MODULE 3

UNIT 1 PROPAGATION OF CROPS

CONTENTS

1.0 INTRODUCTION

Plant species are naturally endowed with the ability to regenerate themselves through self- or cross-pollination of their flowers to produce seeds. When physiologically mature, seed germinate under optimum

environments and generate new individual plants to perpetuate the parent plant. Similarly, plant species whose seeds are not adequately viable to produce new plants and/or sterile (e.g. plantains) and depend primarily on the induction of vegetative sections (leaf, stem, root, flower stalks) containing viable buds are particularly more vigorous in asexual propagation of these plant species. Seed propagation of crops is more ancient than asexual propagation, and evolved with the origin of agricultural crop production in pre-historic times. Historically, human use of seeds marks the transition from nomadic food gathering to sedentary civilizations based on agriculture, in different parts of the world. In recent times, technological advances have led to the development of micro-propagation, which involves the culturing of individual cells or groups of cells (tissues) under highly aseptic conditions to produce whole new disease- and insect-free plants.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- the distinction between sexual and asexual plant propagation
- the various methods of propagating different crop types, including non-food crops
- the advantages and limitations of the propagation techniques
- the practical application of the techniques for self-sustenance.

3.0 MAIN CONTENT

3.1 Types of Propagation Methods

3.1.1 Sexual Propagation

This is a method of plant propagation involving the fusion of distinctly different sex cells (male, female) to produce a plant. The fusion of sex cells allows the exchange of genetic materials leading to heterogeneity and formation of hybrids, which vary widely in their appearance, physiological status, etc. and conforms on the emerging plants diverse adaptation to varying environmental growth conditions.

3.1.2 Asexual (Vegetative) Propagation

This method involves the induction of a vegetative section or part of a living plant to form roots and subsequently, developing it into a whole new plant. Plant multiplication does not involve the seed cycle (exchange of genetic materials) and therefore, it is the best way to maintain some species as clones; individuals identical to the parent.

3.2 Types of Propagating Materials (Propagules)

3.2.1 Seed

'Seed' is the generative part of the plant used for propagation. A seed is a small immature plant (embryo) protected by a seed coat or testa, which is formed from the outer layers of the ovule after fertilization. The seed is the basic unit of propagating many tropical crops, including yam and fruits (mango, pawpaw, passion fruit). Even in crop species whose primary mode of propagation is by vegetative means (e.g. mango, avocado pear), seed sowing constitutes an important method of regenerating new plants, and obviating the limitations (e.g. poor adaptation) of vegetative propagation. Seeds are sown in three different ways, namely by broadcasting, drilling/row-seeding, and pocket drilling/ sowing in holes. Advantages of sexual propagation are ease of transportation of propagating materials, less cost, skill and work to raise seedlings, ease of vegetative propagation in mature plants, hybrid vigour and associated benefits of development of new varieties and wider adaptation to varying environments. The disadvantages include slow seedling growth, non-prototype offsprings, problem of ensuring uniform produce quality since most seeds originate from cross-pollination (by wind, insects), weaker seedlings and longer period to plant maturity than vegetatively-propagated crop species.

3.2.2 Budding/Bud Grafting

A process consisting of the engrafting of the bud (scion) of a plant into the stem (stock) of another plant of the same genus. Generally, it is very suitable for propagating deciduous fruit (Citrus spp.) and shade trees. Budding of improved materials on regenerated chupons is one of the new methods of rehabilitating cacao in Nigeria. In the most common T-budding pattern, the desired scion from a young, actively-growing shoot of a chosen crop variety is immediately slid into a T-shaped slit on the rootstock. The joined bud and rootstock are held by a winding of rubber-band/special tape/wrap which holds it until sealed, which prevents drying or contamination of grafted materials. Chip budding is used for budding species whose barks do not "slip" (when cut, the bark easily lifts in one uniform layer from the underlying wood) easily without tearing. Bud grafting is faster, easier and less messy than other forms of grafting discussed below. Bud grafting allows the production of plants identical to a parent plant. Also, it may give increased productivity of crops through the hardness, superior rooting capacity, drought tolerance and insect or disease resistance of the rootstock. However, the method is labour-intensive, requires great skill of nursery operations (and therefore, expensive) and can only be efficient when performed at very specific times when weather conditions and crop physiological growth

status are optimum. Also, the vascular cambium of the both the bud scion and rootstock must be aligned to stimulate tissue growth on the basal ends before rooting.

3.2.3 Grafting

This is similar to budding in theory, but different in the sense that grafting involves the joining of the upper part (scion wood, 0.63-1.27 cm diameter and only with leaf buds) of one plant to the understock (rootstock) of another plant of the same species (clones, varieties). Grafting is an old art and science of plant propagation in pears, citrus, mangoes, grapes and other fruit tress, traceable back 4000 years to ancient China and Mesopotamia. Some plants graft naturally, where two branches are in close contact over several years (e.g. ivy). Grafting allows gardeners to produce plants identical to a parent plant, allows growers to control size and shape of a tree or shrub (e.g. apples) and gives more vigorous and earlier-fruiting plants. Also, two varieties can be grown on the same tree to facilitate pollination (e.g. in apples). However, like budding grafting is labour-intensive, expensive, inefficient in poor weather and plant growth conditions, and where cambiums of both scion wood and rootstock are not precisely aligned. Other disadvantages are graft incompatibility, sucker production in grafted plants and death of rootstock due to rooting of the scion arising from planting the graft union below the ground. There is a need to protect the grafted area from dislodging the scion out of alignment, especially by bracing. Also, there is a great risk of the topgrowth being very brittle thus, failing to harden off before cold weather.

Reasons for budding and grafting

i. Opportunity to change varieties or cultivars for crop improvement;
ii. Optimising cross-pollination, especially in fruit trees that are not self-pollinating;
iii. Advantage of particular (desired) rootstocks, especially in respect of superior growth habits, disease and insect resistance, and drought tolerance;
iv. Benefit from interstocks, valuable in a situation of graft incompatibility;
v. To perpetuate clones by grafting onto seedling rootstocks when clones of plant species (e.g. conifers) cannot be economically reproduced from vegetative cuttings due to low rooting percentage of cuttings
vi. To produce certain plant forms e.g. weeping or cascading forms as in weeping hemlock (*Tsuga canadensi* Carr var. *pendula*);

vii. To repair damaged plants, arising from maintenance equipment, disease, rodents or winter storms, through in arching, approach grafting, or bridge grafting;
viii. To increase growth rate of seedlings, especially in seedling progeny of many trees requiring 8-12 years to fruit with natural development; and
ix. To facilitate virus indexing, through confirmation of presence or absence of the virus by grafting scions from the plant onto another plant that is highly susceptible and would quickly show symptoms of infection.

3.2.4 Layering

This involves bending a branch/part of the stem of a growing plant and anchoring (with a rock or peg) and burying a portion of it, with a view to establishing a new root system at the point of contact between the bent part and the earth (i.e. on the shoots that are still attached to the parent plant). A light soil increases rooting success as will wounding or girdling of the buried portion. Treatment with a rooting hormone (e.g. Rootone, Hormondin^{R}, Hormonex^{R}) is most desirable, particularly one containing a fungicide. Plants with flexible branches are particularly suited to this method. As soon as the new plant is established, the connection with the parent plant is severed and the new plant becomes independent. Layering is a good propagation choice when only a few plants are needed. A heavy soil will reduce rooting success while covering the tip of the parent plant (bent shoot) kills it. Other types of layering are serpentine/compound layering, continuous/trench layering and mound/stool layering.

3.2.5 Cuttings

A cutting is a vegetative plant part which is severed from the parent plant in order to regenerate the parent plant (by regaining loss tissues), thereby forming a new plant. Both woody and herbaceous plants are asexually propagated by cuttings of stems, leaves and roots. Cuttings regenerate new plants through change of mature cells into meristematic cells that are found at rapid growth sites like buds. As in layering, the use of rooting hormone as a dip, preferably one containing a fungicide, helps to hasten rooting, increase number of roots, or gives uniform rooting, except on soft fleshy stems. Rooting medium may be coarse sand, vermiculite, soil, water or a mixture of peat and perlite. A major advantage of cuttings is the practical regeneration of whole plants from actively-growing plant parts/organs. Cutting technique also, typically as with other asexual methods of plant propagation, produces several whole new plants, and which are genetically identical clones of the parent plant. Important disadvantages are that cuttings should be made

as soon as possible after collection of plant material; not all species of plants can be propagated from cuttings (e.g. *Acacia* spp.); cuttings must be shielded from direct sunlight, especially if they are under glass or plastic; stock plants (plants used for asexual propagation) should be healthy and well-branched as should the tools and conditions for preparing cuttings to ensure healthy new clones; choice of correct rooting medium to achieve optimum rooting within the shortest possible time. There are many types of cuttings. Based on the vegetative part of the plant providing the cutting material. There are:

3.2.5.1 Stem Cuttings

This technique is the most commonly used method of propagating many woody ornamental plants and houseplants; sweet potato, sugar-cane and cassava are food crops propagated from stem cuttings. Stem cuttings of many favourite shrubs are quite easy to root whereas those of a tree species are more difficult to root. A glasshouse is not necessary for successful propagation by stem cuttings but it is critical to maintain high humidity around the cutting. Facilities for rooting cuttings include flower pots, trays, small hoop frame and/or an intermittent mist system. Materials for making stem cuttings should be vigorous, new growth with no flower buds and free of diseases and insects. Cuttings should be 5.08-10.16 cm long, cut from older stems and have 2-3 leaves (2-3 nodes) attached. Dipping the base of the stem, including the node area, into a rooting powder stimulates rooting. The stem should however, be dry when dipped. Four main types of stem cuttings are identifiable based on the growth stage of the stock plant, which is very critical in the rooting of cuttings, namely:

i. **herbaceous cuttings-** cuttings taken from non-woody plants, such as perennials and houseplants e.g. Chrysanthemums, rose. Cuttings are 5.08-15.24 cm stem pieces, with a terminal bud.

ii. **softwood cuttings-** cuttings taken from soft, succulent, new growth from non-woody stock plants, before the new growth starts to harden (mature). The cuttings are used to propagate flowering shrubs. They must be taken after rain or water is required to keep them cool in the morning. The larger diagonal cut gives more area to develop roots. Cuttings should be kept in water before rooting.

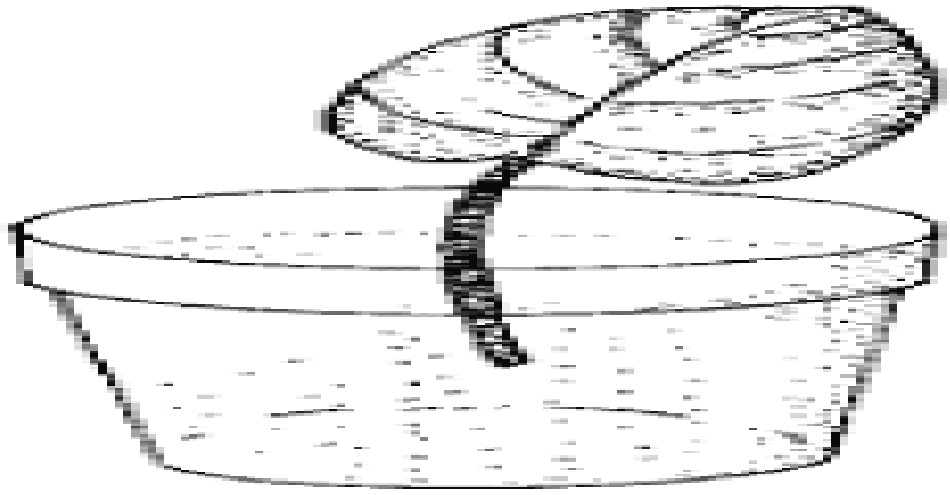
iii. **semi-hardwood cuttings-** cuttings prepared from partially mature (firm) wood of the current season's growth, just after a flush of growth. The method is used for propagating many broadleaf evergreen shrubs, some conifers, holly, rose and cacao (using the tips of shoots).

iv. **hardwood cuttings-** cuttings taken from tissue that has become woody (firm) and the plant is mature and dormant with no signs of active growth. Several cuttings can be made from the same branch of some shrubs. Basal cuts should be just below a node, while the upper cut should be slightly above a bud. Cuttings should be kept moist until rooting. The system is most often used for deciduous shrubs and many evergreen species e.g. grape, fig and rose. The three types of hardwood cuttings are straight, mallet and heel cuttings.

3.2.5.2 Leaf Cuttings

Leaf cuttings are used almost exclusively for propagating a few indoor plants. Leaf cuttings do not include an axillary bud, and thus, can only be used for propagating plants that are capable of forming adventitious buds. The method involves the use of a healthy leaf blade or leaf without petiole in propagating new plants, following the same procedures as for stem cuttings, particularly treating leaf cuttings with growth hormones to stimulate rooting and quick bud development. There are several types of leaf cuttings, and for all of them, the old leaf is not as part of the new plant and is thus, usually discarded. In most cases, the old leaf provides the energy food source for nurturing the newly-generated plant e.g. *Bryophyllum pinnatum*.

i. **Whole leaf with petiole-** This involves a whole leaf with about 3.81 cm of the petiole. The lower end of the petiole is dipped into a rooting medium after which one or more new plants form at the base of the petiole. The old petiole may be reused after the new plants have formed their own roots. African violets and peperomia are propagated in this way.



ii. **Whole leaf without petiole-** This method is used for propagated plants with sessile (petiole-less) thick, fleshy leaves. The leaf is inserted vertically into the medium after which one or more new

plants will form from the auxiliary bud. The leaf may be removed after the plant forms its own roots.

iii. **Split-vein-** The veins on the lower surface of a leaf from the stock plant (e.g. *Begonia* and snake plant) are slit before the leaf cutting is laid on the medium. The rooting medium is used to hold down the margins of a curling leaf. A variation of this method involves inserting leaf wedges cut with at least one main vein into the medium with the main vein partially covered. In both cases, new plants form from the base of the split vein and leaf wedge.

iv. **Leaf-bud cuttings-** These are used for many trailing vines and when space or cutting material is limited. Each node on a stem can be treated as a cutting. A leaf-bud cutting consists of a leaf-blade, petiole, and a short piece of stem with an attached axillary bud. The cuttings are placed in the rooting medium with the bud covered 1.27-2.54 cm and the leaf exposed. Rubber plant, Camellia, Rhododendron and blackberry are propagated using this method.

v. **Flower stalks-** This follows the same technique as leaf cuttings. It involves plant propagation from a flower stalk, usually with large leaf ears devoid of flower buds. This enhances chimera production in African violet.

3.2.6 Root Cuttings

This involves the propagation of plants from a section of a root. In some species, the root cuttings produce new shoots which subsequently form their own root system whereas in others, root cuttings develop root system before producing new shoots. Plants propagated from root cuttings include blackberry and rose. In most cases, root cuttings of woody plants are usually taken during the dormant (inactive growing period) season when roots have large carbohydrate levels. Root cuttings can also be taken from actively-growing plants i.e. throughout the growing season. In plants with large roots that are normally propagated outdoors in a hotbed, the root cuttings should be 5.08-15.24 cm in length, with a straight cut at the proximal end and slanted cut at the distal end of the root cutting. In plants with small roots, the root cuttings are 2.54-5.08 cm in length and are laid horizontally about 1.27 cm below the soil or sand in a flat. The flat is then placed under shade, which is removed after new shoots appear.

3.2.7 Divisions

Divisions are segments produced by cutting or breaking a crown or clump of suckers. Suckers are aerial stems formed from adventitious buds. Each segment consists of a bud and some roots, which when replanted grows into a new plant vertical to the parent plant. In cocoyam and taro, plants are propagated from young shoots. Pears and raspberries are propagated by suckers.

3.2.8 Bulbs and Corms

Bulbs are specialized underground stems whose leaves are used as food-storage organs. The fleshy stem part is usually very short (compressed) and attached to a basal plate while the fleshy leaves (bud scales) protect the terminal bud, which eventually grow into a new plant under appropriate (favourable) environment. Bulbs can be propagated by removing small bulblets (young bulblets) or offsets (mature bulblets/large buds as in lilies) that form at the base of the parent bulb. The small bulbs mature into plants that produce flower in 2-3 years. In other crops such as grape hyacinth (*Muscari* spp.), scooping (complete removal of the basal plate) and scoring (making three knife cuts cross the base of the bulb enough to destroy the main shoot) removes apical dominance and encourage bulblet formation, more than from offset propagation. Also, in daffodil (*Narcissus* spp.) bulblets form from bulb clipping and twin scaling, where respectively, bulblets develop from the basal plate between scale leaves and at the edge of the basal plate. A corm is the swollen base of a stem enclosed by dry scale-like leaves. It is a solid stem structure with nodes and internodes. Natural increase of new corms and cormels (miniature corms) in the field enhance corm propagation. The same procedure of propagating bulbs applies to corms, corm bits and cormels. Both methods are used in gladiolus, lilies, onion, plantain and bananas. In bananas, corm bits are better sources of planting material because corm bits uniquely assure clean planting material free of nematodes and weevils, easily prevent transfer of banana weevils and nematodes from infested banana to new plantations, provide enough planting materials from the few available scarce suckers, are easier to treat with Furadan (nematicide/insecticide mixture) than suckers, and are easier to transport for planting than suckers.

3.2.9 Runners/stolons

These are the lateral stems or vines of crops such as grass species and sweet potato, which run and grow horizontally on the soil surface to produce nodal adventitious roots and subsequently plantlets. The organs are cut into smaller sections, each with one or more buds, and partially buried in the ground to produce new plants. Examples of plants propagated through these organs are strawberries and yarrow.

3.2.10 Tubers

The "tuber" is specialized kind of swollen, modified and compressed stem structure that functions as an underground food storage organ developed from either the base of the stem (stem tuber) or the root (root tuber) of a plant. The tubers of root crops such as yam and Irish potato are sliced into setts from which axillary buds ("eyes") sprout into new plants or by planting whole tubers. In Nigeria, setts are treated with pesticide dip containing 100 g Mancoceb + 70 ml Basudin in 10 litre of water to ensure healthy seed yams at harvest. Sweet potato is propagated from the tuberous roots (swollen secondary roots modified for food storage) which are capable of producing shoots at the proximal end and new roots at the distal end. The tuberous root propagation in dahlia is achieved by crown division.

3.2.11 Suckers

A sucker is a branch of the parent plant that will occasionally appear in a leaf axil of the plant. Propagation can be achieved by cutting the suckers from the parent plant and rooting in a rooting medium, e.g. African violet. Some trees and roots have shallow roots which produce separate plants called suckers. Cutting through the roots around the suckers helps to separate the suckers, more easily with smaller suckers about 60 cm. The advantages of suckers compared to corm bits are ease of preparing suckers for planting and ease of identifying sucker qualities (bad, good) through observations of the parent plant. Suckers are best planted at the onset of the rainy season to allow them access to sufficient and prolonged water supply. In banana, young plants or offsprings (side shoots/suckers) are produced by a mature plant, namely water sucker (a weak side shoot with wide leaves, a surface runner), sword sucker (a side shoot with narrow pale sword-shaped leaves), maiden sucker (a large sucker with wide leaves, t hat has not yet flowered) and peepers (a young shoot with scale leaves). Sword suckers are the only suckers suitable for propagating banana.

3.2.12 Rhizomes

Rhizomes are horizontal stems running at or just below the ground surface, specially modified to food storage organs. Unlike roots, rhizomes have nodes and internodes, with the nodes containing growing points ("eyes").When cut into smaller sections or segments containing one or more viable buds and scale leaves, the buds sprout into new plants. Ginger, iris, couch grass and strawberry are propagated from rhizomes.

3.2.13 Micropropagation or Tissue Culture

This modern technique of plant propagation is based on the principle that each plant cell has the potential to grow into a new plant exactly like the parent plant. In this method, individual or small group of plant cells (tiny pieces of bud, leaf and stem) are manipulated in a way to enable them produce a new plant. Mass propagation of sweet potato tubers is achieved by *in vitro* culture of nodal segments in MS medium containing 9% sucrose under continuous darkness using Jar Fermentor Technique. Begonia and roses are also propagated by tissue culture using the meristem-tip. The advantages of this method are speed and efficiency of plant propagation and production of disease-free (aseptic) plants. Disadvantages include spontaneous natural mutations and very exacting conditions for growing tissue culture materials, such as absolute sterile conditions, strict control of temperature, light, humidity and atmosphere with costly electronic sensors and computer equipment.

4.0 CONCLUSION

In this unit, you have learned that

i. plants can be propagated by both sexual and asexual/vegetative methods, and
ii. crop and non-crop plants are propagated differently.

5.0 SUMMARY

This unit has discussed the distinction between sexual and asexual plant propagation, the various methods of propagating different crop types, including non-food crops, the advantages and limitations of the propagation techniques and the practical application of the techniques for self-sustenance in agriculture.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is a “seed”?
2. Enumerate three advantages and two disadvantages of sexual propagation of plants using the seeds.
3. Define the following terms:

(a) Softwood cuttings, (b) grafting, (c) budding, and (d) divisions.

7.0 REFERENCES/FURTHER READINGS

Hamzat, R.A., Olaiya, A.O., Sanusi, R.A. and Adedeji, A.R. [2006]. *State of Cacao Growing, Quality and Research in Nigeria: Need for Intervention.* The Biennial Partnership of the World Cocoa Foundation (WCF), May 16-18, Brussels, Belgium.

Louwaara, N.P. and Marrewijk, G.A.M. *Seed Supply System in Developing Countries.* Technical Centre for Agriculture & Rural Cooperation. The Netherlands: Wageningen Agricultural University.

Ngeze, P.B. (1994). *Bananas and their Management.* Bukoba, Tanzania: Kagera Writers & Publishers Cooperative Society Ltd.

Ngeze, P.B. and Gathumbi, M. [2004]. *Learn How to Grow and Market Bananas.* Acacia Publishers/CTA. www.cta.int

Adams, C.R., Bamford, K.M. and Early, M.P. (1999). *Principles of Horticulture.* Third Edition, Butterworth-Heinemann, U.K. 213 p.

Simone, van Ee (1999). *Fruit Growing in the Tropics*. The Netherlands: AGRODOK 5, CTA, 88 p.

Akita, M. and Takayama, S. Mass Propagation of Potato Tubers using Jar Fermentor Techniques. ISHS Acta Horticulturae 230. Symposium on High Technology in Protected Cultivation. http://www.actahort.org/

Lakes Area Violet Growers- Minnesota- the Twin Cities and Beyond.
African Violet Society of Canada. Email info@avsc.ca

Garden Advice.co.uk Garden Plants. Propagate Perennials from Division. User Guide.

North Carolina Cooperative and Extension Service (NCSU), College of Agricultural & Life Sciences. http://www.ces.ncsu.edu/depts./hort/hil/budding.html

Asexual Propagation.
http://plantanswers.tamu.edu/misc/asexualpropagation.html

Asexual Propagation.
http://glossary.gardenweb.com/glossary/asexual_propagation.html

Plant Propagation, Wikipedia, the free encyclopaedia. http://en.wikipedia.org/wiki/Plant_propagation

Budding-Wikipedia, the free encyclopaedia.
http://en.wikipedia.org/wiki/Budding.

'Plant Propagagtion' http://www.hcs.ohio-state.edu/mg/manual/propagation.htm

Plant Propagation by Layering. Instructions for the Home Gardener. http://www.ces.ncsu.edu/hil/hil-8701.html

Plant Propagation by Leaf, Cane and Root Cuttings. Instructions for the Home Gardener. http://www.ces.ncsu.edu/hil/hil-8702.html

Plant Propagation by Stem Cuttings. Instructions for the Home gardener. http://www.ces.ncsu.edu/hil/hil-8702.html

Propagation by Cuttings, Create New Plants for your Garden.
http://www.thegardenhelper.com/cuttings.html

The Propagation of Rhizomes and Bulbs.
http://www.tropilab.com/precaution.html

Plant Propagation Chart. http://www.crfg.org/tidbits/proptable.htmlMass Propagation of Potato Tubers Using Jar Fementor Techniques.
http://www.actahort.org/books/440/440_93.htm

Propagation by Suckers.
http://www.rosebudm.com/lavg/lavg_chimera_propagation.htm

Lakes Area Violet Growers. http://www.rosebudm.com/lavg/
Plant Propagation by Layering. http://www.freeplants.com/layering.htm

Propagation by Cuttings, Layering and Division. http://www.ext.vt.edu/pubs/envirohort/426-002/426-002.html

Plant Propagation by Stem cuttings.
http://www.rainysidfe.com/resources/propagation/cuttings.html

Grafting and Budding Nursery Crop Plants.
http://www.ces.ncsu.edu/depts/hort/hil/grafting.html; http://www.ces.ncsu.edu/hort/hil/ag396.htmlGardening with Perennials.
http://www.urbanext.uiuc.edu/perennials/dividing.html

Methods of Plant Propagation.
http://mastergardenproducts.com/gardenerscorner/new_page_4.htm

UNIT 2 CLIMATIC FACTORS AFFECTING CROP PRODUCTION