COVER CROPS

Are crops grown to provide ground cover between widely-spaced tree crops or arables. They should be a fast growing species. They protect the soil from the impact of raindrops, and from the scorching effects of direct sunlight, and also prevent the development of an unwanted weed flora [e.g. *Imperata cylindrical* (L)]. Legumes are most suitable, as they simultaneously contribute on N supply to the main crop due to their N_2 fixing. Ground cover crops should be efficient in the acquisition of mineral elements or nutrients, so that they themselves demand little or no fertilizers, while at the same time mobilizing the mineral resources of the soil for the main crop. They should be deep rooted, so as not to compete with the main crop for water and nutrients. They should also remain green through several months of low rainfall in order to reduce the risk of fires, and should tolerate certain amount of shade. The choice of species depends not only on the local soil and climatic conditions, but also on the growth habit of the main crop.

Ground cover plants can have a decisive role as a means of controlling weeds. If a quick growing ground cover crop is soon immediately after harvesting, the possibility of weed propagation is reduced. Quick growing legumes such as *Lablab purpureus, Vigna phaseolus* are also suitable for keeping down weeds in

the short term. However, vigorously growing ground cover crops are not only used to hinder the appearance of unwanted weeds, but also to suppress existing populations of weeds e.g. include *Pueraria spp, Centrosema pubescens, Mucuna spp*, Cowpea, sweet potato, melon, *Calopogonium mucunoides*, etc.

FORAGE CROPS

Are plants used essentially in their entirety as feed for animals. The condition or form of the forage when fed varies tremendously. When forage is grazed, animals feed directly on fresh plants in the pasture or on the range. Forages can also be fed fresh after being harvested mechanically. Forages include grasses and legumes e.g. of grasses are *Cynodon dactylon* (Bahama or Bermuda grass), *Panicum maximum* (guinea grass), *Pennisetum purpureum* (elephant grass), *Digitaria decumbens* (Pangola grass) while the legumes include: *Calapogonium mucunoides* (Calapo), *Centrosema pubescens* (Centro), *Lablab purpureus* (Lablab), *Stizolobium spp* (Mucuna), *Pueraria spp, Cajanus cajan* (Pigeon pea).

Citrus spp

The most important species in the sweet orange (*Citrus sinensis*). Citrus fruits are borne on large evergreen trees reaching heights of 4.5m-8m. (1) *Citrus sinensis* are classified as common or navel ('Washington', 'Thomson') etc. Other species include: (2)Tangerine or Mandarin (*Citrus recticulata)* is a type of citrus which has a loose skin, peels easily and has attractive orange-red flesh.

(3) Lemon (*C. limon*), (4) Lime (C*. aurantifolia*), (5) Sweet lime (*C. limetta*), (6) grape fruit (*C. paradise*), (7) Pummelo or shaddock (*C. maxima*), (8) sour orange (*C. aurantium*), (9) Tangelos (Tangerine x grapefruit) and (10) temples (tangerine x orange).

Most citrus species are propagated by grafting on rootstocks which has been grown from the seed. The stock has a definite influence on the disease resistance and fruit quality. The choice of stock depends on the local conditions: resistance against phytophthora on heavy soils, resistance against tristeza in places where no virus-free close material is available.

Planting distances depend on the cultivar and stock (growing vigour); for oranges, 7.5-9m, for mandarins, 4.5-6m.

The soil is kept free of weeds. Cover crops and arables can be planted. In large scale cultivation, soil herbicides are used (diuron or biomacil).

Pest and Control

	Pest	Damage	Control
1.	Citrus aphid Toxoptera citricidus	Suck plant sap and cause distortion of the leaves	Diazinon, Malathion, Dinethoate
2.	Citrus black fly Aleurocanthus	Groups of shiny black, scale-like insects underneath leaves. The leaves drop	As above
3.	False codling moth Coyplophebia leucotreta	Moths lay eggs on fruits, caterpillars bore into pulp. Yellow patch on skin of fruit	Spray Fenthion on malathion once a week starting when fruit measure 4cm across Bury infested fruits
4.	Mealybugs	Causes injuries to the growing points of citrus	Spray with Parathion or Malathion

Diseases and Control

	Disease	Symptoms	Control
1.	Tristeza (viral)	Trees do not grow well, leaves become bronzed in colour and fall off and twigs die	-No chemical control -Use resistant root stalks such as rough lemon, sweet orange
2.	Anthracnose	Leaf blight, twig blight and fruit staining	-Spray with copper fungicide -Farm sanitation -Use of tolerant/resistant varieties
3.	Scab	Whitish scabs on leaves, twigs and fruits	-Farm sanitation -Use of tolerant/resistant varieties -Use of fungicide e.g. captan, Bordeaux mixture

4.	Foot rot or brown rot (gummosis)	Kills the bare on trunks and roots resulting in the death of plant	-Use fungicide -Suitable growing rootstocks
5.	Citrus canker (*Xanthomonas citri*)		-Use of tetracylines -Use of disease-free grafting materials

Citrus Herbicides

Dalapon	2-4 kg/ha active ingredient	Annual and perennial grasses	Pre-emergence
Diuron	1.6-3.2kg/ha a.i.	Annuals	Pre-emergence
Simazine	4-9kg/ha a.i.	Annuals	Pre-emergence
Bromacil	1.6-6.4kg/ha a.i.	Annuals Perennials grasses	Used for orchards established more than 4 years(

			pre-emergence).

SPINACH (*Amaranthus curentus)*

It belongs to the family Amaranthaceae and has the following common names: African spinach, Indian spinach, Amaranth, Green leaf etc. Many species probably originated from South America or Mexico and are now widely distributed throughout most tropical areas.

BOTANY

It is usually a short-lived annual, up to 1m in height. The stems are erect, often thick and fleshy and sometimes grooved. The leaves vary in shape depending on variety and are green or purple, normally alternate, petiolate and entire, tips often obtuse. The inflorescence is racemose spikes, either axillary or terminal. Flowers are small, numerous, regular and unisexual with a super-ovary. The seeds are small with shiny testa and are usually black or brown.

VARIETIES

These include: Amarante rouge, Amarante verte etc. Fotete, Fotete Rouge, Fortete vert-rouge etc., *A. blitum, A. lividus*, *A. curentus*.

ENVIRONMENTAL REQUIREMENT

Soils with a high organic content, with adequate mineral reserves are required for optimum yields although some species are tolerant to fairly wide ranges of soil condition. The optimum pH range is 5.5-7.5 but some cultivars tolerate alkaline soils. Most species are tolerant of relatively high temperature and generally thrive within temperature range of 22-30^{o}C. It is grown in both wet and dry seasons although irrigation is normally acquired for dry season crops.

PLANTING: Seeds are sown broadcast on prepared beds at a rate of 3-10g/m^2 (1.5-2kg/ha). They may be sown on nursery beds and the seedlings transplanted to rows 20-30cm apart and 10-15cm between plants. Vigorous species can be transplanted to 30-40m x 30-40cm square spacing. Broadcast sown seedlings may be thinned to15-22cm apart each way. A grass mulch is sometimes used for

covering freshly sown seeds protect them from heavy rain and removed when seeds germinate.

WEEDING

This is done by hand-picking the beds and hoe weeding the furrows.

FERTILIZER APPLICATION

Most cultivars or species have a high rate of nitrogen absorption and surface dressings of nitrogenous fertilizers are normally required during the period of active growth. Additional application of potassium may be also necessary or established plants may be cut back to within 15cm of the base to encourage lateral growths which will provide successive harvests. Yield entire plant harvest: 20-25t/ha; shoots only (successional harvesting) 30-60t/ha.

STORAGE AND PROCESSING

If harvested whole, roots are trimmed and the plants may be washed before being tied into bundles where available, crushed ice or water may be scattered

over the top layers of the basket or container to prevent wilting. Care should be taken to avoid over-packing of the container.

PESTS

PESTS	DAMAGE	CONTROL
Hymenia recurvalis, F (leaf caterpillar)	Feeds on the leaves which it may roll up within a web	-Use of chemicals e.g. Lindane. Malathion (taints leaves) -Biological control
Lixus trunculatus, F (stem borer)	Larvae bore tunnels in the basal part of stalk, weakening the plant and reducing yield	-Burn crop debris -Use insecticides e.g. lindane, carbaryl
Zonocerus variegatus variegated or stink locust	Eats leaves of seedlings	Use Dieldriin or carbaryl sprays or aldrin or BHC baits

DISEASES

DISEASE	SYMPTOMS	CONTROL
Choanephora cucurbitarum (leaf and stem wet rot)	Saprophytic moulds, soft rot of leaves and young stems is covered with grey sporangiosphores with black heads. Young or weak plants may die. Attacks weaker plant	-Promote vigorous growth -Use resistant varieties
Pythium aphanidermatum (damping off)	Seedlings appear water soaked at ground level and topple over often with the leaves still green.	-Use quality seeds. -Plant under optimum conditions for rapid growth. -Avoid overwatering of plants. -Seed dressing e.g. captan, thiram.

FACTORS AFFECTING CROP PRODUCTION

The factors include: environmental, economic and sociological.

1. Ecological or Environmental Factors: These include: rainfall, humidity, and temperature, length of the growing season and soil factors.

Rainfall is one of the most important environmental factors affecting crop production. Rainfall varies in its efficiency, in some sections a considerable part falls during months when crops are dormant. Different crops require different amount of rainfall/annum for optimum yield, and also in term of humidity. The loss of water by evaporation has considerable effect on the efficiency with which water is used by growing plants. Loss of water (moisture) by evaporation and transpiration is high when the relative humidity is low. **Temperature** is important in crop distribution. The date at which crops are planted relates directly to air temperature as this affects soil temperature. Crops that are grown when temperature is low is classed as cool-season crops.

Soil factor: In some areas, much of the land may be broken and rough with many stones at or on the surface, or poorly drained or lacking in fertility. The topography of the land tells sometimes of the soil. Rough, hilly land is not likely to be fertile compared to soil with equal rainfall. The fertility of the soil is lost both by leaching and by erosion.

2. Economic Factors: These include: land value and choice of crops, labour requirement and transportation and other factors (population). **Population:**

- Perishable products raised near centres of high population.
- Non-perishable are produced at great distances from the centres of consumption.
- High demand for food in the market and urban centres.
- Agrobased industries like livestock feedmills, manufacturing plants for pharmaceuticals, soft drinks, textiles and etc. are sited in urban centres.
- High population in these areas provides ready market for products, apart from those produced for export market.
- Large quantities of food produced are consumed in the centres.
- Demand for most of these commodities often dictates the scale of production.

- Oil Boom – recession in economy (shortage of foreign exchange,
- importation): Exchange – reduction, followed by a total ban on importation

– led to increasing demand (maize, rice, wheat and sorghum) to sustain local industries – led to increase in the production (large scale) of these commodities.

Land value and choice of crops: Land that is high in price must be made to produce crops with relatively higher unit value and with a higher production rate than cheaper land.

Labour requirement: The requirement of a given crop for labour at a particular time affects the crop choice to be made and the crop combinations used. Most farmers will plant crops that will increase their economic returns even after labour and other expenses.

Transportation and other factors: Transportation cost is a factor that influences the crops that farmers in certain sections will grow; it also affects other crop products needed to be transported from other sections. Changes in demand for different crops, as measured by prices they bring to the market and in the amounts exported to other parts of the world in response to different needs there will influence the hectarage of the different crops grown.

3. Sociological Factors: Some farmers regard some crops as lesser crops and will not cultivate these crops. Also cultural taboos prevent farmers from growing some crops even when these crops are of economic importance in some areas. This can affect the production of such crops.

DEFINITION OF CROPPING SYSTEM AND FARMING SYSTEM

Cropping system: refers to the scheduling and cultivation of various crops within a farm enterprise in a given agricultural year. It refers to the way and manner in which the farmer actually organizes the growing of various crops and how he arranges them in his field.

Farming system: refers to a system which is influenced by environmental, technical, economic, and human factors. It considers the farmer, his farm operations and the biological and socio-economic environment in which he operates. It incorporates cropping system. The farming system that results is determined by how he produces, uses, market or consumes his farm products, both crops and livestock.

CROPPING SYSTEM COMPONENTS

The components of the environment of crops consist of the soil, sunlight, water and temperature.

Soil: The characteristics of soil for crop production include:

1. Ease of cultivation with conventional tools
2. Ability of roots to penetrate, develop and anchor in the soil
3. Good nutrient content, nutrient-holding capacity and availability to growing crops

4. Absence of a permanent water-table near the surface of the soil

5. Depth of rooting zone

6. Satisfactory rate of acceptance of rainfall and resistance to erosion

7. The soil must be porous enough to permit free circulation of air for the benefit of the roots of growing crops

These characteristics are usually influenced by such factors as choice of soil for specific crops, cultivation practices, irrigation, drainage, manuring, mulching and planting patterns and distances between plants.

4. Air

5. Sunlight

6. Water

7. Temperature

(b) Human preferences (Exogenous factors)

(1) Government policy

(2) Market poll

(3) Institution (ADP etc.)

(4) Politics

(5) Religion

(6) Infrastructure

(2) Air: The O_2 of the air is required for respiration and the carbon dioxide for photosynthesis. The conc. of CO_2 determines in part, the rate of photosynthesis and thereby affects crop yields. High concentration of CO_2 in the rooting zone of crops are harmful to all crops, it is only the green, aerial parts that can benefit.

(3) Sunlight: The techniques used to obtain maximum utilization of sunlight in crop production include the choice of location, type of plant, distribution and density of planting, weeding, shading and time of planting. Control of the distribution and density of plants through spacing, pruning or training ensures maximum utilization of sunlight. Generally, close rather than wide spacing is the most efficient but the optimum spacing is often determined by the quality of yield desired. Competition for light between different parts of the same crop stand can be modified by pruning and training of the canopy of the crop. The intensity and duration of sunlight is controlled by shading i.e. growing companion crops or shade plants with a crop. One of the best ways of utilizing sunlight in crop production is to adjust the time of planting so that the crop grows through a period when sunlight is brightest and longest in duration.

(4) Water: Water is required for the process of photosynthesis and for all metabolic reactions. In fruit and leafy vegetables, water can limit yield. Although

crops absorb water from the soil, all the water required for crop growth and yield come from rainfall which in the tropics is cyclic and fairly dependable. The intensity and duration of rainfall varies. Humidity also affects crop production by influencing evapo-transpiration. Most tropical crops are adapted to intermediate moisture supply conditions and their growth and yield are severely affected by excess or reduced moisture availability. Certain stages of reproductive growth are very sensitive to moisture stress. Perennial tropical crops respond imperceptibly to moisture stress and the effects on yield may not be obvious until one year or more after the occurrence of the stress.

(5) Temperature: Optimum temperatures for crop growth lie between 5 and 34^{o}C. Different parts of plants, respond differently to the same temperature conditions. Temperature fluctuation is only important for crop growth and yield when moisture supply is limiting.

DEFINITION OF SHIFTING CULTIVATION

1) Shifting Cultivation

Farmers cultivate a plot of land large enough to supply their family's needs until soil fertility declined with continuous cropping. The farmers tend to move on to another plot leaving the first plot to return to bush through regeneration of the

natural vegetation. The soil would recover its fertility during this fallow period. The land is planted with crops with high fertility requirements and ending with crops whose fertility is low. It is linked with low levels of inputs of technology and management. Most of the operations are carried out with simple hand tools and the labour requirements are high. Bush burning constitutes a technological easy answer to the problem of cleaning plant debris from the field prior to cropping. Bush left to fallow can stay up to 10yrs where land is abundant. Apart from soil fertility, pests and diseases can also cause a farmer to abandon his land. It requires a great deal of land to maintain the system. Shifting cultivation has low efficiency of labour utilization.

TYPES OF SHIFTING CULTIVATION

Two types of shifting cultivation are recognized under subsistence farming systems in the tropics.

1. The people build temporary villages and practice shifting cultivation in the immediate vicinity for several years until crop yields fall significantly. The whole community then migrates elsewhere to build a new village and open up new land. This practice is a common feature in Africa and Malaysia. The land is usually reopened only after a prolonged period of fallow.

2. The people live in permanent villages or towns with their cultivated land covering a large area. The prolonged use of a relatively limited amount of land naturally results in a more rapid rotation of the cultivated farms and so fallow periods tend to become gradually shorter and as the productivity of the immediate vicinity of the village declines, the distance from dwellings to the farms may continue to increase. The fertility restoration during the period of rest is dependent on the length of the fallow vegetation, the nature of the vegetation and the rate at which soil nutrients are taken up by the fallow vegetation from the subsoil.

CHARACTERISTICS OF CROPPING SYSTEM

(a) Shifting cultivation:

In the practice of shifting cultivation, the farm is not a permanent location. Instead, a piece of land is cleared, farmed for a few years and then abandoned in preference for a new site. While the new site is being farmed, natural vegetation (bush fallow) is allowed to grow on the old site. Eventually, after several years of bush fallow, the farmer returns to the original location. Shifting cultivation involves the moving of the home along with the farm, but this form exists in only a few places today. Shifting cultivation as practiced in the tropics is linked with

low levels of inputs of technology and management. There is no incentive to invest in permanent structures such as strong shed and irrigation facilities. Yields are usually low as inputs are also very low.

(b) Mixed Cropping:

The practice involves growing two or more crops simultaneously on the same piece of land. For example, sorghum and millet or cassava and maize are grown as mixed crops. Millet or maize is usually planted first and, about four weeks later, the sorghum or cassava is sown between the millet or maize stands. It is associated with under-developed farm technology. The system complicated the interpretation of crop performance while making mechanization difficult.

(c) Continuous Cropping:

This implies the cultivation of the same piece of land year after year. Fallowing may occur, but it never occurs for more than a season or two. The absence of a protracted fallow period means that other soil management procedures must be used to maintain high soil fertility. Continuous cropping is usually associated with a higher level of technology and management. In clearing, tree stumps and woody roots are removed from field. The operation is imperative if mechanical tilling devices (ploughs, harrow and ridgers) are to be used with ease in the field.

Continuous cropping relies on fertilizers and other soil amendments to boost fertility and also a good selection of crops and crop combinations. Lastly soil fertility is maintained by introducing short term fallow periods into the cropping cycle.

Land utilization under continuous cropping is extremely efficient. A high percentage of the land is under crops at any given time. It is possible to erect permanent structures on the farm site. Good access roads, irrigation facilities and store houses can be built.

(d) Crop rotation

The practice of growing different crops, one at a time, in a definite sequence on the same piece of land is referred to as crop rotation. The design of a good crop rotation is by no means an easy task. The farmer must decide what crops to have in rotation, in what sequence the crops should occur, and for how many years or seasons each cycle of the rotation must run. Economic considerations are a major factor in deciding on what crops to have in the rotation. Usually there is one main crop (sometimes two) which is the farmer's primary target, and around which he builds the rotation. He designs his rotation so as to obtain the maximum yields of the target crop, while tolerating whatever yields may result from the other crop. Alternatively, the rotation may be designed to maximize the total economic yield

from all crops in the cycle, without giving particular favour to one crop. Invariably, a legume crop is included in the rotation, whether or not it is the target crop. A fallow period is sometimes also included in the rotation although a forage or green manure crop may be grown on the field during the fallow.

Several factors have to be considered in deciding the sequence of crops. Usually the target crop comes immediately after the legume or the fallow period. At this time the fertility of the soil is at its peak. Crops which are known to have a high demand for nutrients are also planted first for the first or second season after the fallow. Crops which are deep feeders should alternate shallow feeders. Crop sequence is also influenced by disease and pests including weeds. E.g. yams should not follow cowpeas if the root-knot nematode is prevalent. The number of years for which each cycle of the rotation should run is determined by the number of crops in the rotation, the length of their growing seasons and how frequently the farmer can grow the target crop without running into problems of disease and soil fertility. In practice each cycle of crop rotation may last from 3-8 years, sometimes with one crop occurring more than once in each cycle. The farmer may consider his entire field as one plot. He then rotates the crops in sequence on the field or divides his field into as many plots as there are years in the rotation. The farmer then starts with a different crop on each plot and

progresses through the rotation. In this scheme, all the crops are present on the farm at any given time e.g.

	Year I	Year II	Year III
Plot A	Cotton	Guinea corn	Groundnuts
Plot B	Guinea corn	Groundnuts	Cotton
Plot C	Groundnuts	Cotton	Guinea corn

(e) Mixed farming

Mixed farming is the integration of animal and crop production on the same farm. It provides for the combination of crop production and livestock in a single enterprise, such that the farmer is able to feed his animals or poultry with his own crops. Farmyard manure produced by livestock is also used on the crops. Crop farms are used as livestock feeding grounds once the crop has been harvested. Cattle feed on the crop residues and leave their dung in the field, thus increasing the fertility of the soil. It provides insurance against failure of any farm enterprise. Bulls are used in the cultivation of crops, thus increasing the total land area available for cropping.

(f) Ley farming: This system alternates pastures with crop production. The pasture usually selected for ley farming is of sufficient nutritional and morphological quality to enable it to fit into a crop rotation system. After the arable crop (a cereal) is harvested, the field is sown to pasture and grazed for one or two seasons before it is ploughed again for arable cropping. The planted pasture is usually a mixture of grasses and legumes. It involves a planted fallow which many farmers are unable to justify in economic terms.

(g) Alley Cropping System:

Is a system of growing small tree or shrub which recycles plant nutrients and at the same time provides material for mulch with an arable crop. The concept of alley cropping retains the basic features of bush fallowing, but has the following modifications:

1) Selected species of fast-growing small trees and shrubs usually legumes with the ability to fix nitrogen are used.

2) The small trees or shrubs are planted in rows with inter-row spacing wide enough to allow the use of mechanized equipment.

3) The trees or shrubs are cut back and kept pruned during the cropping period and the leaves and twigs are applied to the soil as mulch, providing a

source of nutrients and organic matter. Bigger branches are used as stakes or fire wood.

4) The height to which the trees or shrubs are cut back depends on the shade tolerance of the associated crops.

5) The land is periodically ploughed in order to cut tree roots to reduce competition with crops.

6) The trees or shrubs are allowed to recover during the dry season, when they develop new growth ready to be used on the next crop.

TYPES OF CROPPING SYSTEMS

1. CROPPING PATTERN IN RELATION TO TIME:

a) Relay cropping: Involves following one crop with another immediately before harvesting the former crop. In practice, the seedlings of the second crop are established within the maturity field of the first crop. Usually the later crop makes little growth until the early crop begins to mature and then fully utilizes the soil and air environment after the early crop has been harvested. Has similar advantage to phased planting.

b) Phased planting: Is a type of mixed cropping in which planting dates are systematically arranged to ensure continuous sequence of growth and harvesting. This method has the following advantages:

1) Permits the phasing of labour operations.

2) Saves labour costs by combining weeding and planting so that fresh tillage is not necessary.

3) Reduces risk of crop failure from unfavourable weather, pests and disease damage.

4) Leads to phased harvesting thus ensuring continuous food supplies with reduced storage losses.

5) Ensures that the soil is continuously covered and protected from wind and water erosion.

c) Monocropping (monoculture or sole cropping) is the growing of a single crop on a piece of land within a growing season. The practice has the following disadvantages:

1) The practice carries with it the risk that the farmer could lose his entire crop in the event of drought, pests or disease attack.

2) Encourages pest and disease build-up.

3) It creates an imbalance in nutrient removal from the soil.

The advantage is that it encourages specialization in the techniques of production.

d) Double cropping: Is the growing of two crops in a year in sequence.

2. CROPPING PATTERN IN RELATION TO SPACE

a) Sole cropping: The practice of growing one crop variety alone in pure stands on a field is referred to as sole cropping. In this practice, only one crop variety occupies the land at any one time.

b) Mixed cropping: Is the simultaneous growing of two or more crops on the same piece of land. It is the most common of farming systems in the tropics usually associated with under-developed farm technology.

c) Row cropping: This is a type of intercropping system based on the exact spatial arrangement of crops on the field. When the various crops are grown is separate rows, it is called row cropping.

d) Alley cropping: Is the growing of small trees or shrubs which recycles plant nutrients and at the same time provides materials for mulch. It provides support for such twining crops as yam, green leaf for enriching the soil organic matter and increased nitrogen levels in the soil. Apart from tree or shrub species, legumes and non-legumes have been evaluated for use in alley cropping system. Desirable

species are those that can be established easily and which can be maintained from basal sprouts and coppices when periodically cut back.

e) Taungya system: Is a system whereby trees are first planted then followed by crops till the trees form their shape.

Features:

1. Crops are planted together with trees.
2. Permanent crops are not planted together with trees.
3. It helps to stop erosion.

ADVANTAGES AND DISADVANTAGES OF CROPPING PATTERNS

(1) Mixed cropping

Advantages

1. Makes better use of the environment in terms of space, water and nutrient.
2. Permits higher plant population.
3. Reduces the risk of total crop failure resulting from pests and diseases.
4. Gives a good soil structure which in turn minimizes erosion.
5. When legumes are included, they may have some residual nitrogen in the soil which may benefit subsequent crop.

6. The return per unit of labour is higher as a result of greater total yields and more dependable returns can be secured from year to year.

7. Pests and diseases do not spread as quickly in crop mixtures as they do in monoculture.

Disadvantages

1. It complicates the interpretation of crop performance.

2. It makes mechanization difficult.

3. Most fertilizer recommendations are based on monocropping.

(2) Taungya System

Advantages

1. It reduces sunshine intensity on the soil surface.

2. Virgin lands are always put into use.

Disadvantages

1. Continuous cropping is not encourage

2. Use of mechanization is not possible in some cases.

(3) Alley Cropping

Advantages

1. It provides support for twinning crops such as yams, and green leaf for enriching the soil organic matter.

2. It increases nitrogen levels in the soil.

Disadvantages

1. It makes mechanization difficult.

2. It can result in substantial decrease in crop yield.

(4) Sole Cropping

Advantages

1. Mechanization can be practiced.

2. It encourages specialization in crop production.

Disadvantages

1. Failure of the planted crop leads to total loss for the farmer.

2. Encourages pest and disease build-up.

(5) Crop rotation

Advantages

1. It is an effective means of controlling pests and diseases.

2. Is a device for maintaining high soil productivity over several years of continuous cropping.

3. Offers the farmer some insurance against crop failure if field is divided into several plots.

Disadvantages

1. The growing of one crop means that the demand for labour occurs in peaks. Labour demand is more evenly spread if many crops are grown simultaneously.

2. The risk of crop failure is ever present.

3. Facilities for target crops are only utilized once in several years.

(6) **Shifting Cultivation**

Disadvantages

1. It wastes land because of large area of land is left fallow.

2. It does not encourage long term planning e.g. erection of a homestead, irrigation facilities.

3. It requires a great deal of labour and money in cleaning new land every time a farmer moves to another land.

CACAO (*Theobroma cacao*)

1.0 The Origin of Cacao

Cacao developed in the upper amazon region of Latin America. It was first discovered and grown in Mexico. The word cacao refers to the tree while cocoa refers to a drink made from its seed. Cacao has been cultivated in America for

2000 to 4000 years. The crop was discovered by Christopher Columbus during his fourth voyage to the new world. The specific centre of origin of cacao has been accepted as the area from the forests of the Amazon to Orinoco and Tabasco in South Mexico.

Spain introduced cacao to Africa around 1840. Cacao was introduced into Nigeria in 1974. Other sources of introduction of the crop to West Africa include: trading companies, Christian missionaries, soldiers, chiefs, farmers' associations, cooperatives, various departments of agriculture and more recently the West African Cocoa Research Institute (WACRI), the Cocoa Research Institute of Ghana (CRIG), the Cocoa Research Institute of Nigeria (CRIN) and the Institute Francaise du Cacao et du Café (IFCC). The first cultivation of cacao was at Ibadan; other cacao producing countries include: Ghana, Ivory Coast, Sierra Leone, Togo and Republic of Benin.

TAXONOMY

Cacao belongs to the genus Theobroma in the family steruliocene. Over 20 species of Theobroma are recognised. All cacao cultivated belong to a single species *Theobroma cacao* (L). There are three large and distinct groups within the species T. cacao. These are Criollo, Trinitario and the Forastero Amazon.

1. Criollo: The trees are slender, green pods or pod coloured by anthocyanin pigments, warty, thin, soft pericarp, lignified mesocarp, beans plump and embedded in pulpy mucilage, white cotyledons. On fermentation and drying the cotyledon colour turns light brown.

2. Trinitario: Is a hybrid of mainly: Forastero Amazon and Criollo. Pods are green or pigmented. The beans vary in colour from very light to very dark purple.

3. Forastero: Is characterized by green pods, absence of anthocyanin pigmentation, thick pericarp, strongly lignified mesocarp, plump but slightly flattened beans, and deep purple cotyledons when fresh. Large scale cultivation is dominated by the Forasteros (80%) especially the Amelonados which are the form almost exclusively cultivated in West Africa.

MORPHOLOGY

The tree is low, reaching an average height of 5 to 10m. The main trunk is short, branching (jorquetting) in whorls of five branches: branches are dimorphic.

1. Verticals or chupons growing from the trunk have leaves arranged in 5/8 phyllotaxy.

2. Lateral branches (fans) with ½ phyllotaxy.

Cacao is naturally outbreeding. Various insects have been associated with pollination in cacao. The main pollinators are thrips, midges, ants and aphids. After successful pollination, fertilization takes place within 36 hours; the sepals, petals and staminodes drop away, the stamens and the pistil wither. The young pod known as cherelle, commences development by longitudinal elongation, followed by increase in girth. The period between fertilization and pod maturation varies from 150-180 days depending on the variety. The pods turn light yellow when ripe in all varieties. Pods are ready for harvest.

CLIMATIC FACTORS

Cacao is a low-altitude crop. It can grow from sea level up to an altitude of 700m. It has a wide range of rainfall from 1500-3000mm per annum or more. In selecting a site for planting cacao, it is desirable to ensure that the site enjoys rainfall averaging 150mm per month, 1500mm-2000mm optimal/year for at least 9 months of the year distributed evenly. It is susceptible to damage by strong winds. Different winds such as the harmattan, also can dehydrate of floral organs rendering them incapable of opening, thus resulting in failure of pollination. Cacao is a tap-rooted plant and requires deep well-drained soils, free from non

concretions, high in nutrient content and a topsoil rich in organic matter. Cacao soils should have adequate clay content.

NURSERY PREPARATION

Seeds do not pass through a dormancy period. They lose viability on extraction from pod within 5-7 days unless specially treated. Seeds are mixed with moist fine sand, moist sawdust or moist ground charcoal for storage, and should be stored in a cool place. Wooden boxes are preferable to closed jars because the permit aeration for the respiration of seeds. Storage of this type lasts for 2-3 weeks as some already germinated seeds will be noticed within this period.

In nursery beds single seeds are planted per hole which is usually 15 to 20 mm deep and 15-16 cm apart. Seeds should be watered lightly every day. Germination of seeds will be noticed within 7-10 days. After germination, amount of water should be increased, depending on the quantity of raw water in the mornings or evenings.

Seeds can also be sown in poly bags. These should measure 20 x 12 cm and have drainage holes. The poly bags are filled with fertile sifted topsoil. Bags are watered heavily the night before the seeds are sown. Seed are sown one per bag.

Light watering is done after sowing daily until germination. Adequate water should be provided after germination. Seeds should be provided with shade after germination. Examination for pests and diseases should be done regularly and once noticed should be uprooted and burnt for viral bacterial diseases. For fungal and insect attacks, it should be controlled with chemicals. No need for fertilizer application of cacao seedlings in the nursery.

About a week before transplanting the seedlings in to the field, seedlings which are raised in nursery beds should be partially dug in situ to stimulate new roots before transplanting in the field. It also ensures that fragile young roots are not damages. Seedlings should be planted with a ball of earth or with clay slurry. Seedlings should be sprayed against diseases and pests prior to transplanting in the field.

ROLES FOR SEEDLINGS IN NURSERIES

1. Site nursery on clear-felled land near a permanent water supply and provide seedlings with artificial shade of palm fronds.

2. Use forest topsoil for seeds to be sown ports, actual sowing should not be done at the hottest time of the day. Sow in Dec-Feb. to allow the seedlings a period of four months of growth in the nursery.

3. Water thoroughly when seeds are sown, thereafter lightly every second day for the remainder of the dry season except during harmattan periods when watering everyday may be necessary.

4. Fronds should be removed in stages (2-3), all shade being removed after a week before transplanting.

5. Seedlings should be no more than 4-5 months old when transplanting, care must be taken not to damage seedlings from the nursery to the field.

Cacao can easily be vegetatively propagated by leaf bud cuttings, multiple bud cuttings, marcotting, budding, grafting and layering.