

**COURSE  
GUIDE**

**ACP 301  
ARABLE CROP PRODUCTION**

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## MODULE 1

### **GRAMINEAE (POACEAE) (10,000 SP.)**

#### 1.0 INTRODUCTION

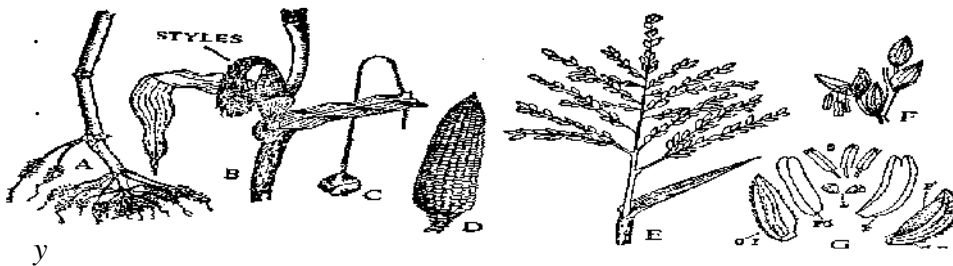
#### 2.0 OBJECTIVE

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##### 3.1 Botany of Gramineae

Habit—herbs, rarely woody, as bamboos. They are very widely distributed all over the earth. Stem cylindrical with distinct nodes and internodes (sometimes hollow), called *culm*. **Leaves** simple, alternate, distichous, with sheathing leaf-base which is split open on the side opposite to the leaf-blade; there is a hairy structure at the base of the leaf-blade, called the *ligule*. **Inflorescence** usually a spike or panicle of spikelets (FIG. 74); each spikelet consists of one or few flowers (not exceeding 5), and bears at the base two empty bracts or *glumes*, ( $G_1$ ;  $G_n$ ), one placed a little above and opposite the other; a third glume called *lemma* or flowering glume stands opposite glume II; the lemma encloses a flower in its axil; it may have a bristle-like appendage, long or short, known as the *awn*; opposite the flowering glume or lemma there is a somewhat smaller, 2-nerved glume called *palea*. The spikelet may be sessile or stalked. Flowers usually bisexual, sometimes unisexual, monoecious. Perianth represented by 2 or 3 minute scales at the base of the flower, called the *lodicules*; these are regarded as forming the rudimentary perianth. Androecium—stamens 3, sometimes 6 as in rice and bamboo; anthers versatile and pendulous. Gynoecium—carpels generally considered as (3), reduced to 1 (according to some authors) by their fusion or by suppression of 2; ovary superior, 1-celled, with 1 ovule; styles usually 2 (but 3 in bamboos, and 2 fused into 1 in maize, rarely 1), terminal or lateral; stigmas feathery. Fruit a caryopsis. Seed albuminous. Pollination by wind is most common; self-pollination in a few cases, as in wheat. *Floral formula*— $\frac{P}{L} \frac{G_1 G_n}{G_3} \frac{A_3}{A_3} \frac{C_3}{C_3}$  or  $\frac{P}{L} \frac{G_1 G_n}{G_3} \frac{A_3}{A_3} \frac{C_3}{C_3}$  *Gramineae*. FIG. 74. A, spikelet of a grass; B, floral diagram of the same. G<sub>1</sub>, first empty glume; G<sub>n</sub>, second empty glume; FG, flowering glume; P, palea; L, lodicule; stamens and carpels of the florots are apparent.

**Examples.** [The larger genera are: *Panicum* (over 500 sp.), *Digitaria* (over 350 sp.), *Aristida* (over 300 sp.), *Eragrostis* (300 sp.), *Paspalum* (250 sp.), *Poa* (over 200 sp.) *Stipa* (over 200 sp.), *Andropogon* (200 sp.), *Agrostis* (over 150 sp.), *Sporobolus* (150 sp.),



spadix in the axil of a leaf; C, female spikelet; D, ripe cob; E, a panicle of male spikelets; F, two pairs of male spikelets; and G, a male spikelet "dissected out—GI, first empty glume; Gil, second empty glume; P", palea of the lower flower, FG, flowering glume; P, palea of the upper flower; L, lodicules; and S, three stamens of the upper flower.

and *Pennisetum* (130 sp.)]. **Cereals** such as rice (*Oryza sativa*— FIG. 75), maize or Indian corn (*Zea mays*—FIG. 76), wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), oat (*Avena*

### MAIZE OR CORN

Maize, or corn, is one of the main cereal staples of West Africa. It originated in the American continent, probably in Guatamala or Mexico. Maize is an important food crop grown in much of Nigeria, Ghana and to a lesser extent in Sierra Leone. It can be grown in areas with a rainfall higher than 760 mm a year. In drier areas, guinea corn is grown instead of maize. The grain is prepared in different ways to be eaten by man. It can be boiled or roasted, or made into a paste which is eaten by adults or by children who are being weaned. It is also

used to make and in Nigeria and and in Ghana. A popular refreshment called or popcorn is eaten all over West Africa. Industrial [uts.es](http://uts.es) include the production of breakfast cereals e.g. corn flakes, corn oil, glucose, starch, fuel for cars and alcohol.

Maize forms the base of most livestock feeds and is particularly relished by poultry, cattle and pigs. It can be made into silage.

The quality of maize determines its uses. If the grain is to be used as seed, it should be pure, alive, have a good yield and be free from disease and insect pests. If the grain is to be eaten by man or livestock, a high protein content is desirable and it must taste good.



### 3.1.1.1 CLIMATIC AND SOIL REQUIREMENT

Maize grows best on a rich, well-drained, neutral or alkaline soil because maize uses large quantities of nutrients from the soil. Yield can be increased by the application of nitrogenous and phosphatic fertilizers. A rainfall of 760 - 1520 mm per annum is adequate, although it is possible to obtain good yields with only 460 - 760 mm of rainfall, if it is evenly distributed during the growing season. There are many different varieties of maize grown in West Africa (Only Dent and Flint types — see below are grown in Ghana). All types of maize are eaten directly or indirectly by man. The best known varieties used in breeding programmes in Nigeria include the following: Lagos White, NS-1, NS-4, NS-5, Eafro 231, Bende Local, Calabar Local, Ikom White, etc. Maize types may however be classified for commercial purposes as follows:

(i) **Dent maize-** The grain contains soft starch granules which are less densely packed than in other types of maize. This results in the shrinkage of the starch within the outer layer of the grain. The grain is thus characterized by an indentation at the distal end. Dent maize has either a yellow or white grain. The most popular varieties of Dent Maize are TZB (FARZ - 34), TZB (FARZ -27 and 096EP6) (FARZ - 23).

ii) - **floury maize** The floury maize seed (or grain) consists largely of soft starch which is surrounded by the corneous layer under the pericarp. This maize is grown mainly in the most southerly parts of Nigeria. Some varieties are-. Lagos White, Bende Local, Ikom White and Akwete Local, all of which are used in the breeding programmes in Nigeria.

(iii)**Flint maize** This variety has very little soft starch in its grain (unlike Dent corn). Some varieties of this maize are NS-1, Diacol-V-153 and Samaru 123.

(iv)**Popcorn:** This is an extreme form of Flint maize. It has small kernels (grains) on a small ear. It is fried in oil to make . The starch granules are enclosed in a very tough and elastic membrane. When heated this tough membrane resists steam pressure until it explodes.

(v) **Sweet maize**-. This is valued for its sweet flavour. This variety has a much higher sugar content than all the other types, and it is usually boiled or canned. The variety recommended in Nigeria is USDA-

### **3.1.1.2 CULTIVATION**

Before sowing the maize seeds, the land is cleared and tilled. In West Africa, maize seeds are sown by hand in hills or ridges made with hoes, or on flat land. Tractors, ploughs and harrows are used for tilling and sowing on government farms, research stations and by some individual farmers. The seeds are sown 2-4 cm deep at a spacing of 40 cm along the row. The space between rows is 90 cm. Usually, 25-30kg of seeds are sown per ha for one crop. (The amount of planting material used for an area of land is called the seed rate.) Two or three seeds are sown per stand (hole). When the seedlings are 1-5 cm high, they should be thinned if necessary to one or two seedlings per stand. (Thinning is the removal of extra seedlings from a stand. It should be done after rain when the soil is moist, and when it is easy to remove the weakest plants and press the soil firmly round the remaining plants).

Maize is often intercropped with yams or cowpeas. In this case the spacing is wider, and the average distance between the row is 180 cm.

In much of West Africa there are two distinct rainfall peaks, so two crops of maize can be grown in one year. The planting date for early maize is March - April, and for the late crop, August -September. In northern areas with one rainy season only one maize crop is grown, and planting is done in June. The maize is interplanted with guinea corn.

The seeds begin to germinate after four days.

### **3.1.1.3 WEEDING**

The first weeding is done about two to three weeks after planting and two more weedings are done at equal intervals of fifteen days thereafter. The method of weeding that is used is to hoe upwards from the furrows towards the top of the ridges, so the soil is heaped up around the plant. Chemical weeding can be done by applying Atrazine, a selective herbicide for maize, at 1g per 5m<sup>2</sup> or at 2kg per ha immediately after sowing or ten days after sowing. Thereafter no weeding is required. Atrazine however has five to six months residual effect, hence only maize or sorghum can be grown after the first maize crop which lasts for



approximately 100 days. Primextra is also applied to control weeds on a maize farm. As the maize plants mature, they first produce the male inflorescence or tassels at the top of the plant and then the female flowers below. The stigmas of the female flowers are called silks. Because the tassels shed their pollen before the silks mature, cross-pollination usually occurs. Maize is harvested by hand fourteen to twenty weeks after sowing, depending on the variety and the climate.

#### **3.1.1.4 HARVESTING**

The cobs can be harvested green twelve to fourteen weeks after sowing, before they are fully mature. This practice reduce yield.

#### **3.1.1.5 STORAGE**

Maize cobs are usually stored after being dried to eleven to thirteen per cent moisture content under the leaves of houses or on the rafters or beams of huts. The smoke from the\* cooking fire below prevents pests from attacking the maize, but maize can be stored in this way for a limited time only. If the grains are taken off the cob, they are usually stored in earthenware containers, or in bins made of earth or plant material, raised from the ground and covered with a thatched roof. These containers' should be tightly sealed to prevent pests from entering.

Farmers who have formed cooperative sometimes build Silos to store dry grains. The grains are dried to ensure good storage and chemicals are sprayed to kill any pests or diseases already present.

#### **3.1.1.6 DISEASES**

***Maize Rust*** This is the commonest disease and is caused by a fungus. It can be avoided by planting resistant maize varieties.

***Corn Smut*** This is another fungus disease which attacks the leaves, stems, tassels and cobs, forming tumors of black spores. Infected plants should be uprooted and burnt.

***Streak***- This is caused by a virus which is carried by insects called leafhoppers. It causes yellowish streaking of the leaves and the plants become stunted or deformed. All infected plants should be uprooted and burnt.

## **PESTS**

Pesticides applied to control insect infestation include Cymbush, Furadan, Monocrotophos 4. Some of the most important pests of maize are listed below:

**Army worms.** These pests eat young plants. They can destroy the crop if uncontrolled. Spraying with Vetox 85 can control the pest.

**Stem borer:** These are insects which bore into stems or eat the growing points of maize. They attack the late crop particularly. Spraying with Attacke 2.5C will kill most of the insects. Infected plants should be burnt. Crop rotation will reduce the incidence of this pest.

**Weevil:** These are pests of stored maize. Storing maize cobs in the rafters of a smoky room will prevent weevil attack. Storage and fumigation of shelled or threshed grains in silos (aluminium or concrete) or polythene bags are very effective control methods. The commonly used fumigant (insecticide) is Phostoxin. It is available in a tablet form and a single tablet is enough to treat a 25kg of maize in an air-tight polythene bag. While the insecticide kills the insects present in the grains at the time of storage, the aluminium, concrete walls and polythene bags prevent a re-infestation by other insects. Farmers used to apply DDT (dichloro diphenyl trichloroethane), Endrin and Gammalin 20 to control these pests. However, they have all been banned because of their toxicity persistence in the environment, and their ability to accumulate in living tissue.

### **Other non-insect pests are:**

(iv) Birds: Bird damage is particularly common in Liberia on high-yielding maize varieties which do not have tough husks. Varieties that are resistant to bird damage are being bred and there are five, namely CArgil 5005, Cuban Maize and Tinchin No. 5

### **3.1.2 RICE (*Oryza sativa*)**

Rice, originated in an area extending from Central India to China and has become the world's most important cereal. It is the most important staple food in Liberia, Sierra Leone, Guinea, The Gambia and Senegal where it is eaten every day and sometimes twice a day. It is widely cultivated along the Scarcies and on the Bolis of Sierra Leone, Nzima in Ghana, the riverain regions and savanna area of northern Nigeria, and on the coastal plains of Guinea Bissau. In West Africa about 60 per cent of rice is grown under rainfed or upland conditions. Considerable areas with deep water or floating rice are also found in parts of Mali and

Nigeria. Rice production is dispersed over the whole of Liberia mainly as upland rice. Total annual rice production in West Africa in 1972 was about 1.5 million tonnes, while consumption was about 1.9 million tonnes. This necessitated the importation of about 400,000 tonnes of rice annually into West Africa.

To achieve self-sufficiency in rice, which is possible because of the land?

and water resources of West Africa and because the climate is suitable for rice production, the West Africa Rice Development Association (WARDA) was established on 1st December 1971. The headquarters of WARDA was initially in Monrovia, Liberia, but later moved to Bouake, Cote d' Ivoire. The members of the association are as follows: the Republic of Benin, The Gambia, Ghana, Cote d' Ivoire, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Burkina Faso. Guinea Bissau became an associate member in 1975. Production of paddy rice at the time of the establishment of WARDA was 1, 733, 500 tonnes. This rose to 2, 365, 000 tonnes in 1975 - 1976. Rice production in Nigeria alone is now 4.1 million tonnes.

Rice is eaten by man, cattle and poultry and is also used in the manufacture of starch, wine and beer.' Rice has good storage qualities and can be easily transported from one place to another.

### **3.1.2.1 CLIMATIC REQUIREMENT**

Rice is grown in tropical, sub-tropical and temperate regions. It grows well on light or heavy soils with a pH ranging from 4.0-8.0, provided adequate quantities of water are available. The upland types of rice will grow well in areas with 760-1270 mm of rainfall per annum. Irrigated rice has been grown all the year round at, for example, the International Institute of Tropical Agriculture, Ibadan, Nigeria

These differ in shape, size and colour of grains, and in the presence or absence of awn (the slender bristles at the end of the stalk). West African rice types are brown, yellow or red. Before the introduction of *Oryza sativa* some eighty-four years ago, 'red' rice, derived from the indigenous West African cultivated species, *Oryza glaberrima* was grown. *Oryza glaberrima* is still grown on unprepared plains in Mali, Sierra Leone and Nigeria where in 1959 it accounted for 20 per cent of the crop. This rice is fairly drought resistant, grows well under a good water regime especially when suddenly flooded, has a short enough cycle to

allow production even when the flood waters subside very early, and it manifests dormancy at maturity, thus preventing germination under water if the flood water subsides late. However, because of poor response to nitrogen fertilizer and little resistance to shattering, its yield is not high.

The maturity for rice varieties grown in West Africa ranges from 80 to 200 days and they are classified as short duration (90-120 days), medium (120-150 days) and long (more than 150 days) duration rice. The main types grown are swamp, upland and floating rice.

#### (i) Swamp Rice

Varieties of swamp rice are grown in mangrove, inland swamps or under irrigation. The recommended varieties with high yields are:

**For Irrigated Rice.-** IR5 in Liberia, Nigeria, Ghana, Sierra Leone and Cote d' Ivoire: FARO 15, 16, 19 and 21 and SML 140/10 in Nigeria: IR8 in Nigeria, Senegal and Cote d' Ivoire: BD2, CP4 and IR20 in Sierra Leone,- IR20, SML Alupi and SML Awini in Ghana; Sintane diofor, CICA 4, D52-37 and C74 in Niger,- Ikong Pao, IR20, DJ346D and DJ684D in Senegal,-and Sintane diofor, H7, C74, IR20 and Gambiaka in Burkina Faso. WARDA s best varieties are IRI 529 - 680 - 3, Vijaya, Ikong Pao, IR20 and CICA4.

**For Dip Flooded Conditions** D52-37 in Niger, Mali and Senegal; Ebandioulaye and Bentoubala B in Senegal; Oma Rosso and L78-9148 in Ivory Coast; FARO 14 iiv Nigeria,-and Sigadis, HFG — 98 and Gambiaka Kokum in Mali, WARDA recommends AA8A and Phar Com En.

#### **For Mangrone Swamp Condition**

ROK5, Mange 2, BD2, CP4, RH and SR26 in Sierra Leone, and SR26 and XA228 in the Gambia. These varieties can be grown on normal farmland with adequate rainfall. The best varieties are Agbede, E-425, Oshodi and OS6 (Ofada) in Nigeria,-Anethoda in Sierra Leone; LAC23 and LAC5 in Liberia, Palawan, OS6, and C21 in Ghana, Moroberekan, Iguape Cateto and Dourado Precoce in Cote d' Ivoire,- 63-83 and Ikong Pao in Senegal; and Dourado Precoce in Burkina Faso. WARDA recommends IRAT 10,

#### **3.1.2.2 FLOATING RICE**

Grows in water which is 1 50 cm or more deep. This type of rice is particularly important in Mali, Niger and Nigeria. The best varieties are Malobadian, Nang Kiew, Khao Gaew and Mali

Sawn in Mali; FRRS-43/3. I.C.B., FARD 14, nas Mali-Ong in Nigeria; and Radin China in Sierra Leone. Others recommended by WARDA are Neang Kheaw 5, Cula and Indochine.

### **3.1.2.3 CULTIVATION**

It is advisable to use pure seeds for planting (i.e. seeds which maintain certain important characteristics of their parents and which are unmixed with other types) to ensure higher yields, uniform ripening, better quality and ter milling percentage. If seed rice is ig sent to another country, such seeds flfoould be subject to hot water treatment kill seed-borne nematode eggs. The [seeds are soaked in warm water at 40°C for ten minutes, then put into water at |, 60°C for twenty minutes while stirring. They are then cooled in running water at room temperature. Drying the seeds immediately after heating, however, gives better results. Transported seeds are also treated with an organo-mercuric compound to disinfect them against seed-borne diseases such as rice blast, brown spot and seedling infections. Thiram powder can also be used as a dry dressing. The major producers of rice in Nigeria are Niger, Taraba, Benue and Ebonyi States.

### **3.1.2.4 CULTIVATION OF UPLAND RICE**

The bush is cleared and the land is hoed or ploughed 10-13 cm deep. On large farms and government experimental farms where machines are used, the land is then harrowed. Levelling operations are not usually carried out, but they are advisable in some cases. The land is made as flat as possible to allow,even distribution of water during irrigation. Seeds can be either broadcast at the rate of 66 kg per ha, or drilled in rows 92 cm apart and spaced closely along the rows, at the rate of 66 kg per ha. Seeds are normally sown in March-April or May-June, but in February in the south-eastern counties of Liberia such as Maryland.

### **3.1.2.5 CULTIVATION OF SWAMP RICE**

The process of converting newly acquired inland swamp into suitable land for rice cultivation can be described under three headings: clearing, terrestrial work and infrastructural work.

**CLEARING:** The undergrowth can be removed either with a cutlass or by the application of a weed killer (herbicide). The weed killer sprayed on the undergrowth dries it and the whole bush is later set on fire and burnt.

This is followed by the removal of the trees which are left after the undergrowth has been cleared. The trees can be cut down with an axe or a chain saw. The stumps that are left are uprooted with a hand-operated mechanical winch or a tractor-mounted winch. Uprooting the tree with hand-operated winch is slow, but is much faster than uprooting with a cutlass or an axe. The operation takes about 5 minutes as compared with half a day if a tree is to be uprooted without the assistance of a winch. The tractor-mounted winch accomplishes the task faster, taking a maximum of two minutes.

### **3.1.2.6 TERRESTRIAL OR EARTH WORK •**

The operations include: land levelling, construction of irrigation canals and construction of bunds.

**Land levelling** The conventional way of levelling is a process whereby the topsoil is first moved, the land then levelled and the top soil moved back with a grader. The levelling is done by man using a hoe or levelling board, small tools or a tractor winch levelling board. The levelling of the land is a tedious, intricate operation. Two types of levelling boards are used. The first type has no skid. This is used to move the earth first, as it is able to move more earth than the board leveller with a skid. The board leveller with a skid is used towards the end of the operation, as it moves less soil because the skid acts as a float.

Levelling can also be done by using a power tiller. Many problems have been encountered when using a power tiller at, for example Suakoko, Liberia. For instance, the power tiller sinks in the soil, particularly when there is no hardpan. Similarly, the wheels of the tractor easily get stuck in the mud. Ideally equipment is needed that can float in water. It has been found that in places which are completely flooded, a locally-made drum wheel will assist the power tiller to do a good job. The only disadvantage of this drum wheel is that it is heavy and tends to reduce the mobility of the power tiller.

### **3.1.2.7 CONSTRUCTION OF INFRASTRUCTURE**

When the land is completely levelled, irrigation canals are constructed and bunds are made to demarcate the plots. Access roads, bridges, etc. must also be constructed.

**COST OF DEVELOPMENT:** Preliminary figures assembled from the Suakoko project in Liberia in 1972-1973 indicate that 192 dollars per 0.4 ha was spent to develop the first plot, while 131 dollars per 0.4 ha was spent on the other plot. The difference in cost of development was due to

the higher density of tree population and the rather uneven nature of the first land. Levelling can be a most expensive operation especially in an uneven area where much more soil has to be moved. The above cost figures are only a guide since swamp clearing in many other parts of West Africa is relatively easier and cheaper.

Immediately after development, the land was planted with IR5. A low yield was obtained from the first crop which was severely affected by bronzing induced by iron toxicity. This is thought to be characteristic of newly developed swamps in Liberia. Liming is an appropriate remedy, but is rather expensive. Iron toxicity is however said to disappear as soon as the soil is stabilized.

### **3.1.2.8 NURSERY**

For swamp rice, a nursery consisting of a fertile, moist seedbed is necessary. This is started from May to June. When transplanted, 3 3-3 8kg of seeds planted in a nursery will be enough to plant 1 ha of swamp. Seedlings are transplanted between July and August about three to four weeks after sowing the seeds, when they have four-six leaves. Two days before transplanting, the nursery is flooded with 2.5-5 cm of water to make pulling of seedlings easier, thus causing less damage to the roots and stems. The seedlings are lifted from a depth of 1 cm under the soil with a sharp-edged shovel. Water, to a depth of about 5 cm, is also let into the field into which seedlings are to be transplanted at 25 cm apart. A space marker is used to achieve this spacing. The space markers can be made of wooden strips, using a nail in the strips every 25 cm to indicate where to plant seedlings. Seedlings should be held upright and a hole for the seedling made with two fingers. Care should be taken to prevent the roots turning upwards as the stem may break. Seedlings should not be planted too deep as this will encourage the growth of new roots and the seedling will not grow well. However, if the seedlings are not planted deeply enough, they may fall over. Dead plants should be replaced after ten days. Five days later, excess water should be drained off the field to reduce the depth to 2.5 cm.

Spacing is important and is determined \*w tillering ability (ability to produce shoots from the root or base of the main stem) and plant type. It may not be very important for the varieties which tiller heavily. Wide spacing of 45 cm between stands is deleterious to yield, especially if the nutrient status of the soil on which the rice is planted is low. For the International Rice Research Institute (IRRI) improved varieties, 20 cm between stands in each direction is favoured. In Liberia, where cultural practices and fertilizer rates are adequate, 20cm

between stands is used, but most farmers are advised to adopt a closer spacing since they do not apply fertilizers.

### 3.1.2.9 METHOD OF PLANTING

Rice can be transplanted into the swamps or drilled in. The two-row planter can be used for drilling in seeds both for the dry soil (or upland) paddy or for the swamp paddy. The seeds are spaced about 30 cm between the rows and 30 cm along the rows. Planting should be done immediately after the levelling operation is completed, but the plot should be drained slightly first to remove some of the excess water. If sowing of seeds is done about two days after levelling, when virtually all the water has drained out, the seeds would be exposed when planted, and subjected to high losses from birds.

For direct seeding with a two-row planter, pre-germinated seeds are used to accelerate growth. This has obvious lime are needed to neutralize the iron. The best practical approach is to plant rice varieties which are tolerant to iron toxicity, e.g. IR442.

### 3.1.2.10 PESTS

**Birds:** *These are probably the worst pest of rice. They reduce yield unless effective means are designed to scare them away.* Birds attack the plants from the milk stage (i.e. when the seeds are still immature, and if pressed release a milky juice) until harvest. The most notorious bird is the village weaver (*Placeus cucullatus*)

. Control measures include destroying the nests of the birds, shooting them, using coloured flares or birds scarers to frighten them away. Experimental plots are often protected with fish netting which exclude the weavers but not the smaller seed-eating birds.

**Borer** These pests, particularly the Diopsis, attack tillering rice in large numbers causing stem damage and dead tillers. Compensatory tillers are sometimes produced by young affected plants, which reduce crop loss, although borer damage itself does not induce the formation of new tillers. Borer damage at the later stages of growth can result in many white and empty panicles. ;

**Nymphula depuntails:** This pest, popularly known as or is a serious pest of rice in We Africa. It lays its eggs on the plat and the larvae (caterpillars) whic hatch virtually defoliating the ric plant. The caterpillars cut section of leaves to form a protective cas and rapidly defoliate the rice plan! To achieve control, the pests shoul< be killed as soon as they are seen Damage is minimized and



the plant; grow vigorously. If neglected, whole patches of rice fields will have to be replanted. Pesticides such as Karate, Vetox 85 and Laraforce will kill the caterpillars.

Rodents; Rodents such as the cutting grass or groundhog and field rats can cause destruction of rice fields by eating the young plants. The groundhog is the second most serious pest of rice in Liberia. Fencing of experimental plots with 1.9 cm galvanized chicken wire will keep most rodents out, although not the small field rats. Baiting with rice stems or wax blocks is helpful. Rodents can also be trapped.

### **3.1.3 'GUINEA CORN**

Sorghum (guinea corn) probably originated in tropical Africa. It forms the staple food of people living in the northern parts of West Africa. It is used mainly for making in Ghana, but also for brewing a local beer called . Sorghum is higher in protein and starch but lower in fat content than maize. Sorghum grains are also eaten by horses and poultry, while cattle feed on the dry leaves of the plants after the grains have been harvested. Sorghum is the third most important grain food in the world (wheat being the first and rice the second most important). Sorghum grows well where the rainfall is 380 — 640 mm during the period of growth and where the weather is hot and dry when the grains are ripening. A mean temperature of about 28°C is ideal. Sorghum grows well on a wide variety of soils, with a pH of 5.5 to 8.5, with the exception of pure sands and clays.

#### **3.1.3.1 VARIETIES GROWN**

There are many Varieties, they differ in height, shape of fruiting and size, shape and colour of the grain. The different varieties are used in different ways. Recommended varieties in Ghana are Local Belko, improved Mankaraga, Bakwu White and Ladore. The major West African varieties are:

Guinea corn (*S. guineense*) This is the most common type in West Africa and probably originated in Sierra Leone. It attains a height of 3.5 m. The same variety can have grains of different sizes and colours — white, yellow, orange or red. The seeds are sweet, and either soft or hard. They are eaten by man.

Feterita (*S. caudatum*) This is of tropical African origin. It has white grains, attains a height of 4 m and is good for making bread.

. Kaura: This has yellow seeds. It grows to 1.8 - 2.5 m high. It is used as livestock feed because the grains have a bitter taste. The Hausa people call this sorghum *Farafara*.

*S. magaritiferum*: This is grown in areas with heavier rainfall. It attains a height of 3 m and has white seeds. It / is highly susceptible to damage from birds. It originated in Sierra Leone.

Egyptian corn (*S. durra*) It reaches a height of 4 m and is a dry season crop grown beside Lake Chad. It has white, yellow or red grains. It is eaten by man.

**Faffir corn-** (*S. caffrorum*) It grows to about 1.8m tall when *it is* mature. The white-grained types are eaten by man, while the red and yellow types are bitter and are therefore fed to livestock.

**Sweet Sorghums** - The best known in West Africa are and

. The stems are very sweet and are chewed like sugar cane or used for molasses and sweetmeats.

Seeds are sown in May to June in the northern parts of West Africa or in July in the drier parts of southern West Africa. Four or five seeds are sown in each hole 2-3 cm deep. Spacing is 7-15 cm apart in the row if the sorghum is being grown as forage for animals, but 30-50 cm apart in the row if it is being grown for animal consumption. Spacing between rows is 90 cm apart. Germination occurs in four — five days. Sorghum can be intercropped with millet. In some places yams are planted as the guinea corn ripens. If cowpeas are planted among guinea corn, the fertility of the soil is improved. In northern Nigeria, the application of 2,506 - 7,531 kg of FYM per ha, as well as the application of superphosphate and sulphate of ammonia, has been shown to give increased yields. Weed control is achieved by the application of any of the following herbicides — Atrazine and Primextra.

### 3.1.3.2 YIELD

Yield varies with the variety and the location. Guinea corn can give a yield of 448 — 784 kg of grain per ha. Feterita gives an average of 360 - 840 kg of grain which can rise to 1,120 - 1,630 kg under better conditions. Crop rotation assures good average yields.

Grains are stored in home-made earthen granaries with openings at the top. Ashes are left with the grain to lessen weevil attack. stores best. Actellic 25 dust or Actellic 25 in the liquid form can be used to control the storage pest. Because of the poisonous nature of the insecticides, they must be handled only by experts or on their advice.

### **3.1.3.3 DISEASES**

**Loose or open smut:** This is a fungus disease which will turn the grains black. Seeds should be treated with copper carbonate to prevent infection. Infected heads should be cut off and burnt before the fungus shed spores. Crop rotation helps to reduce this disease. C Iraitai or covered

**Grain or cover smut:** This is the most common fungus disease in West Africa. It attacks individual grains causing spore masses to cover the grains. Treating seeds with Copper carbonate, Fernosan D, minimizes the attack.

**Downy mildew:** This is another fungus disease causing yellow streaks on the leaves and turning them brown. Infected heads should be burnt.

**Weevils:** These pests damage stored grains. Control is achieved by fumigating stored grains with D.D. Force.

### **3.1.3.4 PESTS**

**Stem borers;** these pests can cause serious damage in young plants if the attack is severe. Crop rotation and field sanitation helps to reduce attack. Control may be achieved with Phostoxin.

**Birds:** Birds are a menace during the period of harvest and efforts should be made to scare them off. Varieties such as BR-100, with resistance to bird damage, should be planted.

**Midge Larvae:** The larvae of the species can reduce yield by 50 per cent. Control is achieved by planting early or by spraying the crop at flowering or ten days later with 0.8 per cent Sevin mixed at the rate of 43 gm in 4.5 litre of water: 110 litre will spray 2 ha.

#### **Parasitic weeds**

*Striga spp.* These are parasitic plants growing on the roots of guinea corn. They should be weeded out to give a high crop yield.

### **4.0 Conclusion**

### **5.0 Summary**

### **6.0 Tutor marked assignment**

### **7.0 Referencing and further reading**

## **MODULE 2**

### **Unit 2**

#### **1.0 Introduction**

#### **2.0 Objective**

#### **3.0 Main content**

##### **3.2.0 Family *Leguminosae*<sup>1</sup> (12,000 sp.—951 sp, )**

##### **3.2.1 PULSES (GRAIN LEGUMES)**

##### **3.2.1.1 CULTIVATION**

##### **3.2.1.2 YIELD**

##### **3.2.1.3 PESTS**

##### **3.2.1.4 BEETLES**

#### **4.0 Conclusion**

#### **5.0 Summary**

#### **6.0 Tutor marked assignment**

#### **7.0 Referencing and further reading**

##### **3.2.0 Family *Leguminosae*<sup>1</sup> (12,000 sp.—951 sp, )**

Habit—herbs, shrubs, trees, twiners and climbers. Roots of many species, particularly of *Papilionaceae*, have tubercles . Leaves alternate, pinnately compound, rarely simple, as in rattlewort (*Crotalaria sericea*), camel's foot tree (*Bauhinia*) and some species of *Desmodium*, e.g. *D. gangeticum*, with a swollen leaf-base known as the pulvinus; stipules 2, usually free. Flowers bisexual and complete, regular or zygomorphic or irregular, hypogynous or slightly perigynous. Calyx—sepals usually (5) or 5, with the odd one anterior (away from the axis), sometimes (4), united or free. Corolla—petals usually 5, with the odd one posterior (towards the axis), sometimes 4, free or united. Androecium—stamens usually 10 or numerous, sometimes less than 10 by reduction, free or united. Gynoecium—carpel 1; ovary 1-celled, with 1 to many ovules, superior; placentation marginal; ovary often on a long or short stalk, called stipe or gynophore. Fruit commonly a legume or pod (dehiscent), sometimes a

lomentum (indehiscent). This is the second biggest family among the dicotyledons (being second only to *Compositae*), with varying characters, and as such it has been divided into the following sub-families: *Papilionaceae*, *Caesalpinieae* and *Mimoseae* (see footnote). The division is primarily based on the characters of the corolla and the stamens (see FIGS. 2-4). All these sub-families are well represented in India. From an economic standpoint this

<sup>1</sup> The order *Rosales* according to Bentham and Hooker and also Engler includes both *Rosaceae* and *Leguminosae*; while Hutchinson has separated *Leguminosae* from *Rosales* and raised it to the rank of an order with three families—*Caesalpinieae*, *Mimosaceae* and *Papilionaceae*. It may also be noted that *Leguminosae* is the biggest family in India.

### 3.2.1 PULSES (GRAIN LEGUMES)

Cowpea (*Vigna sinensis* or *Vigna unguiculata* (Walp.)

The cowpea or bean as it is popularly called is indigenous to West Africa. It is an important item in the diet of West Africans, as it is a rich source of plant protein. It is eaten in various ways, either alone or mixed with maize, rice, fish or Bean flour is made into fried cake or boiled cake called . Cowpeas are sometimes grown as cover crops. Because the cowpea is a leguminous plant, it is valuable for improving soil fertility. It plays an important part in crop rotation, and can be dug into the soil while it is green. The major producers of cowpea in Nigeria are the States of Borno, Zamfara and Kaduna.

Cowpea grows best on fertile, loamy soils with a rainfall of 760-1520 mm during the growing months. It grows best in the dry areas of the northern parts of West Africa.

Many varieties are grown in West Africa. They differ in the colour of their seeds which can be either white, black, brown or variously mottled; or in their plant form, which is either dwarf, prostrate, creeping or climbing. In Nigeria the recommended varieties are Mala, Nigeria-67, Ayi, Kwarra, Alabama Black-eye, Prima, Farin Juda C, Kudi and Dinner (FARV - 13), while Black-eyed cream seeded variety is recommended in Ghana. A new cowpea variety — Ife brown — was released by the Institute of Agricultural Research and Training (IAR & T), Obafemi Awolowo University, He Ife. It flowers 35 days after planting, is erect and day neutral. It is acceptable to consumers because of its brown, wrinkled seed coat. Dinner is used primarily as a green vegetable. Its succulent green pods are harvested for eating 8 — 10 days from the date of flower opening.

### **3.2.1.1 CULTIVATION**

Seeds are sown as a single crop in July to August in northern areas, and in September in the south. They can be interplanted with yams, maize, sorghum and other crops. Three seeds are planted in holes 4 cm deep. The seeds may be drilled in rows 75-90 cm apart, and 25-30 cm apart along the rows. In areas such as Kabba province of Nigeria where two crops are grown annually, the first crop is planted from March to April.

Germination occurs 4-5 days after planting. Beans mature 2-4 months after planting. Weeding is done at least twice before the crop covers the ground, care being taken not to damage the vines. This explains why hand weeding may be preferred to the use of a hoe in weed removal. Herbicide such as Pendimethal at the rate of 40-50ml/4 litre of water can also be applied. Most local bean varieties have long flowering periods and are subject to insect attack all the time. The long flowering period is an advantage since farmers are able to obtain a crop from the few pods set. But for this attribute of the local varieties, the beans may not have set any pods in view of the continuous attack by insects. The beans are harvested when their pods turn yellow, but before they shatter. This happens between December and January in the south, and in November and December in the north. The beans are usually handpicked. Threshing is done by putting the dry pods in sacks which are beaten with sticks. The seeds are winnowed to remove empty pod husks, stones and other foreign matter. On a few mechanized farms, the beans are first cut with a bean cutter and later threshed with a hauler, thresher or combine.

### **3.2.1.2 YIELD**

Yields are low because of serious pest attacks. If cowpeas are grown as a sole crop, 7001,000 kg per ha are obtained, whilst yields of 168-448kg are obtained when the cowpeas are interplanted with other crops. Seed yield may be increased to 1,680-2,240 kg per ha by the proper timing of insecticide application, e.g. Cypermethrin during the flowering and podding phases of production. Seeds should be fumigated with Phostoxin tablets or a mixture of Ethylene dichloride and Carbon tetrachloride in a ratio of 3:1, before storage in air-tight and insect-free containers.

### 3.2.1.3 PESTS

Cowpeas provide food for very many types of insects, all parts of the plant being susceptible to attack. The most important pests can be divided into three groups:

- (i) Those which attack the beans before flowering occurs (pre-flowering pests) e.g. *Ootheca mutabilis* and *Alcidodes leucogrammus*
- (ii) Those attacking after flowering (post-flowering pests) e.g. *Maruca testlalis* and *Piezotrachelus varium*, and
- (iii) Those attacking cowpeas at harvest time and in storage, e.g. *Callosobruchus Maculates*.

Insect pests of cowpea can be controlled with the application of Cypermethrin at 20ml/10 litres of water.

### 3.2.1.4 BEETLES

Many beetles or bean weevils feed on the leaves and pods, thereby causing poor growth and low yields. They attack bean seeds in the field and in the store. It is estimated that one weevil larva causes about 5 per cent loss in weight of an infested bean. Estimated total bean weight loss for 1968 in Nigeria alone was 24, 000 tonnes. Field control is difficult, but storage losses can be prevented by dusting the beans with insecticides such as Phostoxin. The beetles can be divided into the following groups:

- (i) Those attacking the plant before flowering occurs (pre-flowering pests) e.g. *Ootheca Mutabilis* and *Aicidodes leucogrammus*.  
*Ootheca Mutabilis* is a leaf-eating beetle which defoliates the bean plant before flowering occurs thus causing reduced yields. This beetle is also the vector of the cowpea yellow mosaic virus.  
*Aicidodes leucogrammus* may cause stem breaking at points where the stems are girdled. The larvae also bore into stems causing stunted growth with consequent reduction in yield.
- (ii) Those which attack the flower buds and flowers (flowering stage pests), e.g. *Maruca testulalis* and *Teniothrips spp.* *Maruca testulalis* damages flowers. The larvae bore into young flowers, feed within and cause the flowers to drop. Later, instar larvae bore into newly formed pods and feed on the seeds.

- (iii) Those attacking at the pod production phase (post-flowering pests), e.g. Coreids such as *Anoplonemis curvipes*, *Acanthomia spp.* and the codling moth *Laspeyresia spp.* *Piezotrachelus varium* is a coleoptera (beetle) which damages cowpea seeds inside pods. Adults lay eggs within the green pods and emerging larvae (white grubs) feed in large numbers on the seeds and pupate there. Adults emerge as small black weevils from holes in the pods when they are dry.
- (iv) Those attacking cowpeas at harvest and which may continue as store pests, e.g. *Callosobruchus maculatus* and *Bruchidices atrolineatus*.

*Callosobruchus maculatus* is a bruchid although commonly referred to as a weevil. Its eggs are laid on bean pods in the field and the apparently healthy bean seeds may in fact contain developing larvae. Infestation builds up in the store where major losses occur. This is why is *C. maculates* called a *field-to-store* pest.

Root knot eelworms such as *Meliodogyne* and *Rotylenchulus spp.* Affected plants have roots with irregular galls. The plants become stunted and have low yields. The affected plants should be destroyed and resistant varieties planted. A good crop rotation also helps.

#### **4.0 Conclusion**

#### **5.0 Summary**

#### **6.0 Tutor marked assignment**

#### **7.0 Referencing and further reading**



## **MODULE 3**

### **Unit 3**

#### **1.0 Introduction**

#### **2.0 Objective**

#### **3.0 Main content**

##### **3.3.0 ROOT AND TUBER CROPS**

##### **3.3.1 CASSAVA (*Manihot utilissima*)**

###### **3.3.1.1 CLIMATIC AND SOIL REQUIREMENT**

###### **3.3.1.2 VARIETIES GROWN**

###### **3.3.1.3 CULTIVATION**

###### **3.3.1.4 YIELD**

###### **3.3.1.5 DISEASES**

###### **3.3.1.6 PEST**

##### **3.3.2 YAM (*Dioscorea spp.*)**

###### **3.3.2.1 CLIMATIC AND SOIL REQUIREMENT**

###### **3.3.2.2 VARIETIES GROWN**

###### **3.3.2.3 CULTIVATION**

###### **3.3.2.4 YIELD**

###### **3.3.2.5 STORAGE**

###### **3.3.2.6 DISEASES**

##### **3.3.3 SWEET POTATO (*Ipomea batatas*)**

###### **3.3.3.1 CLIMATIC AND SOIL REQUIREMENT**

###### **3.3.3.2 VARIETIES GROWN**

###### **3.3.3.3 CULTIVATION**

###### **3.3.3.4 YIELDS**

###### **3.3.3.5 PESTS**

#### **4.0 Conclusion**

#### **5.0 Summary**

#### **6.0 Tutor marked assignment**

#### **7.0 Referencing and further reading**

### **3.3.0 ROOT AND TUBER CROPS**

#### **3.3.1 CASSAVA (*Manihot utilissima*)**

Cassava, which originated in Brazil, South America, is one of the most important food crops of West Africa. It is a root tuber. It is a latex-producing plant which reaches a height of 1.83.6 m, depending on the variety. Because it is easy to cultivate and will grow on poor soils, it is grown throughout West Africa. The tuber is processed into *gari*, tapioca and cassava flour for human consumption, while the leaves are cooked and eaten especially in Sierra Leone and Liberia. Sweet cassava tubers can also be eaten boiled, or boiled and beaten into 'dumboy', as in Liberia. They can be fed raw or boiled to pigs, goats, horses and cattle. The main industrial use of cassava is the manufacture of starch and alcohol.



##### **3.3.1.1 CLIMATIC AND SOIL REQUIREMENT**

It will grow in different climates, but gives highest yields on rich, well-drained loamy soils with a light or medium rainfall. The tubers tend to decay in badly-drained, swampy soils, which must therefore be avoided. It requires no shade but can be adversely affected by strong winds.

##### **3.3.1.2 VARIETIES GROWN**

Two main kinds of cassava are commonly grown in West Africa: sweet cassava (*Manihot pulmata*) and bitter cassava (*Mutilissina*). The bitter cassava contains a juice which is poisonous to humans and livestock. This juice (called hydrocyanic acid) must be extracted before the cassava is safe to eat. Cooking is one way to do this.

The varieties of cassava differ in their stem, tuber skin, and leaf petiole colour, in the time they take to mature and in the quality of the tuber.

The commonest varieties in Nigeria are Nwangoye, which matures early but does not have a high yield/ Nwaiwa, which matures late; Okotbronwa, which is tall and has a high yield,- Karagba which also has a high yield; and Dan Warri, which has been found particularly suitable for the northern states of Nigeria. High-yielding hybrids have been developed by crossing local varieties. These are: CH50, CH125, CH28, and €C779B. In 1974, the varieties recommended by the National Root Crops Research Institute, Umudike in Nigeria were 53, 101 grown by farmers in western areas of Nigeria, 60, 444 in the eastern areas of Nigeria and 60, 447 and 60, 506 in the northern areas of Nigeria. The four varieties give a standard high yield of 30, 120 - 37, 643 kg per hectare, but are capable of 50, 198 kg per hectare. They mature in nine to twelve months instead of up to twenty-four months. They contain reduced quantities of hydrocyanic acid (HCN), hence they are much safer to eat. They are also resistant to the cassava mosaic disease and have increased protein content (4 to 6 per cent compared with 1 per cent for other varieties). The best varieties in Sierra Leone are *Mayugbe*, *Two cent* and *Cocoa-cassava*, and in Ghana are *katawia*, *Obwenyanka*, *Enyan Abasa*, *katawere* and *Ankra fufue*.

### **3.3.1.3 CULTIVATION**

Cassava is planted from March—October in southern areas and June — July in northern areas. Mature stem cuttings, usually 20-30 cm long are planted either in a slanting position or straight up. Two thirds of the cutting is buried in the soil, the rest appearing above the surface of the soil. The spacing varies from 90 cm x 90 cm to 1m x 1m, on ridges, mounds or on flat ground. Longer cuttings of 60 cm give higher yields. Between 6913-13 580 cuttings, i.e. fifty bundles are needed to plant a hectare.

Sprouting occurs after 7—14 days. The cassava tubers are ready for harvest 1 – 2 years later, depending on the variety of cassava, and the way the cassava is to be used. Weeding and manuring, especially with potassium fertilizers, help to boost yield. Diuron at 3 kg ai per hectare and Pendum Fusilade are effective for controlling weeds. Harvesting is done by hand. Each tuber is detached from the roots. Bruised or damaged tubers are thrown away. The tubers are only dug up if they will be used within two-three days, because they rot

quickly. If tubers are left too long in the soil, they become fibrous and unsuitable for eating. The major producers of cassava in Nigeria are Benue and Kogi States.

#### **3.3.1.4 YIELD**

Cassava is one of the most productive crops in the world, yielding 15 tonnes of tubers per ha on an average, and over 30 tonnes per ha under the best growing conditions. Because of this high yield, it exhausts the soil in which it is grown. Crop rotation as well as fertilizer application are needed to ensure that good yields are maintained. For best yields, 200 kg/ha NPK 15:15:15 and 100 kg/ha MOP (Muriate of Potash) should be applied.

#### **3.3.1.5 DISEASES**

- (i) *Cassava Mosaic*: This serious viral disease, transmitted by a white fly (*Bemisia spp*), spreads rapidly. Leaves of infected plants become mottled and later, both the leaves and the stems become distorted. The disease reduces starch formation, which affects the yield. The use of resistant varieties is helpful, although these do not yield as well as the non-resistant varieties. Healthy cuttings should be used for propagating cassava, so that the plant can withstand this disease.

#### **3.3.1.6 PEST**

##### **(i) GRASSHOPPERS:**

Grasshoppers, especially *Zonocerus variegatus*, can cause serious damage to the young plants by feeding on their leaves. They can be controlled by spraying Fenithotrim or Sevin at 2 kg per ha.

##### **(ii) ANIMALS:**

Animal Serious damage to cassava tubers is caused by the cane rat, cutting grass, ground squirrel, monkeys, baboons and bush pigs. The best method of control is to trap these animals.

### **3.3.2 YAM (*Dioscorea spp.*)**

Yam, a major staple in Africa, is a crop, grown for its stem tubers, which is indigenous to West Africa. An estimated 48.7 million tonnes of yam were produced in 2005, with sub-Saharan Africa accounting for 97 per cent of the total production. Yam tubers are eaten boiled, roasted, fried, mashed or pounded. Yam flour is the best form to preserve and

store yams. Yams are produced in all parts of West Africa, but the area of greatest concentration of production is between Cote d'Ivoire and Cameroon.

Average daily consumption per capita is highest in Benin Republic (364 kcal), Cote d'Ivoire (342 kcal), Ghana (296 kcal) and Nigeria (258 kcal). However, in Nigeria, the major producers are Niger, Taraba, Benue and Enugu States.



### **3.3.2.1 CLIMATIC AND SOIL REQUIREMENT**

Yams grow well on fertile, free-draining, well-prepared, loamy soils. Mounds of varying sizes are usually prepared and the yams are planted at the top of the mounds. If the soil is closely-packed, yam tubers cannot grow to a large size. Water-logged soils hinder root

and tuber development and cause rotting of newly planted sets. A rainfall of 1020-1780 mm, well distributed, is adequate, but a clearly demarcated dry season of two to five months is desirable.

### 3.3.2.2 VARIETIES GROWN

There are six main species of yams of commercial importance in West Africa.

They are:

- (i) **White yam (*D. rotundata*):** this is the best quality yam for eating. Its tubers are usually large, but vary in size, and shape. The colour of the flesh is always white to cream. It matures eight months after planting and stores well.
- (ii) **Yellow yam (*D. cayenensis*):** The flesh of this variety is yellow. The leaves are thick, broadly heart-shaped with dents near the stalk. They are dark, glossy green in colour. It matures in twelve months and does not store well.
- (iii) **Water yam (*D. alata*):** This is the only yam grown in West Africa with petioles. The leaves are large and broad. The tubers are large with soft texture and high water content. The flesh is yellow or purple. It has a poorer storing quality than white or yellow yam. It matures in ten months. In Nigeria it is used to make *ikokore* and *ojojo*
- (iv) **Chinese yam (*D. esculenta*):** This yam has pale, broad, heart-shaped leaves and grows best in drier and open districts. It produces very many small tubers in a hill. The tubers have a pale-yellow, smooth skin which bruises easily. Because of this, the yam does not store well. This yam matures twelve months after planting.
- (v) **Aerial yam. (*D. bulbifera*):** This yam bears tubers both on the vines and underground. The tubers have strong corky skins which enable them to store well for long periods. Two or more types are edible but they are not widely grown.
- (vi) **Three-leafed yam (*D. dummtom*):** This has prickly leaves which climb clockwise. The tubers are large, and the bark is coarse. The flesh is finegrained, yellow, white or pink in colour.

### 3.3.2.3 CULTIVATION

Yams are planted in mounds, hills or heaps varying in width from 90-150cm at the base. Mounds are constructed by drawing the top soil together with a hoe. Mounds provide sufficient depth of loose soil to allow proper development of tubers. In some localities yams

are planted in ridges or holes on a flat surface. Usually, a sett (a slice of seed yam weighing between 95-185g from which the new yam plant will grow) is planted. Many farmers plant as many as 10,000 setts per ha and this gives 2 to 2.5 tonnes/ha. Early yam is planted in October-November at the beginning of the dry season, while the late crop is planted between February and April.

The spacing on ridges which are 120cm apart is 90-120 cm along the ridge. With big mounds, the spacing reaches 1m x 1m. Ridging is cheaper than making mounds and is particularly advantageous in hilly areas as it helps to prevent soil erosion. In this case of course the ridges should be constructed along the contours. It is essential to mulch the top of the heap to reduce soil temperature. Capping each sett with grass or leaves is often done, but experiments have shown that continuous mulching along the entire ridge gives better results than capping individual heaps.

Whole small tubers known as 'seed yam' are best for planting. Setts should be cut from the top, bottom or centre of the tuber. The setts should be 95-185 g in weight and planted 15 cm deep. The cut surface should be placed upwards, at an angle of 45° to prevent water settling on top. The setts should be covered with 8-15cm of soil. Healthy eyes or buds must be present on each set. Quick sprouting can be obtained by cutting and planting the setts immediately, provided the sett skin is not bruised. However, allowing the cut surfaces to dry for one or two days prevents them from rotting, which is very important.

In many cases, the weight of setts sown varies from 2,509 — 5,020 kg per ha, depending on the variety, the size of the setts and the spacing. Sprouting occurs 20-60 days after planting, depending on rainfall. It is advisable not to add manure during sprouting as setts that sprout late may be damaged.

The IITA recently developed an innovative way of propagating yam through vine cuttings with carbonized rice husks as the growth medium. The carbonized rice husks could be got by farmers at very low cost, or even free. This technique therefore eliminates the use of tubers for propagating yam. By eliminating the use of tubers, many advantages are conferred. These include:

- (i) Freeing more yam tubers that farmers could either eat as food or sell at markets to make more money.



- (ii) Promotion of faster multiplication and better, more uniform crop quality.
- (iii) The possibility of quickly making available to farmers high quality, improved yam varieties.
- (iv) Reduction in cost of production as it reduces the amount of yam tubers invested as seeds.
- (v) Lowers significantly the risk of nematode infestation linked to the use of tubers as planting materials.

**The use of tubers (whole) or setts has the following disadvantages:**

- (i) A significant part of harvested tubers (30-50 per cent) goes back into planting material as seeds.
- (ii) It reduces farmers' income.
- (iii) The system has a low multiplication rate of 1:5-10 compared with cereals which have a propagation ratio of 1:300.
- (iv) Increases the risk of nematode infestation and consequently leads to a reduction in yield.

Stakes are used to support the yam vines in order to obtain good yields by exposing maximum leaf area. When new land is cleared, some shrubs and young upright growing trees can be left to act as stakes. The disadvantage of this method is that the living plants will compete with the yams for soil nutrient and moisture. Good stakes can be cut from cassia, siamiea or bamboo poles, and should be about 2-2.5 m high. In the dry or Guinea savanna areas where trees are scarce, yams are planted after sorghum or maize, so that the yam vines can climb on the cereal stalks left after the sorghum or maize has been harvested. Weed control is achieved by hand or hoe, or with primextra (herbicide) at 2.5-3 kg ai per hectare.

Yam matures 8 — 12 months after planting. (Some are cut after six months and are covered again to act as seed yam.) When the leaves and the vine die and dry up, the yams - are mature. The surface of the soil around the yam tuber sometimes cracks, especially in dry weather. The yams are harvested by digging out each tuber carefully with a cutlass to avoid bruising or cutting them. The early crop is harvested from July to mid-September, while the main crop is harvested between mid-October and January.

#### **3.3.2.4 YIELD**

This ranges from 5-10 tonnes per ha depending on the variety planted and the size of the sett used at planting. Bigger setts produce higher yields than smaller ones. Most varieties produce one large tuber or at most, two or three tubers per plant. High yields of up to 15-25 tonnes per ha are possible on good soil which has been fertilized, if there is adequate rainfall. The fertilizer commonly applied is NPK 15-15-15 at 400 kg/ha.

#### **3.3.2.5 STORAGE**

The yam tubers must be kept dry and away from the soil, and protected from the, strong rays of the sun. When the tubers are harvested, they are either put in piles or, better still, they are tied to racks. A large framework of poles is first erected. 'Living posts' are preferred. Long cross poles are then placed in position and tied to erect poles with ropes. The space left between each pair of erect poles should be about 60-120 cm. The space between the horizontal poles should be 30-60 cm. Clean yam tubers are tied to the erect poles starting from the bottom. Each yam tuber is kept slightly apart from the next. The bark of the tubers can be peeled and the peeled tuber dried in the sun: These tubers will store for a very long time. They are made into yam flour by pounding in a mortar, or by a flour mill. Considerable numbers of yams are damaged during storage, through decay and the high rate of respiration which causes the yams to lose moisture and weight through sprouting.

#### **3.3.2.6 DISEASES**

- (i) **Mosaic:** This is a virus disease causing stunted and discoloured plants. Good crop rotation helps combat the disease.
- (i) **Yam beetle:** The larvae of these large black beetles burrow into yam tubers causing considerable damage. This is the greatest pest of yam. Control can be achieved by treating setts and seeds with Furadan. Crop rotation and late planting also help.
- (ii) **Yam shoot beetle:** The larvae of this beetle attacks young yam shoots. They surround themselves with frothy slime. Heavy rains wash it off the leaves. During dry weather it can be picked off by hand.
- (iii) **Yam eelworm:** This pest attacks yam tubers in the soil when the yams are stored, causing them to rot. Attacked tubers become brown and soft, and are unfit for

consumption. Burning of the bush around the yam farm at the time of planting reduces this pest, but crop rotation is the main control.

### **3.3.3 SWEET POTATO (*Ipomea batatas*)**

Sweet potato is indigenous to South America from where it has spread to most parts of the tropics and sub-tropics. It is a minor root crop in most parts of West Africa, but is important in Sierra Leone, Guinea, Ivory Coast and Ghana.

Sweet potato tubers are eaten either boiled or fried in oil. Its leaves are also used as spinach in soups. The tuber, especially the yellow one, is a rich source of vitamin A and calcium. A local alcoholic drink is also brewed using the tuber.

#### **3.3.3.1 CLIMATIC AND SOIL REQUIREMENT**

It performs best in well-drained, loamy soil high in humus. A rainfall of 640-780 mm is considered adequate.

#### **3.3.3.2 VARIETIES GROWN**

West African sweet potatoes are white, red or yellow tubered. The texture of the tuber, the sweetness, size and shape, vary with the different varieties. Recommended varieties in Liberia are Hsinchu No. 1 and IT No. 1.

#### **3.3.3.3 CULTIVATION**

Planting is done during the rainy season with stem cuttings taken from the vines or with whole tubers. Cuttings are about 30 cm long and have eight nodes. The stem cuttings are usually planted at an angle in mounds about 60 cm apart heaped up with hoes. The cuttings begin to germinate in four to fourteen days. This practice should be discouraged as it leads to the production of tubers of varying sizes, most of which are not marketable because of their small size. It is therefore advisable to plant the stem cuttings horizontally in the mounds. This encourages the production of many uniform, marketable tubers.

The luxuriant growth of the vines soon covers the ground and the crop matures in three to five months depending on the variety. In Liberia, the crop matures in 100 days. The application of Farm Yard Manure (FYM) increases yield. Weeding should be done, preferably with herbicide called Amiben. This is a pre-emergence herbicide which should be sprayed before the stem cuttings are planted. It is so effective that no further weeding is necessary. Harvesting of tubers should be done promptly to minimize attack from weevils.

#### **3.3.3.4 YIELDS**

Average yields of 5-15 tonnes per ha are possible. The improved varieties such as IT No. 1 are capable of 25 tonnes per ha. In Liberia this is a very profitable crop to grow, especially as the variety IT No. 1 matures in only 100 days.

#### **3.3.3.5 PESTS**

- (i) **Lear miner:** This is a serious pest of sweet potato. Its larvae destroy the leaves and a badly infested farm may produce no crop. Control can be achieved with the spraying of Karate, Aldrex 40 or Diazinon.
- (ii) **Weevils:** Weevils, mainly *Cylas brumus* and *C. formicarius*, bore into tubers while still in the soil especially between the 95th and 100th day after planting. Attacked tubers produce offensive odours which render them unsaleable. They can be controlled with MOCAP granules. MOCAP granules are applied at the rate of 50 g per 10m to the land before the heaps are made. This is a nematocide which protects the potato tuber against attack by weevils.

#### **4.0 Conclusion**

#### **5.0 Summary**

#### **6.0 Tutor marked assignment**

#### **7.0 Referencing and further reading**

## **MODULE 4**

### **Unit 4**

#### **1.0 Introduction**

#### **2.0 Objective**

#### **3.0 Main content**

##### **3.4.0 FAMILY MALVACEAE<sup>1</sup>**

##### **3.4.1 COTTON (*Gossypium* spp.)**

##### **3.4.1.1 CLIMATIC AND SOIL REQUIREMENT**

##### **3.4.1.2 VARIETIES GROWN**

##### **3.4.1.3 CULTIVATION**

##### **3.4.1.4 PROCESSING**

##### **3.4.1.5 YIELD**

##### **3.4.1.6 DISEASES**

##### **3.4.1.7 PESTS**

#### **4.0 Conclusion**

#### **5.0 Summary**

#### **6.0 Tutor marked assignment**

#### **7.0 Referencing and further reading**

##### **3.4.0 FAMILY MALVACEAE<sup>1</sup> (1,000 sp.—105 up. in India)**

Habit—herbs, shrubs and trees. Leaves—simple, alternate and palmately-veined; stipules 2, free lateral. Flowers regular, poly-petalous, bisexual, hypogynous, copiously mucilaginous, with a whorl of bracteoles known as the *epicalyx* (except in *Abutilon* and *Sida*). Calyx—sepals (5), united, valvate. Corolla—petals 5, free, attached to the base of the staminal tube; aestivation twisted. Androecium—stamens numerous, monadelphous, i.e. united into one bundle called staminal column or tube, epipetalous (staminal tube adnate to the petals at the base); anthers reniform, unilocular; pollen grains large and spiny. Gynoecium — carpels commonly (5 to oc), syn-carpous, (2-3) in *Kydia*; ovary superior, 5- to oc-locular, usually 5-locular, with 1 to many ovules in each loculus; placentation axile; style passes through the staminal

tube; stigmas free, as many as the carpels. Fruit a capsule or sometimes a schizocarp. Seed endospermic. *Floral formula*— $\textcircled{\text{R}}^{\text{K}}(\text{s})\text{C}^{\text{K}}(\text{G}(\text{s}_x))$ .

Malvales may be allied to Guttiferales by various degrees of union of stamens, 5-merous calyx and corolla, and hypogynous flowers, and may have a common origin

Examples. [The larger genera are: *Hibiscus*, (over 200 sp.), *Sida* (200 sp.), *Abutilon* (100 sp.), and *Malva* (40 sp.)]. Useful plants: *Gossypium* (20 sp.) yields commercial textile cotton, roselle (*Hibiscus sabdariffa*)—fruits used for a sour jelly. Madras or Deccan hemp (*H. cannabinus*)—a source of strong fibres, musk mallow (*H. abelmoschus*; B. MUSHAKDANA; H. Malvales of Bentham and Hooker—*Malvaceae*, *Tiliaceae* and *Sterculiaceae*; the Eames order of Engler—*Tiliaceae*, *Malvaceae*, *Bombacaceae*, *Sterculiaceae*, and a few more; Hutchinson has split the order into two: Malvales—*Malvaceae*, and Tiliales—*Tiliaceae*, *Sterculiaceae*, *Bombacaceae* and a few more.

MUSHAKDANA)—seeds smell like musk and are used as a flavouring agent and as a medicine, mallow (*Malva verticillata*)—cultivated as a winter vegetable, lady's finger (*Abelmoschus esculentus*)—green fruits used as a vegetable; ornamental: several species of



*Malvaceae*. FIG. 19. China rose (*Hibiscus rosa-sinensis*) flower. A, an entire flower; B, the same split open longitudinally showing the four whorls, more particularly the staminal column with the style passing through it; C, calyx with epicalyx; D, corolla opened out; E, twisted aestivation of corolla; F, androecium showing monadelphous stamens; G, one-celled anthers—young and mature (dehiscing); H, gynoecium showing five carpels united; and I, ovary in transection showing axile placentation.

*Hibiscus*, e.g. shoe-flower or China rose (*H. rosa-sinensis*), *H. mutabilis* (B. STHALPADMA; H. GUL-AJAIB), *H. radiatus*, etc., Chinese lantern (*Achania malvaviscus*; B. LANKAJABA). and

hollyhock (*Althaea rosea*); shade tree: Portia tree (*Thespesia populnea*); other common plants: *Sida cordifolia*, *S. rhomboidea*, *Urena lobata*, *Hibiscus vitifolius* (B. & H. BAN-KAPAS), Indian mallow (*Abutilon indicum*; B. PETARI; H. KANGHI), *Malachra capitata* (B. & H. BAN-BHINDI) and *Malvastrum spicatum*—common weeds of waste places. Family 11 *Sterculiaceae* (700 sp.—75 sp. in India]

Habit—shrubs or trees, rarely herbs. Leaves—leaves and stipules are like those of *Malvaceae*. Inflorescence cymose, often complex. Flowers (see FIG. 1/95(7) regular, sometimes zygomorphic, bisexual, rarely unisexual (as in *Sterculia*), hypogynous. Calyx and Corolla as in *Malvaceae*, sometimes corolla absent; no epicalyx. Androecium—stamens usually 5-25 (but varying from 5-25), typically in two whorls, the outer whorl opposite to sepals and often reduced to staminodes or absent, while the inner whorl opposite to petals, fertile and often branched; all stamens more or less united below into a tube; sometimes on gonophore; an-

## **FIBRES**

### **3.4.1 COTTON (*Gossypium* spp.)**

Cotton is a seed fibre whose exact origin is not known. It probably originated in the drier parts or even in the desert areas of the world. Some cotton however is indigenous to Africa. Cotton is an important cash crop in Nigeria, Ghana and Sierra Leone. The two most important commercial cotton species are *G. hirsutum* (American Upland Cotton) with relatively short fibre, 1.2-2.5 cm staple length; and *G. barbadense* (Egyptian or Sea Island Cotton) which produces the finest lint (the hairs which grow from the seed coats) with a staple length of 5 cm or more.

Cotton lint is used in the manufacture of textiles. Many textile factories, using mainly locally-produced lint, exist in Nigeria, Ghana and Cote d' Ivoire. The cotton lint requirement of these factories is so great that 'some West African countries, e.g Nigeria, have become net importers of cotton. Even before the advent of European traders, locally-woven attractive cloths using West African cotton flourished in Nigeria, Ghana and Sierra Leone. The lint was spun into long threads which were dyed, before being woven into 'Kente or 'Aso-oke' cloths. The short hairs, called fuzz or linters, which are removed after further ginning, are used for making cellulose acetate, rayon, carpets and in the manufacture of upholstery.

Cotton seed oil forms about 25 per cent of the seed. It is a semi-drying oil used after refining as cooking oil or in the manufacture of soap and margarine. The residue after oil removal is called cotton seed cake. It contains up to 5 per cent nitrogen and is rich in protein. It can be fed to livestock as a concentrate for milk production or used in the manufacture of nitrogenous fertilizers.

Raw cotton seed contains a poisonous substance called *Gossypol*. It should therefore not be fed to livestock, especially the young ones which are more susceptible to this poisoning.

#### **3.4.1.1 CLIMATIC AND SOIL REQUIREMENT**

Cotton will grow well on a wide range of soils but is better on fertile, well-drained deep loams and clay loams with pH of 5.7-8.0. Water and nitrogen are two important factors which affect the yield of cotton. Its water requirement varies with the spacing, temperature and soil conditions. It requires little water during the first two months, when its leaf area is small, but its need increases at flowering, reaching a peak some six weeks later. Thereafter, the water requirement declines. Inadequate water supply during the third, fourth and fifth months in the field can lead to premature shedding of leaves, flowers, buds and bolls and to the development of short immature lint. High rainfall is undesirable as it encourages increased disease and pest attack and discolouration of the lint.

#### **3.4.1.2 VARIETIES GROWN**

Most cotton introduced to West Africa belongs to the short staple American Upland Cotton type. The best known of these is the Alien type from which the improved Nigerian Alien (N.A.) 26C was bred. It is the commercial cotton of the northern areas of Nigeria, has a short fibre and yields up to 560 kg cotton seed per ha on government farms but only 112-224 ,kg per ha on small farm holdings.

The recommended varieties in Ghana are BJA 592 and Alien 333. Nigerian Ishan (N.I.) is an indigenous cotton with short fibre selected from cotton in the Ishan district of Benin in Edo State of Nigeria. Botanically, it is *G vitifolium*. It is a tall, bushy plant (shrub) with deep yellow flowers and has a longer and silkier fibre than the average locally grown cotton of southern Nigeria, e.g. the Meko type (*G. peruvianum*). It performs better than the Alien type when intercropped.



### **3.4.1.3 CULTIVATION**

Cotton is sown alone or intercropped with other crops such as maize or yam. It is always grown in rotation with other crops. In Ghana, a three-year rotation (A Cotton, B Cowpeas or Soyabeans, and C Maize), or a four-year rotation (A Cowpeas, B Groundnuts, C Cotton, and D Sorghum) is followed. Sowing date, spacing and thinning are extremely important. Spacing varies with the area and cotton variety. For a sole crop, 90 x 30 cm or 75-105 cm apart on ridges are used, but close spacing promotes an early yield. In July, 6 to 10 seeds are sown per hole at a depth of 2 cm giving a seed rate of 17.0-22.5 kg per ha. The seed rate in Nigeria is even higher, thus raising the cost of production. Seeds germinate in 4 — 6 days. The seedlings are thinned to one to two per stand when 3 weeks old and 10-15 cm high to prevent excessive competition among the plants for nutrients. Weeds are removed and mulching with grass or weeds is helpful. Flowering occurs 2 to 4 months after field planting. Pollination occurs during the day and the first bolls open 1 to 2 months later. Picking is done by hand as soon as enough bolls open fully and the lint is dried properly. This is usually at the end of January in northern areas of Nigeria but extends to March and April in southern areas of Nigeria. Frequent picking is desirable to reduce insect attack. A good picker will pick 27-32 kg per day and one picker will be needed to cover 1.6 ha.

### **3.4.1.4 PROCESSING**

After harvesting, the seed cotton is ginned (i.e. the lint is removed from the seed and fuzz). Two types of gins can be used: saw gin for the shorter staple American Upland Cotton in which the lint is very firmly attached to the seed; and roller gin for the longer staple cotton in which the lint is more easily removed from the seed. In Nigeria and most of West Africa, the saw gin is used. The saw gin consists of a large number of circular pieces of metal with notched edges which look like a saw, mounted on a common axle. It rotates at a steady speed inside a closed box, one side of which is notched. An arc of each small circular saw protrudes through these notches. The seed cotton is placed against the notch side of the box and the rotating saw tears the lint quickly from the seed. The Ginning Out Turn (G.O.T.), i.e. the percentage of the lint to the total weight of the seed cotton is usually 30 — 33 per cent. The lint which is light and bulky with a moisture content of about 12 per cent is then baled under pressure. Bales of cotton lint vary in size: one bale weighs 182 kg in Nigeria as

contrasted to 144 kg in Sudan. The leftover seed cotton is further ginned to remove the fuzz or linters.

#### **3.4.1.5 YIELD**

Yield varies with the variety planted, the sowing date and incidence of pests and diseases. The average yield is around 112-336 kg per ha, as most farmers interplant their cotton with other crops. Yields of 560-672 kg per ha are possible for Nigerian Ishan and Nigerian Alien as sole crops under good supervision on government farms.

#### **3.4.1.6 DISEASES**

- (i) **Black arm:** This is a bacterial disease caused by *Xanthomonas malvacearum*. It attacks the leaves, stems or bolls at any stage of growing. It can cause seedling blight, which makes the leaves to turn brown and dry up, or it can cause black lesions on older plant stems or branches which may break off. This phase is known as '*black arm*'. If bolls are attacked, they rot, thereby causing cotton staining if the attack is mild, or total destruction if it is severe. Infected remains of the crop should be burnt to prevent a carry-over of the disease. Seed dressing with a copper fungicide can prevent attack. The use of healthy seeds should be encouraged and varieties that are resistant to attack should be planted.
- (ii) **Leaf curl:** This is a virus disease whose vector is a white fly (*Bemisia spp.*) It causes the leaves to curl, and the plants become stunted and die. Infected plants should be burnt.

#### **3.4.1.7 PESTS**

- (i) **Pink boll worm (*Platycaea doszypiella*):** The larvae, which have a double pink bar on each segment of the body, bore through minute holes into the cotton fruit, thus damaging it and reducing yield substantially. Some control is achieved by spraying carbaryl.
- (ii) **Jassids (*Empoasca spp.*):** These are small green flies which bore holes in cotton leaves and cause them to curl. Cotton varieties with leaf hairiness discourage attack by these insects. Diethoate 30% EC gives effective control of the insects. Mix the insecticide in 100 to 200 litres of water and spray thoroughly on the plants and leaves.
- (iii) **Cotton stainer (*Dysdercus spp.*):** These insects with red, brown and black markings are abundant in West Africa, often feeding on alternate host plants such as okra, when not attacking cotton. They pierce the boll walls and introduce a fungus (*Nematospora*

spp) which stains the lint bright green, thus lowering the grade of the cotton. Attack at an early stage causes shedding of bolls and yield reduction. Control is achieved by spraying carbaryl, but it is expensive.

#### ***4.0 Conclusion***

#### ***5.0 Summary***

#### ***6.0 Tutor marked assignment***

#### ***7.0 Referencing and further reading***

## **MODULE 5**

### **Unit 5**

#### **1.0 Introduction**

#### **2.0 Objective**

#### **3.0 Main content**

##### **3.5.0 Zingiberaceae**

##### **3.5.1 GINGER (*Zingiber officinale*)**

##### **3.5.1.1 CLIMATIC AND SOIL REQUIREMENT**

##### **3.5.1.2 VARIETIES GROWN**

##### **3.5.1.3 CULTIVATION**

##### **3.5.1.4 YIELD**

##### **3.5.1.5 DISEASES**

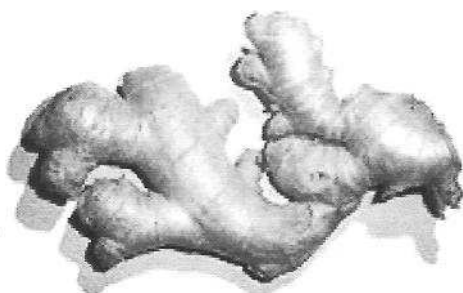
#### **4.0 Conclusion**

#### **5.0 Summary**

#### **6.0 Tutor marked assignment**

#### **7.0 Referencing and further reading**

**3.5.0 Zingiberaceae** (700 sp.). Leaves distichous, sheathing, and with a distinct ligule. Perianth of 6 segments in 2 whorls, generally distinguishable into calyx and corolla. Stamens in 2 whorls—only 1 perfect, adnate to corolla-throat (this is the posterior one of the inner whorl), the other 2 stamens of this whorl are united to form a 2-lipped labellum; the anterior stamen of the outer whorl is absent and the remaining 2 modified into petaloid staminodes or absent. Style slender, passing through the two anther-lobes. *Floral formula*— $-\overset{K}{s}CsA_1G(B')$   
Examples. *Zingiber* (80 sp.), e.g. ginger (*Zingiber officinale*), wild ginger (*Z. casumunar*), turmeric (*Curcuma longa*), wild turmeric (*C. aromatioa*), mango ginger (7, *amada*), butterfly lily (*Hedychium eoronarium*; B. DULAL-CHAMPA), *Kaempferia* , e.g. *K. rotunda* (B. BHUI-CHAMPA), *Costus* (150 sp.), *s speciosus* (B. KUST; H. KEU), *Alpinia* (225 sp.), e.g. *A. allughas*<sup>Q</sup>. TARA), *A. galanga*—medicinal, *Globba* (100 sp.) e.g. *G. bulbifera*



### **3.5.1 GINGER (*Zingiber officinale*)**

Ginger originated in tropical Asia but it is now grown all over the tropics. West Africa is an important exporter of the crop, Sierra Leone being the leading producer. Ginger has a variety of uses - as a spice in cooking, and in the preparation of confectioneries, pickles and beverages such as ginger ale. It is used in Sierra Leone and Liberia to make ginger beer, and as a preparation for stomach disorders.

#### **3.5.1.1 CLIMATIC AND SOIL REQUIREMENT**

It grows best in lowland forest areas, under shade. The rainfall should be heavy (2,000-2,500 mm), but it does well under light, well-distributed rainfall of 780-1,000 mm if irrigated. The soil should be a deep loam, rich in humus and well-drained.

#### **3.5.1.2 VARIETIES GROWN**

The most popular and recommended variety in Sierra Leone is the Yellow type.

#### **3.5.1.3 CULTIVATION**

It is propagated by pieces of rhizomes 2.5-5cm long containing one or two eyes. They are planted in holes 5-7.5 cm deep and 30-45 cm apart. Planting is done in March or April. The rhizomes sprout and appear above the ground 10-15 days after planting. It benefits from weeding and manuring. Fertilizer is applied before planting or at the beginning of the rainy season. The plant matures in 9 — 10 months and the rhizomes are harvested when the leaves turn yellow and wither.

In Sierra Leone the rhizomes are carefully lifted to avoid bruising and these are washed in water and then peeled with specially designed spoon-like knives. Peeling of ginger is a skilled job, otherwise the skin containing the volatile oil upon which the aroma and flavour depends may be injured. The peeled ginger hands are washed again and sun-dried for 6 — 8 days on concrete floors or on palm fronds until the moisture content is reduced to 7-12 per cent. This helps them to maintain their white colour. During drying, the hands are turned over at about mid-day and they are taken indoors in the evening.

In Nigeria, ginger is more often split than peeled although this fetches far less money.

#### **3.5.1.4 YIELD**

An average yield of 750 kg per ha is obtained in Sierra Leone. The potential of the best variety is 2,241kg cured ginger per ha per annum. Four tonnes of rhizome will give one tonne of sun-dried "ginger.

#### **3.5.1.5 DISEASES**

(i) **Black rot:** The leaves of diseased plants turn yellow and wither and the rhizome disintegrates. The disease is common under wet conditions. Control is achieved by removing infected plants and treating the soil with lime or sulphate of iron.

(ii) *Vermicularia zingiberæ*: This disease affects the leaves and prevents rhizome development. Spraying with bordeaux mixture gives effective control.

#### **4.0 Conclusion**

#### **5.0 Summary**

#### **6.0 Tutor marked assignment**

#### **7.0 Referencing and further reading**