but susceptible to pest attacks. The grain is broad, short and thick. The cooked rice tends to be sticky.

Most of the varieties now grown all over the world are crosses (hybrids) between indicas and japonicas. The aim was to combine the high yield and response to heavy fertilizer application of japonica with hardiness and adaptability to tropical conditions of indica. Examples of such a variety bred at the International Rice Research Institute (IRRI), Philippines is cross between *Dee-geo-woo-gen* a short, early maturing Taiwan variety with *Peta*, a tall vigorous, heavy tillering, disease resistant variety from Indonesia. Varieties of rice grown in Guyana prior to 2000 are *Rustic*, *Diwani*, ‘N’, ‘T’, *Starbonnet*, *Guyana 91* and *Guyana 98*. These varieties had occupied about 80 % of the rice lands cultivated in Guyana.
Table 8.2 Varieties of rice and their characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aromatic</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Growth Duration (days)</td>
<td>115-125</td>
</tr>
<tr>
<td>Lodging incidence</td>
<td>0</td>
</tr>
<tr>
<td>% head rice</td>
<td>66.5</td>
</tr>
<tr>
<td>Grain Size (mm)</td>
<td>11.2X2.5</td>
</tr>
<tr>
<td>Disease resistance</td>
<td>Resistant to blast and tolerant to brown spot</td>
</tr>
<tr>
<td>Grain yield (tonne per hectare)</td>
<td>5.5-7.1</td>
</tr>
</tbody>
</table>

CULTURAL SYSTEMS

There are two main systems under which paddy is cultivated, (i) the ‘upland’ or ‘hill rice’ culture where rice is grown as a rain-fed crop if there is adequate well distributed rainfall (not less than 30 inches) for 3 - 4 months. Approximately 10% of world rice is under upland rice culture. Seeds that have not sprouted are broadcast (shy) or row sown (in some parts of Asia) in the field. (ii) ‘lowland’ or ‘swamp rice’ culture where rice is grown on flooded, low lying swamp lands.

The crop is grown in water from the time off planting until the approach of harvest. Under lowland culture sprouted seeds can be broadcast, row sown in the field or sown in nursery bed and seedling transplanted in the field. The main criterion for choice of system is water supply. If water supply is inadequate one could go for upland type. Modifications of these systems such as dry land preparations and sowing followed by flooded culture are also used in some places. Lowland rice culture accounts for 90% of the world production of this crop. The following description of paddy cultivation is concerned with cultivation of rice on flooded fields.
SELECTION, TREATMENT AND SPROUTING OF SEED PADDY

In order to obtain a uniform plant stand of vigorous seedlings in the field and finally a high yield it is important to select good seeds. The seeds must be well matured, full and heavy. It is always safe to use certified seed paddy from reliable sources. The Rice Research Station (RRS) situated in Burma, East Coast Demerara is responsible for the production of certified seed paddy in Guyana. It is a branch of the National Agricultural Research and Extension Institute (NAREI). Certified seed paddy will fulfill the following requirements:

- Germination- 85% minimum
- Purity- 75% minimum
- Inert matter- 4% maximum
- Moisture- 14% maximum
- Weed seeds- not more than 100 seeds per pound of paddy

LAND PREPARATION

In order to hold water and maintain it uniformly in the field, a series of bunds (meres) are built with sloping sides on new land so that the machinery can pass over them without damage. The size and shape of land vary with the topography. In fairly flat lands, the fields may be 0.4 hectare or more in size. During the dry season, or a few days after harvesting the previous crop, the farmer sets fire to the field to get rid of dried rice straw, stubble and weeds.
Before the onset of rains, when there is some moisture in the soil, land preparation begins.

**REASONS FOR LAND PREPARATION**

- To place the soil in the best physical condition for crop growth
- To ensure that the soil surface is left level
- To control weeds
- Fertilizer incorporation before planting requires soil tillage

Land preparation seeks to place the soil in the best physical condition for plant establishment and crop growth, through a combination of tillage practices. As such:

- Soil must be tilled to a depth so plants can develop a root system which will physically support the rice plant and also allow the extraction of sufficient moisture and nutrients so yield potentials can be realized.
- Soil disturbance should be sufficient to control weeds.
- Tillage must leave the soil surface level. Level fields improve water use efficiency and help control in crop weeds. The field also needs a drainage system that will allow the rapid removal of excess water.

In lowland rice cultivation, as in Guyana, land preparation normally involves:

1. **Primary Tillage**

Primary tillage is the first working after the last harvest and normally the most aggressive tillage operation. These operations are normally carried out under dry conditions and may involve:

- First and second cut, using the rome or disc plough at a depth of 4 - 6 inches (10 - 15 cm)
- Harrowing, using the rome or disc plough.

2. **Secondary Tillage**

Secondary tillage is done after primary tillage. It is usually shallower and less aggressive than primary tillage. In situations where there is inadequate rain fall, fields are irrigated to allow for the following secondary tillage operations:
- Harrowing or puddling, using the disc plough.
- Raking and leveling or dragging (henga or drag wood).

After final land preparation (raking and dragging), bunds (meres) are weeded, strengthened, and cracks and holes are sealed with mud. Fields should not be drained when water is turbid as the suspended clay and organic matter will be lost. Fine leveling assist in the control of weeds, even distribution of water and fertilizer in the field and allows for uniform emergence of seedlings, especially in the case of broadcasting. Good land preparation takes about 4 - 6 weeks to be completed.

**WEED CONTROL**

Weeds are one of the causes of low yields in rice. Severe damage is caused, if weeds are not controlled at the early stage (i.e. 3 - 4 leaf stage). Heavy growth of weeds may reduce yields even more than 30 % in lowland fields and up to 75 % in upland fields. Weeds are worse in broadcast crops than when the rice is transplanted. Flooding the paddy field during plant growth and drying the land in the off season control weeds, eliminating aquatic weeds in the off season and dry land weeds when the place is flooded.

The weeds of economic importance in lowland rice fields in Guyana are grouped into three broad categories. These are the grasses, sedges and broad leaf weeds.

**Table 8.3 Weeds and their characteristics**

<table>
<thead>
<tr>
<th>Category</th>
<th>Main Features</th>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>Long narrow leaves with parallel veins</td>
<td>Schoonord grass</td>
<td><em>Echinochloa glabrescens</em></td>
</tr>
<tr>
<td></td>
<td>Round, hallow stem</td>
<td>Mauraina grass</td>
<td><em>Ischaemum rugosum</em></td>
</tr>
<tr>
<td></td>
<td>Two rows of leaves occurring along the stem</td>
<td>Birdseed grass</td>
<td><em>Echinochloa colonum</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monkey tail</td>
<td><em>Echinochloa crus-galli</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red rice</td>
<td><em>Oryza spp.</em></td>
</tr>
<tr>
<td>Sedges</td>
<td>Stems are usually solid and triangle</td>
<td>Jhussia</td>
<td><em>Fimbristylis miliacea</em></td>
</tr>
<tr>
<td></td>
<td>Leaves occur in three rows along the stem</td>
<td>Water sedge</td>
<td><em>Cyperus difformis</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Umbrella sedge</td>
<td><em>Cyperus iria</em></td>
</tr>
<tr>
<td>Broad leaves</td>
<td>Leaves are usually wider than those of grasses and sedges.</td>
<td>Soap bush</td>
<td><em>Sphenoclea zeylanica</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wild clove</td>
<td><em>Ludwigia spp.</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duck weed</td>
<td><em>Sagittaria guyanensis</em></td>
</tr>
</tbody>
</table>
Weed control can be grouped under four broad categories and entails the use of an integrated program which combines the various practices that have a direct or indirect impact on the weed population, (Integrated Weed Control). These practices include:

1. **Mechanical weed control**
   - Land preparation

   As mentioned earlier, ploughing, harrowing, puddling and leveling destroy the initial weed population before the crop is sown and improve the effectiveness of other control methods.

2. **Cultural weed control**
   - **Clean implements and machinery**: This is important, especially when moving from weed infested fields to clean fields to avoiding the transfer and spread of weed seeds.
   - **Keep cattle out of rice fields, where possible**: Many weed species remain viable after passing through the digestive system of cattle.
   - **Choice of variety**: Varieties with good seedling vigour develop an early canopy and compete better with weeds for environmental resources.
   - **The use of weed free seeds**: These seeds prevent the introduction of new weeds into fields as well as re-infestation with weeds that were satisfactorily controlled.
   - **The use of appropriate seed rate**: Plant density contributes to successful weed management. Low plant density encourages weed development.
   - **Proper water management**: Flooding is a very effective method of control of non aquatic weeds. Early flooding or the growing of seedlings through a moderate flood can be very effective. Fields should be relatively level to avoid some areas having too much or too little water.
   - **Field sanitation**: Keep meres, dams and water courses weed free.
3. Manual weed control

- **Rogueing**: Rogue or remove weeds by pulling them out by hand when sparse population exists. This should be done before seeds are produced or mature.

4. Chemical weed control

- Chemical substances used to control weeds are called Weedicides or Herbicides. They are most effective when applied to weeds at the seedling stage.

<table>
<thead>
<tr>
<th>Types of Weeds</th>
<th>Weedicide/ Herbicide</th>
<th>Application Rate (Product/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jhussia, Wild clove, Watersedge and Umbrella sedge</td>
<td>2,4-D Super 2,4-D</td>
<td>284 to 426 ml 400 to 480 ml</td>
</tr>
<tr>
<td>Schoonord grass, Monkey tail, Muraina grasss, Birdseed grass, sedges and some broad leaf weeds</td>
<td>Nominee Nominee Nomina Designee</td>
<td>40 to 60 ml 160 to 200 ml 80 to 100 ml 80 to 100 ml</td>
</tr>
<tr>
<td>Soap bush, sedges and some broad leaf weeds</td>
<td>2,4-D Super 2,4-D</td>
<td>240 to 240 ml</td>
</tr>
</tbody>
</table>

Red Rice is the most serious weed of rice in a number of rice producing countries. It is prevalent in North and South America, and is common in Guyana. The panicle of Red Rice shatters readily before or during harvest so that the paddy field becomes heavily infested with drop seeds, which can grow with the crop to follow and also remain viable in the soil for several years. The red rice lowers the market value of the crop by reducing its quality.

The following are effective interventions in the control of Red Rice:

- Early application of nitrogen fertilizer for early rapid growth.
- Use varieties with early growth vigour for early canopy cover
- Use high seed rate for increase plant competition
- Use pre plant herbicide at tillage to destroy Red Rice seedlings
- After harvesting, burn rice straw to destroy weed seeds on soil surface

COMMON WEEDS OF RICE IN GUYANA

Grasses

Birdseed Grass (*Echinochloa colonum*)

Monkey Tail (*Echinochloa crus galli*)

Muraina Grass (*Ischaemum rogosum*)

Schoonord Grass (*Echinochloa glabresence*)
Sedges

Umbrella Sedge (*Cyperus iria*)

Water Sedge (*Cyperus difformis*)

Jhussia (*Fimbristylis miliaceae*)
Broad Leaf Weeds

Duck Weed (*Sagittaria guyanensis*)

Soap Bush (*Spenoclea zeylenica*)

Wild clove (*Ludwigia erecta*)
NUTRITION OF THE RICE PLANT

About nineteen elements are required for the growth of rice plants, of these Nitrogen, Phosphorous and Potassium are required in large amounts and are referred to as the macro elements.

NITROGEN

Nitrogen is generally regarded as the most important plant nutrient and is supplied in the form of urea. It is:

- generally associated with carbohydrate metabolism.
- required for vigorous vegetative growth
- an important constituent of chlorophyll.

DEFICIENCY SYMPTOMS

- Stunted growth
- Yellowing of leaves and tillers
- Reduced tillering

SOURCES

- Nitrogen applied as fertiliser
- Nitrogen fixation by non-symbiotic organisms
- Nitrogen resulting from the mineralization of organic matter in the soil
- Nitrogen present in irrigated water and rain fall

PHOSPHOROUS

Phosphorous is the second most important nutrient of rice. It is supplied to the crop in the form of Triple Superphosphate (TSP) which contains 46% P2O5. There are other sources such as Mono Ammonium Phosphate (MAP) and Di Ammonium Phosphate (DAP).
FUNCTIONS

- It aids in the stimulation of root growth, hasten crop maturity and improve straw strength
- It is a constituent on nucleic acid and phytins
- Phosphate compounds play essential roles in photosynthesis, the inter-conversion of carbohydrates, amino acids and fat metabolism, biological oxidation, the energy transfer process and a host of other life-process reactions.

DEFICIENCY SYMPTOMS

- Stunted plants with few tillers.
- Narrow leaves and erect shoots, with a dirty dark green colour.
- Younger leaves are generally healthier than the older leaves.
- The presence of a reddish or purplish colour on leaves.
- The number of leaves and the length of the leaf blade may also be reduced.

POTASSIUM

Potassium is supplied to the rice plant in the form of the fertilizer, Muriate of Potash. It contains 60% K2O.

FUNCTIONS

- It plays a major role in photosynthesis and grain filling
- It is associated with the resistance to fungal disease and lodging

DEFICIENCY SYMPTOMS

Dark green leaves with yellowish brown margins, or dark brow necrotic spots appearing first on the tops of older leaves.
CONTROL

The first application of fertilizer is usually done within 18 to 21 days after sowing, if possible. Phosphorus and Potassium should be applied during land preparation. However, Nitrogen (Urea) is usually applied in three splits, ¼, ½ & ¼ of the total amount at 18 to 21, 42 and 60 days after sowing (DAS).

Weed control should be done before fertiliser application.

When urea is applied during standing water, ensure that the water remains in the field for 24 hours to avoid loss due to run off.

If possible, drain the field before application of fertiliser and re-flood 1 - 4 inches 2 - 3 days after application.

Current recommended fertiliser rates:

- Urea 75 kg/ha (1.5 bags/ac)
- Triple Super Phosphate 40 kg/ha (1 bag/ac)
- Muriate of Potash 40 kg/ha (1 bag/ac)

DISEASES OF RICE

In Guyana, 4 fungal diseases are major constraints to rice production.

Leaf blast

Causal Agent: *Pyricularia oryzae*

SYMPTOM

- Lesions varying from small round, dark spots to oval spots with narrow reddish-brown margins and gray white centre.
- Spots becoming elongated, diamond-shaped or linear with pointed ends.
- Lesions have gray dead areas in the centre surrounded by narrow reddish brown
CHEMICAL CONTROL

Treat with fungicide:

- Carbendazim at a rate of 200-300 ml/acre
- Fugi-One at a rate of 200-300 ml/acre

Sheath rot

Causal Agent: *Sarocladium oryzae*

Symptoms:

- The disease affects at booting stage.
- The uppermost leaf sheath enclosing the young panicle shows oblong or irregular spots (0.5-1.5cm long) with grey center and brown margin.
- The boot leaf becomes brownish black and rotten
- Grains ill filled and discolored.
- The disease spreads through airborne conidia.

*Note*: Close planting, high humidity and low temp. (25°C-30°C), injuries caused by earhead bug predispose the plants to infection.
Chemical control

Treat with fungicide:

- Carbendazim at a rate of 200-300 ml/acre
- Fugi-One at a rate of 200-300 ml/acre

Sheath Blight

The disease is soil borne and is problematic in areas where irrigation facilities are abundant.

Causal Agent: *Rhizoctonia solani*

Symptoms:

- Sheath blight disease usually appears in the later growth stages of the plant.
- Appearance of one or more relatively large oblong or irregularly elongated lesions on the leaf sheath.
- In advance stages, centre of the lesion becomes bleached with an irregular purple brown border.
- At severe condition, drying of leaves.
Chemical control

Treat with fungicide:

- Carbendazim at a rate of 200-300 ml/acre
- Fugi-One at a rate of 200-300 ml/acre

Brown Spot

Causal Agent: *Bipolaris oryzae*

Symptoms:

- Infected seedlings have small, circular or oval, brown lesions.
- Infected seedlings become stunted or die.
- Young or underdeveloped lesions on older leaves are small and circular, dark brown or purplish brown.
- A fully developed lesion on older leaves is oval, brown with grey or whitish center with reddish brown margin.
- Infected grains with black discoloration or with brown lesions.

*Note:* Infected seeds give rise to infected seedlings. Fungus spreads from plant to plant by airborne spores.
Chemical control

Treat with fungicide:

- Carbendazim at a rate of 200-300 ml/acre
- Fugi-One at a rate of 200-300 ml/acre

CULTURAL PRACTICES

- Avoid using infected seeds.
- Apply moderate ‘N’ levels (80 - 100 kg/ha) in 3 - 4 splits.
- Avoid excess ‘N’; skip final ‘N’ in sheath blight infected fields.
- Destroy stubbles/weeds, etc.
Exercises

1. What are the major varieties of banana?
2. Which sucker is best used as planting material?
3. Describe how pruning should be done.
4. State any two methods by which Black Sigatoka can be controlled.
5. What is the ideal source for planting suckers?
6. What causes suckers to rot?
7. What is the minimum temperature for heliconia to grow?
8. In what way mulching is helpful in heliconia production?
10. Give one reason rice is an important crop in Guyana.
11. List 3 main varieties of rice grown in Guyana.
12. Describe the land preparation practices done by the farmer before sowing paddy seeds.
13. Name 2 main types of fertilizers applied in paddy cultivation.
14. State the amounts of fertilizers used and at what stages they are applied
15. Name and describe an insect pest which is harmful to the rice crop
16. Describe the layout of a sugar cane field in sugar estates in Guyana. Illustrate by a labelled diagram.
17. How are weeds controlled on sugar estates in Guyana?
18. (a) List TWO chemicals commonly used to control weeds after the setts have been planted in the field.
   (b) Discuss the methods of application of the named chemicals
19. (a) Name ONE major pest of sugar cane.
   (b) List the damage it causes and the methods of control employed.
20. Explain the term ‘ratooning’?
9. **SOIL CONSERVATION**

**SOIL DESTRUCTION**

Soil is normally a rich store house of minerals. These minerals were built up over many centuries from the growth and decay of vegetation. The removal of natural vegetation causes serious problems that can lead to soil destruction.

Soil is mainly destroyed through erosion and burning.

**EROSION**

Erosion is the removal of valuable surface soil by the following agents:

- Rain
- Wind
- Soil type
- Ocean waves
- Tides and currents
- Man

This phenomenon removes organic matter from the soil, pollutes water supply, reduces the fertility of the soil to the point of totally destroying the land.

Natural erosion is always taking place but it is erosion induced by man through mismanagement that causes serious problems.

The types of erosion caused by running water are:

- Sheet
- Rill
- Gully
SHEET EROSION

Surface soil is gradually and uniformly removed from high to lower ground. The soil becomes shallower and less fertile, especially on cultivated land that is cleared of vegetation.

RILL EROSION

This is the flow of water through small channels or rills that were made by the concentrated flow of water.

Figure 9-1 Sheet erosion

Figure 9-2 Rill erosion
**GULLY EROSION**

This is caused by the action of water resulting in the formation of gullies on slopes. This action does not only remove surface soil but also results in greater volume of run-off water.

![Figure 9-3 Gully erosion](image)

**RAIN**

The action of rain drops on sloping soil can cause the soil to loosen and be removed bit by bit. While on level land, the splashing of rain drops causes mud to fill up cracks and pores in the soil. In periods of intense rainfall, the amount of water going into the soil is reduced. There is an increase in the volume of water that will run off.

**WIND**

When the land is bare and the particles become loosened, winds can blow away large amounts of top soil. Winds can wear away rocks as the winds act as a sand blast and blow sand and dust against rocks. Wind erosion is more prevalent on flatter surfaces. It is dependent on the:

- texture and structure of the soil
- degree and intensity of the rainfall
- velocity of the wind
- degree of man's interference of vegetation
- nature of tillage or crop cultivation
- degree of the slope of the land

**SOIL TYPE**

The texture and structure of the soil determine how much water can be taken in or absorbed or drained to lower levels. These activities would determine the extent of run off ocean waves, tides and currents.

The waves of the ocean shift sands on the beach. By tides and currents waves can wash land away by scouring, breaking and rolling away rocks, bit by bit over a long period of time. The sea is forever cutting the shore and washing this soil into it.

**MAN**

Man speeds up erosion by intensive cultivation, over-grazing, logging, construction and mining. In order for these activities to take place, the trees in the forest are cut down. This destroys the natural protection of the soil. Trees normally protect the soil against the force of winds, run-off water and rain splash. Most of the water is slowly absorbed into the soil.

Mismanagement and wrong farming systems such as over cropping, monoculture, and shifting cultivation can result in erosion. When a wide variety of crops are intensively planted for a number of years without a crop rotation system or application of fertilizers, the soil deteriorates. Even the cultivation of one crop over a long period of time leads to soil destruction. In many cases, when a soil becomes infertile, the farmer finds it too expensive to replace the lost nutrients. Valuable minerals such as nitrates, phosphates and potash are lost through erosion.

**BURNING**

Burning of vegetation before cultivation destroys the organic fraction of the soil. It leaves the land unprotected from wind and water. In some places, burning is permitted before the cutting of sugar-
cane. This is to get rid of cow itch, wasps, snakes or other harmful creatures. It is also done to remove cane thrash so that cane cutters could do a faster job.

SOIL CONSERVATION

Soil erosion is caused by the mismanagement of land. In order to control soil erosion, the land must be used in the correct way. It must always be covered with grass, bush, cover crop, trees or mulch. The flow of water must be controlled. These vegetative covers protect the soil and enrich it by supplying humus.

MAJOR SOIL CONSERVATION MEASURES

BENCH TERRACING

This method is to break up the sloping land into steps. A bench terrace is a broad bank of earth, with gently sloping sides contouring the field. The system looks like a set of steps.

The purpose of this soil conservation measure is to reduce the speed and amount of run-off water and to ensure proper land use.

HILLSIDE DITCHING

This method breaks up a long slope into series of short slopes so that the water run off would be interrupted or prevented from running down the slope. Practices employed are:

- The crops are planted between the two hill side ditches. A cover-crop or mulch must be used.
- The ditch is done along the contour of the slope.
- The planting of grass or small trees on the land around a gully.
- Check dams can be built across gullies to reduce the speed with which the water flows.
- Crops can be grown in ridges, which would be along the slope.
- Ridges are similar to terracing but are smaller. This would prevent water from running straight down the hill.
• Contour ploughing along the slope of the land would prevent the formation of rills and gullies.

• Planting different crops in strips which run along the contours helps to control erosion. When one crop is harvested, only a fraction or single band would be exposed at a time. Thus the run-off would be very slow.

• The soil structure should be maintained by ensuring that an adequate amount of humus is present.

MANGROVE

Guyana has a low-lying coastal plain that is below sea-level. This area is therefore very vulnerable to flooding, erosion and overtopping waves. Mangrove vegetation has played and will continue to play an even more important role in protecting sections of Guyana’s coasts.

This is an important function and role of mangroves, and it is the general feeling that the most effective and affordable sea defence is a band of mangroves with a simple earthen dam behind.

While mangrove does not form an impervious layer as masonry wall or earthen embankments, when these trees are fully established they form effective natural vegetation barriers which help to protect the coast.

Mangroves are nature’s sea defence as they dampen the wave action and protect our coastline from the encroaching sea. It also plays a significant role in carbon sequestration, which makes even more important that this precious natural resource is protected, for its valuable role in combating climate change, and as a pillar in Guyana’s sea defence. The mangrove is also used as stain for leather and a good foraging ground for bees.

WHAT ARE MANGROVES?

Mangroves are tropical plants which are found along much of the world’s tropical coasts. They grow in loose, wet soils and in salt water, and are periodically submerged by tidal flows. Mangroves grow in areas that are generally tough for other plants to grow. During low tides, intertidal zones are exposed to air. However, mangroves survive and thrive in these harsh conditions. There are three main species
found in Guyana:

- The Black Mangrove
- The Red Mangrove
- The White Mangrove

They are normally grown at 2.3m – 2.7m above chart data (mud aggregates)

**Exercises**

1. What is erosion?
2. (a) List 4 agents of erosion.
   
   (b) Explain anyone listed above
3. How does man contribute to erosion?
4. List 2 major methods of soil conservation
10. FARMING AS A BUSINESS

Farming, like any other business, requires several items of input, which when used together, result in
the production of specific commodities. Regardless of the type of farming, the main inputs are
land, labour, capital and management. The amount of each used and the skill with which the farm
manager puts them together directly affect the quantity of output (farm product) to be expected.

The occupation of farming is very beneficial to farmers who are good managers of their farms. Large
scale farmers who produce for domestic consumption, as well as for the export market, have found this
profession financially rewarding. They are always looking for new farming enterprises, whereby they
can invest more capital. Each new enterprise offers them challenges which keep them alert and
abreast with modern techniques. Farmers who get this sort of satisfaction are extremely reluctant
to stop farming even though they are aging.

FARM INPUTS

Farmers are always striving to minimize the cost of farm inputs while they try to increase the level of
farm output. The cost of input is distributed among the four main types of farm inputs mentioned
earlier: land, labour, capital and farm management.

LAND

Land is a natural resource. Generally, all farmers need land since farm activities are impossible
without it and are reduced in areas where land is limited. The main purpose of land is to provide
farmers with a site where farm products can be produced. Land should be adequate and suitable for the
purpose. Access roads leading to and from the farm and market place should be in good condition.

The top layer of land commonly referred to as the soil is of vital importance to agriculture. Soil is the
mixture of minerals, organic matter, gases, liquid and a myriad of micro-and macro organisms that can
support plant life.

Sunshine, air, minerals, wild animals and indigenous trees all interact with the soil to make it suitable
for growing crops, some of which will feed livestock.

Supplies of water and electricity should be continuous. In crop production, the best farm lands are in high demand. They are very expensive since high crop yields will be expected. In livestock production, land is needed to produce animal feed, construct pens, barns and garages. Professional farmers must acquire farmlands. This can be done in one of many ways namely:

- **Legacy or inheritance** - Ownership of land by an ancestor is transferred to a relative within the family, from generation to generation.

- **Purchase** - Ownership of land is transferred from one farmer to another by the full payment of an agreed sum of money. When full payment is made, the title of the property is transferred also.

- **Rent** - land is hired and an agreed sum of money is paid for its use during a specified time. The rent for a piece of land is much less than the sale value.

- **Lease** – land is held by the farmer for a fixed known length of time with conditions identified and agreed on. Periods of time specified may be 25 years or 99 years).

Once acquired, farmers should make maximum use of their land so that they get the highest income from it. To do this, land acquired must be carefully and skillfully managed so as to maintain its fertility.

**LABOUR**

Labour can be defined as the work done by human beings during the production process. Farm work is done primarily by labourers, either manually with the use of simple tools and equipment or mechanically by machines. Labourers who work with complex machines are often called skilled labourers. The work of unskilled labourers requires limited amount of training and skill.

Generally, farm labour may be classified as operator labour, family labour and hired labour. With operator labour, the farmer is the only labourer on the farm. He does the farm work and makes all the farm decisions. A farmer's capacity to work and the amount of training and skill he has developed, will determine the quantity and quality of farm work.

Family labour is supplied by the farmer and members of his family. The amount of work done and the quality of work are again dependent on the input of each labourer
Hired labour is the use of labourers other than the farmer and members of his family. Hired labour may be permanent or temporary.

Permanent labourers are available throughout the year on the farm. There is a great demand for temporary labourers during the peak periods of work such as at planting and harvesting time.

Temporary labourers may be paid each day according to the number of hours worked (1 man day = 8 hours) or they may be paid according to the amount of work done (piece -work). With piece-work, labourers can go home as soon as the work is finished.

In paying labourers, farmers must bargain with the workers and decide on an agreed price. The unit of labour is the work of one man for a specified period of time. For example, one man working for one hour has worked 1 man-hour two men working for one hour have worked 2 man hours or one man working for two hours.

The total number of man-hours worked is found by multiplying the number of men by the number of hours worked (i.e. no. of men x no. of hours worked= no. of man- hours). This calculation can be very useful in determining the total cost of labour for a particular job.

**CAPITAL**

Capital as one of the main types of farm inputs can be defined as all farm inputs which are produced by human activity and which can be used in the production process over a period of time. In other words, capital is all man- made productive assets. It includes buildings, machinery, equipment, tools, roads, irrigation, livestock, rations, fuel, fertilisers, seeds, cash, etc.

Farm capital can be classified as fixed capital or working capital. Fixed capital is all farm inputs which have more than one year of useful life (such as building, machinery and equipment). Working capital are all farm inputs which are constantly being used up. They are needed for the everyday running of the farm business. They have one year or less than one year of useful life, (e.g., fuel, feed).

The availability of capital on a farm determines the amount of business to be done there and the type of farming system to be practised. On farms where land is limited, large scale crop cultivation cannot be planned. Farmers may decide to specialise in the cultivation of one crop which they grow intensively to ensure that all land is profitably used.
Intensive farm operations demand high capital input since cash will be needed to acquire machinery, fertilisers and other inputs as well as to pay for labour. The best way of acquiring farm capital is from the farmer's savings.

When farmers have to borrow cash to acquire capital inputs, they need to pay a small cost to the lender for making the money available for such use. This small cost paid on money borrowed is called an interest. The amount of interest to be paid is usually a small percentage of the money borrowed. It is usually an annual payment. However, interest could be paid on a monthly, quarterly or half yearly basis.

**MANAGEMENT**

Farm managers are required to combine the other three types of farm inputs (land, labour and capital) in such a way that they get maximum output on the farm at a minimum cost of inputs. This exercise demands very skillful managers who may be the farmer themselves, as seen on small farms, or qualified personnel, as seen on large farms. To achieve this requirement, managers are expected to do the following:

- Plan farm programmes.
- Make complete budgets for each programme for the farm.
- Ensure all important records and accounts are properly kept.
- Keep informed on current market conditions.

In planning the production programmes, the manager must know what farm inputs are available, decide on what farm products to produce on the farm, how to produce them and how much to produce. To help him/her in deciding which plans to carry out, a manager prepares a complete budget for each programme so that he/she has an estimate of the expenses, total income and net income he/she should be expecting. He/she then analyses each budget and identifies the programmes worth carrying out on the farm.
Table 1 shows Income and Expenditure for a batch of 100 broiler. Study the table carefully.

Table 10.1  Income and Expenditure

<table>
<thead>
<tr>
<th>DATE</th>
<th>INCOME</th>
<th>COST</th>
<th>DATE</th>
<th>EXPENDITURE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DESCRIPTION</td>
<td></td>
<td></td>
<td>DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>2014-04-17</td>
<td>100 broiler</td>
<td>$246,000</td>
<td>2014-02-16</td>
<td>Cleaning agents</td>
<td>$1500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Disinfectants</td>
<td></td>
</tr>
<tr>
<td>2014-02-16</td>
<td></td>
<td></td>
<td></td>
<td>● 2 – 90watt bulbs</td>
<td>$500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• 100 Plastic</td>
<td>$300</td>
</tr>
<tr>
<td>2014-02-16</td>
<td></td>
<td></td>
<td></td>
<td>Transportation for</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• shaving</td>
<td>$2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Feed and broilers</td>
<td>$2500</td>
</tr>
<tr>
<td>2014-02-17</td>
<td>105 broilers</td>
<td>$18,900</td>
<td>2014-02-17</td>
<td>6 pks Broiler booster</td>
<td>$6000</td>
</tr>
<tr>
<td>2014-02-17</td>
<td>3 bags - 45 kg broiler starter</td>
<td>$18,000</td>
<td>2014-02-17</td>
<td>5 bags – 45kg grower</td>
<td>$29,000</td>
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<tr>
<td>2014-02-17</td>
<td>20 bags – shaving</td>
<td>$2000</td>
<td>2014-03-17</td>
<td>Electricity</td>
<td>$3500</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2014-04-17</td>
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<td>$2500</td>
</tr>
<tr>
<td>2014-04-17</td>
<td>Labour</td>
<td>$21,000</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>$246,000</td>
<td></td>
<td></td>
<td>$107700</td>
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</tr>
</tbody>
</table>
The net income can be increased with the efficient use of labour. More broilers raised per man-hour means more total income. The farm manager may decide to increase broiler production by rearing 5 times as many broilers. The net income will increase to $691,500 ($138,300x5) for the same period of 42 days. In addition, 3 batches of broilers can be produced annually using the same buildings and equipment.

Hence, the annual net income for a 500 broiler unit can be calculated ($691,000x3) $2,074,500.

Preparation of a good budget can help a farmer to obtain a loan for the purpose of financing his/her production programme. Although farm managers may have good budgets and the capital requirement for the production programme, if he/she does not supervise labour and ensure that the programme goes according to his/her plans, the enterprise can suffer tremendous loss of income through time wasting and costly mistakes made because of lack of knowledge.

Very often a good manager ensures that there is a good system in place for him/her to communicate important instructions and messages to his/her workers and also for workers to communicate problems and successes to him/her. A good communication system also allows for communication among workers. The need usually arises for the manager to plan training sessions for farm workers so as to increase their skill in doing farm work. When this is done, money is not paid for bad jobs and the need to employ new workers regularly is reduced.

In order to construct good plans and accurate budgets, the manager needs the use of reliable and specific information. This information he/she obtains by studying farm records and accounts of previous farm projects. For such information to be reliable, records must be accurate, neat and complete. They should be made up as soon as possible after the transaction or operation. Regular checking increases the accuracy of the records. All quantities to be entered into a record should be accurately measured and not estimated.
Some basic records kept by farmers are:

**FINANCIAL RECORDS**

- Profit and Loss Account
- Produce used in the Home Account
- Monthly Cash Flow
- Cumulative Cash Flow Plan
- Sales Book

**PRODUCTION RECORDS**

- Crop Production
- Crop Record Book
- Plant Propagation Record
- Orchard Crop Record
- Livestock Production
- Egg Production Record
- Milk Production Record
- Breeding Record
- Fattening Record

**INVENTORIES**

- Inventory of Tools and Equipment
- Inventory of Agricultural Chemicals
- Inventory of Livestock
• Inventory of Feeds
• Inventory of Crops
• General Farm Inventory

LABOUR
• Wages Book
• Weekly Time Sheet
• Individual Labour

Most of all, the farm manager must be aware of the existing market conditions as it relates to the demand for specific products, the quantity supplied on the market and the unit price for each product. If farm records are available with this information for previous products, then he/she can study them, identify marketing trends and predict what the market condition would be for a given product, if everything else remains the same. When a glut of a particular commodity is expected, the manager may decide not to produce that commodity but execute another of his/her farm plans which will be more profitable.

INPUT - OUTPUT RELATIONSHIP

The basic farm inputs referred to earlier in this chapter are land, labour and capital. Recall that the farm manager is required to use these inputs to produce farm products or outputs. As a manager, he/she needs to decide how much of each input to use in the production process to give a specific output level. More importantly, in his/her efforts to increase output level, he/she must know what level of input he/she must use. To answer these questions, many managers do small field experiments. Table 10.2 shows figures a manager got in his/her field experiment when he/she wanted to find out how much fertilizer he/she must apply to his/her field so as to get maximum output of corn.
Table 10.2 Relationship between fertilizer application and crop yield.

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Input of fertilizer (kg)</th>
<th>Output of corn (kg)</th>
<th>Increase in output (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>440</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>500</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>580</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>680</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>680</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>42</td>
<td>640</td>
<td>-40</td>
</tr>
<tr>
<td>8</td>
<td>48</td>
<td>560</td>
<td>-80</td>
</tr>
</tbody>
</table>

In designing this experiment, 8 plots with the same area were identified on the same block of land. The same number of labourers worked on each plot and the same treatment was given to each plot, except that they were given different amounts of fertilizer. Table 10.2 shows that Plot No. 1 was given no fertilizer treatment but it yielded 400 kg of corn. Plot No. 2 was given 12 kg of fertilizer and yielded 440 kg of corn, showing an increase in output of 40 kg. As the level of fertilizer application to the plots increased by 6 kg, the output of corn continued to increase until 36 kg of fertilizer was applied. At that level of production, 6 kg of fertilizer was wasted because it did not increase the last output. Although 6 kg more of fertilizer was applied, the output of corn failed to increase, instead it decreased from 680 kg to 640 kg. The farmer got 40 kg less than the maximum output level of 680 kg corn. The table shows that since the maximum output level of corn was reached, increase in fertilizer application was wasted since output of corn continuously dropped. This means that the farmer is incurring great loss to the business by increasing the cost of fertilizer unnecessarily.
FARM INCOME

Farm income is the term used to describe all money coming into the farm business. It includes money obtained from the following sources:

- Sale of farm produce (crops, meat, milk, eggs, weaners etc.)
- Farm produce consumed by the farm family (money coming into the business is equal to the current market price of produce consumed)
- Inventory changes (increase) that means there is an increase in the net worth of the business when the inventory is balanced.

The total farm income is the sum of all income values.

FARM EXPENDITURE

Farm expenditure or farm cost can be described as the payments which must be incurred by farm managers in order to ensure the production of goods. Payments are made for inputs.

This cost is subdivided into Fixed costs and Variable costs. Fixed costs are payments which do not vary with changes in the level of output. These costs have already been incurred in the farm operation even if the inputs are not in use, e.g., payments made for machinery and land. If the farm manager decides not to use machinery, for a period or not to cultivate any crop for a season, and payments were already made, the cost of depreciation and maintenance of machinery must be taken into consideration in calculating the net income of the farm. Similarly, the costs are still incurred when the decision is to maximise cultivation. Variable costs are those payments which will vary with changes in the level of output. As more land is cultivated, output level is expected to increase and cost of fuel, fertiliser, seeds, etc increase since larger quantities are required. Similarly, if only a small area is cultivated, output level is expected to be reduced and cost of input items is also reduced, since smaller quantities are needed. Total expenditure or cost is the sum of the total fixed cost and total variable cost.

NET INCOME

Net income can be calculated by finding the difference between the total income and total cost. This difference may be positive or negative. A positive difference indicates that the farm has made a surplus. A negative difference indicates a loss.
Exercise

1. What are the main types of farm inputs?
2. Explain the different types of farm labour.
3. Explain the importance of each farm input.
4. What are some basic farm records to be kept?
5. List 3 types of farm inventory.
6. How is net income calculated?
7. Differentiate between fixed and variable cost
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorption</td>
<td>The movement of digested food across the mucous membranes of the small intestines into the blood capillaries.</td>
</tr>
<tr>
<td>Alveolous</td>
<td>A hollow ball of cells.</td>
</tr>
<tr>
<td>Ammonia</td>
<td>A colourless alkaline gas with a penetrating odour. Its chemical formula is NH₃. It is soluble in water.</td>
</tr>
<tr>
<td>Amylopsin</td>
<td>An enzyme secreted by the pancreas; it splits starch and dextrin to maltose.</td>
</tr>
<tr>
<td>Assets</td>
<td>Property owned by the business.</td>
</tr>
<tr>
<td>Bacteria</td>
<td>A large group of widely distributed one-celled, non-spore forming micro-organisms which may appear singly or in colonies as spherical, rod-shaped or spiral thread like cells.</td>
</tr>
<tr>
<td>Breding</td>
<td>Mating a mature male animal with a mature female with a view to produce an off-spring.</td>
</tr>
<tr>
<td>Bulk</td>
<td>The capacity of food to form a heavy mass in the intestine.</td>
</tr>
<tr>
<td>Carcass</td>
<td>Dead body of animals</td>
</tr>
<tr>
<td>Castrate</td>
<td>To remove or destroy the gonads (ovaries and testes).</td>
</tr>
<tr>
<td>Chromosome</td>
<td>Thread-like structure appearing in pairs in the nucleus of acell. It carries genes along its structure. Genes contain the genetic material of an individual.</td>
</tr>
</tbody>
</table>
Glossary

Cost - Payments made by the farm manager for farm inputs which are needed to ensure the production of goods.

Dam - Female parent.

Demand - The quantity of produce that consumers are willing to purchase at a given price per unit at a particular time.

Degenerate - To change from a higher form to a lower form of existence.

Diaphragm - A muscular membrane which separates the abdominal cavity from the chest cavity.

Digestion - The process of physical and chemical break down of complex food into simpler substances.

Disaccharide - One group of sugars which are composed of 2 monosaccharides.

Dressed weight - Weight of carcass with intestines, offals and sometimes the skin removed.

Ejaculation - Sudden or rhythmic discharge of spermatozoa and seminal fluid from the male.
Glossary

Embryo - The stage of development of an individual between conception and the completion of organ formation.

Enzyme - An organic compound which is usually a protein and is capable of accelerating or producing, by catalytic action, some change in a substrate.

Faeces - Excrement discharged from the rectum.

Fatty acid - A group of compounds which have the chemical formula CH₃, (CH₂)ₙ, COOH. It usually combines with glycerol to form glycerides or fats.

Fertile - Capable of producing off-springs.

Fertilization - The union of a fertile sperm and a mature egg.

Follicle - A structure of the ovary which contains the ovum and its encasing cells at any stage of development.

Foetus - The development of mammal between completion of organ formation and birth.

FSH - Follicle stimulating hormone is produced by the anterior pituitary gland of the brain. It stimulates the growth and maturation of Graafian follicles in the ovary and stimulates the production of spermatozoa in the testes.
Glossary

Gland - A collection of cells specialized to secrete or excrete materials not related to their ordinary metabolic needs.

Glucose - The primary sugar in the blood. Its chemical formula is \( \text{C}_6 \text{H}_{12} \text{O}_6 \). It is used in the making of energy, lactose, RNA and glycerol. It is a mono-saccharide.

Glycerol - A 3-carbon molecule \( \text{CH}_3\text{OH, CHOH, CH}_2\text{OH} \) which normally contains 3 fatty acids to form a triglyceride.

Gonad - A gamete producing gland, e.g., an ovary or a testis.

Hormone - A chemical substance produced in the body by an organ or cells of an organ. Hormones regulate the activity of specific organs.

Infertility - The capacity for reproduction is reduced but not eliminated.

Invaginate - To fold one portion of a structure within another part of it.

Labour - Physical energy used in production.

LH - Luteinizing Hormone is produced by the anterior pituitary gland of the brain. It acts with FSH to cause ovulation of Graafian follicles and the secretion of oestrogen by the ovary. It helps
Glossary

in corpus luteun formation. In males it stimulates the development and function of the interstitial cells.

Masticate - The act of chewing.

Off-spring The young of an animal

output - The quantity of produce arising from the production process.

Pasture grazing - Allowing animals to go into the pasture to graze.

Pepsin - An enzyme which splits proteins into polypeptides in the stomach.

Pepties - Short chains of amino acids

Penis - The male organ of copulation and of urinary excretion. It consists of a root, body and glans penis.

Polypeptide - A small peptide that contains a chain of many different amino acids or protein.

Protein - A class of compounds which is composed of many amino acids which contain carbon, hydrogen, oxygen, nitrogen and sometimes sulphur.

Puberty - The period during which secondary sex characteristics are developed and animals are capable of sexual reproduction.
**Glossary**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putrefy</td>
<td>To decompose with a foul smell</td>
</tr>
<tr>
<td>Quarantine</td>
<td>A period of isolation imposed on persons or animals that have arrived from elsewhere, or were exposed to and might spread, infections or contagious diseases.</td>
</tr>
<tr>
<td>Ruminate</td>
<td>Chew the cud; re-masticate a bolus of food which has been regurgitated from the rumen.</td>
</tr>
<tr>
<td>Scalding</td>
<td>Loosening the hair and scruff from the skin.</td>
</tr>
<tr>
<td>Scraping</td>
<td>Removing hair and scruff from the body.</td>
</tr>
<tr>
<td>Scrotum</td>
<td>An external pouch which contains testes and accessory duct.</td>
</tr>
<tr>
<td>Sire</td>
<td>Male parent.</td>
</tr>
<tr>
<td>Starch</td>
<td>Carbohydrate with the general formula ((C6H10O5)n) from any plant tissue.</td>
</tr>
<tr>
<td>Sterility</td>
<td>The inability of an organism to produce offspring.</td>
</tr>
<tr>
<td>Stimulus</td>
<td>A change in the environment which evokes an action.</td>
</tr>
<tr>
<td>Subsidy</td>
<td>Financial assistance given by a government, organization or person to reduce cost.</td>
</tr>
</tbody>
</table>
Glossary

Subsistence farmer - A farmer who produces for his own consumption.

Urea - A white crystalline substance found in urine, blood and lymph. It is the final product of protein metabolism in the body. Artificially made urea can be used by bacteria in the rumen as a source of nitrogen for building protein in the body.

Vulva - The external genitals of the female.