CHAPTER 8: PRODUCE HORTICULTURAL CROPS/ PRODUCE HORTICULTURAL CROPS

8.1 Introduction

This unit specifies competencies required to produce horticultural crops. It involves: determining horticultural crops to produce, procuring horticultural crop planting material, managing horticultural crop nursery, managing horticultural green houses, managing drip irrigation system, managing horticultural field and managing horticulture post-harvest. Currrenty, the horticulture industry is growing fastest in the agricultural sector. Therefore, this unit is very important to a learner in that the knowledge and skills acquired from this will be used to produce more of the horticultural crops in the country whether it is during the on season or off season due to innovations in technologies thereby increasing on productivity thus increasing on foreign exchange from the export of the produce.

The critical aspects of competency to be covered include; understanding of different horticultural crops.,understanding of different horticultural planting materials, ability to establish a horticultural crop nursery and ability to manage horticultural crop nursery according to crop water requirement, type of crop quality among others. The basic resouces required for this particular unit include; land, propagation materials, pangas, fork jembe, rakes, shovelwatering can, water hose pipe, drip lines,water tank, nursery trays, pumps chemicals, PPEs, green house kit, harvesting crates, harvesting knifes, harvesting pails and baskets, packaging materials, shade nets, soil containers/ poly tubes, soil sterilizers, soil sampling tools, media among others.

The unit of competency covers seven learning outcomes. Each of the learning outcome presents; learning activities that covers performance criteria statements, thus creating trainee's an opportunity to demonstrate knowledge and skills in the occupational standards and content in curriculum. Information sheet provides; definition of key terms, content and illustration to guide in training. The competency may be assessed through written test, demonstrations, practical assignments, interviews/oral questioning and case studies. Self assessment is provided at the end of each learning outcome. Holistic assessment with other units relevant to the industry sector work place and job role is recommended.

8.2 Performance Standard

Understanding of different horticultural crops, understanding of different horticultural planting materials, ability to establish a horticultural crop nursery and ability to manage horticultural crop nursery according to crop water requirement, type of crop quality among others.

8.3 Learning Outcomes

8.3.1 List of learning outcomes

a) Determine horticultural crops to produce
b) Select/procure horticultural crop planting material
c) Manage horticultural crop nursery
d) Manage horticulture green houses
e) Manage drip irrigation system
f) Manage horticultural field
g) Horticulture post-harvest management

8.3.2 Learning Outcome No 1: Determine horticultural crops to produce

8.3.2.1 Learning Activities

Learning Outcome No 1: Determine horticultural crops to produce	
Learning Activities	**Special Instructions**
1.1 Undertake Soil sampling as per required crop.	Field Excursion
1.2 Select Horticultural crops in accordance with the farm plan, land, agro ecological zone EAZ.	Group discussion

8.3.2.2 Information Sheet No8/LO1: Determine horticultural crops to produce

Introduction

This Learning Outcome Covers different types of horticultural crops, principles of horticultural, production and good agriculture practices.

Definition of key terms

Horticulture: This is the growing of fruits, flowers, vegetables and other medicinal trees mainly for food, medicinal and ornamental purposes.

Bolting: Early flowering due to low temperatures

Content/procedures/methods/illustrations

1.1. Soil sampling is undertaken as per required crop.

Soil sampling is the analysis of soil to determine its nutrient content, composition and other physical and chemical characteristics such as texture and acidity level of the soil.

Importance of soil sampling

It is important to carry out soil sampling of a particular piece of land before carrying out any crop production because of the following reasons:

- To be able to know nutrient level of the soil so that one is able to know which nutrients lack in the soil.
- To know which type of crop to be grown in a particular soil.

Soil sampling timing

The ideal time to assess soil nutrient status is just before a crop is grown and needs to determine soil nutrient. The following guidelines are used to select an appropriate time to sample the soil. For annual crops grown from late October when the soil temperature has dropped to upto7degrees Celsius and below, collect samples early enough before the short rains season.

For the perennial crops collect samples about one week prior to seeding and fertilization. The tools used for sampling of soil include truck mounted hydraulic coring

equipment for samples deeper than 30cm and soil auger, for soil samples less than 30cm deep. The recommended sampling frequency should be annually but this may not be practical depending on the framers need

Methods of sampling

Some of the sampling methods that can be used include:

- Random composite sampling
- Directed random composite sampling
- Benchmark sampling
- Grid sampling

Random composite sampling

This involves taking samples in a random pattern across a field while avoiding some areas such as swampy areas, compost pit remains, under a shade area, the fence among others. This is done by collecting cores from 15-20 sites and separate each core by depth to obtain representative samples for each depth.

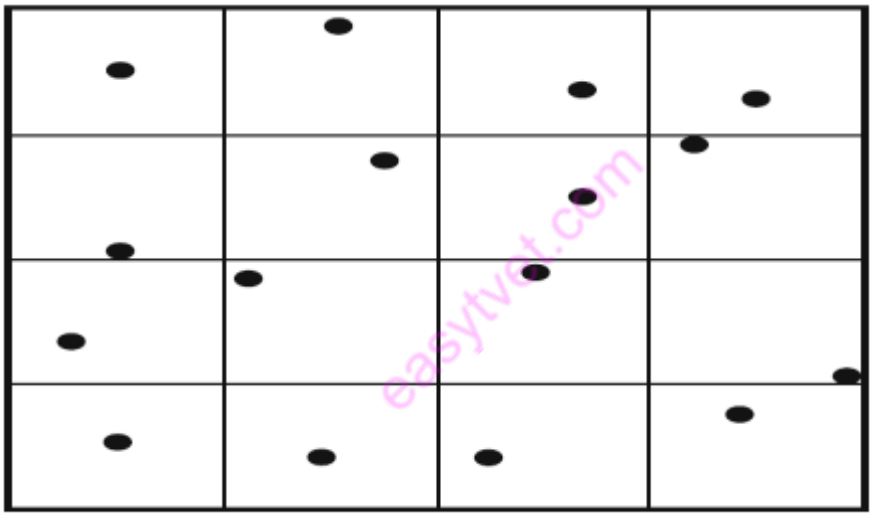

Figure 44:Random composite sampling

https://www.researchgate.net/figure/Example-of-a-simple-random-sample-stratified-using-a-regular-grid-The-strata-all-have_fig2_260427223

Directed random sampling

This is a modified random sampling method. It is mostly used in areas where it is difficult to identify a single dominant area that would represent a whole field.

Procedure of carrying out directed random sample

i. Subdivide the field into management zones based on the unique characteristics. The characteristics might be in terms of yield differences per year.
ii. Take 15-20 cores randomly from each main agent zone. Take as much as possible samples from the field depending on the number of management zone.
iii. Take as much as possible samples from the field depending on the number of management zones. This method is more appropriate for areas with more than one soil type and fields under strip crop management.

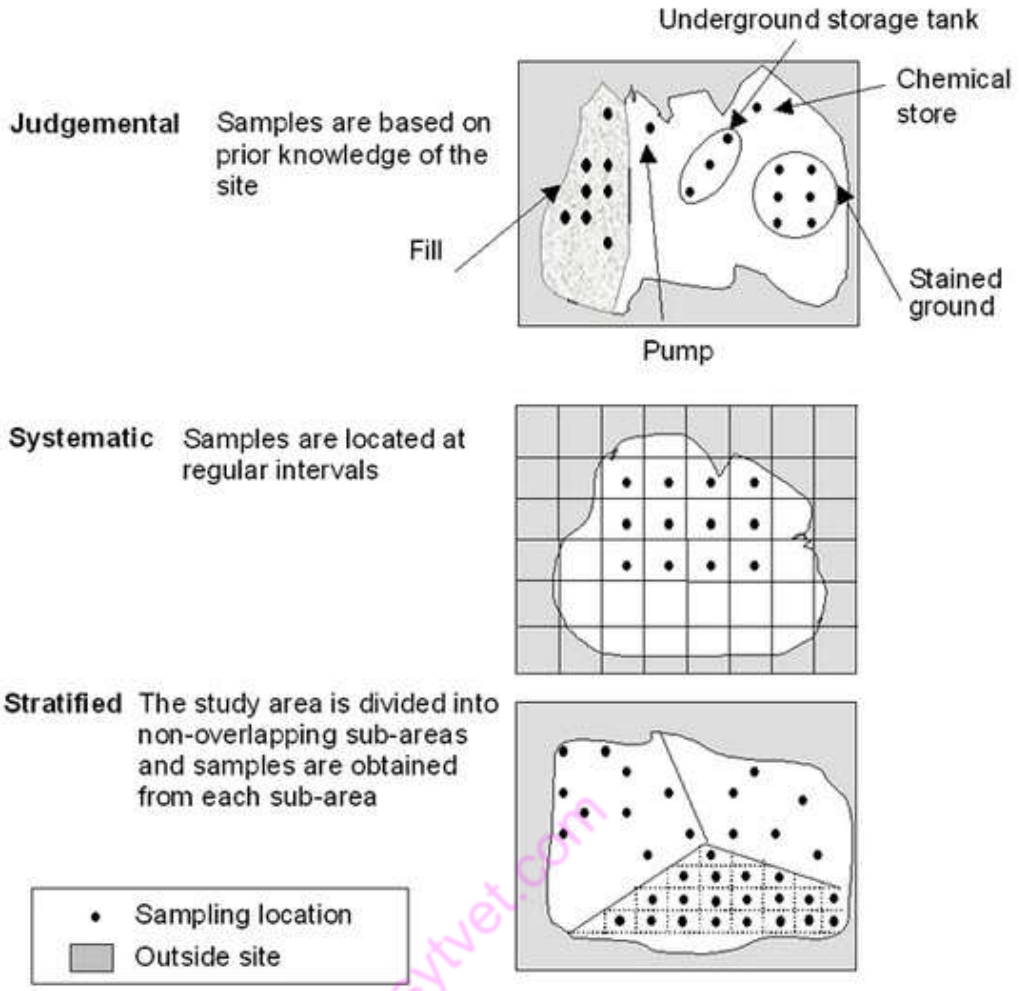

Figure 45: Directed random sampling

https://www.mfe.govt.nz/publications/hazards/contaminated-land-mgmt-guidelines-no5/3-preparing-fieldwork-and-soil-sampling

Benchmark sampling method

This involves selection of a small representative site of a field which is used as a guide for fertilizing the entire field.

Procedure

i. Select sampling sites in a grid pattern within the benchmark area.
ii. Prepare a composite sample for each depth.
Note, Sampling from same small area each year reduces on the sampling variability and reflects better on the changes in the nutrient levels of the soil.
iii. Mark sampling sites with GPS or any other appropriate means.

Selection of a benchmark sites

- Look at the features such as soil color and landscape to identify where different types of soil occur.
- Select a site that has characteristics similar to most of the field or the dominant type of soil.

- Observe crop development patterns to assist in identifying different soil conditions.
- Differences in crop establishment and vigour are important at the beginning of the growing seasons making a representative location easier to identify.
- The benchmark sites can also be selected based on yield, photos and topographical map.

Grid sampling

This is the most intense soil sampling method which uses systematic method to reveal fertility patterns and assumes there is a topographical reason for fertility patterns to vary within a field.

Procedure

i. Divide the field into small blocks

ii. A sample location within each block is sampled 3-10 times.

N/B: The smaller the sampling unit the greater the accuracy

The benefit of grid sampling is that a field map can be prepared for each nutrient which can facilitate variable rate of fertilizer application.

Table 16: Grid sampling

	r	r	r	r	r
	r	r	r	r	r
r	r	r	r	r	r
r	r	r	r	r	r

r= probe sites

1.2 Horticultural crops are selected in accordance with the farm plan, Land, agro ecological zone EAZ.

Horticultural crops section is guided by general principles of production. The general principles of production to be covered include:

- Climatic adaptations
- Soil aspects
- Biotic factors
- Abiotic factors

Climatic adaptations

These include aspects such as temperatures, rainfall, wind, light.

Temperature

Temperature is very important in growth and development of all plants. It affects many physiological processes such as flowering, pollen viability, fruit set, hormonal balance, rate of maturation among others. Soil temperatures are also important since they determine the rate of microbial growth and development, organic matter decay, seed germination, root development, water and nutrient absorption.

Effects of low temperature

- Retard growth and may lead to death at the plant
- Reduce enzymatic activities and metabolic processes such as photosynthesis.
- May cause early flowering in some vegetables such as Brassica and carrots (bolting).

Effects of high temperature

- Promote vegetative growth in some vegetables thus hiding fruit formation.
- May cause burning of fruits resulting in yield and quality reduction.

Light

Source of energy for plants that is it is important in the process of photosynthesis. It is therefore important to ensure that horticultural crops get the optimum light intensity for optimum growth.

Effects of light

- Affects photosynthesis
- Increases heat head and this way cause heat injury and kill the plant.
- Affects shoot multiplication in tissue culture.

Rainfall

Important aspects of rainfall to be considered include: Amount, distribution and onset. Water requirements of horticultural crops should be known because different crops require different quantities of water at different physiological stages.

Factors to consider in water management

- **Weather:** Monitor the weather and apply when the weather is cool.

Soil type and structure: After drainage that is sandy soil requires frequent watering compared to loamy and clay soils.

Plant roots: Deep rooted crops require less water compared to shallow rooted

Irrigation method: Drip irrigation saves water compared to overhead and furrow.

Physiological stage of crop: For most crops flowering and heading period are most critical because translation and translocation of assimilates will be affected by inadequate moisture.

Cultural practices applied: Mulching prevents water loss through evaporation. Thus, reducing on the frequency of irrigation.

- **Soil aspects**

Most horticultural crops are heavy feeders. Therefore, in order to obtain maximum yields, a grower must have some knowledge on soil nutrient content. The soil for growing horticultural crops should be fertile and well drained. One should avoid rocky areas. Clay soils are not good for horticultural crops in that they get sticky when wet and crack when dry which is not suitable for root and bulb vegetables and fruits which are deep rooted.

- **Soil nutrients**

For optimum growth, there is need for sufficient supply of essential growth nutrients which are divided into macro-nutrients and micro-nutrients. N.P.K. (Nitrogen, Potassium and phosphorous) are most limiting soil elements especially in the tropics although micronutrient deficiencies have been observed in some vegetables and fruits

- **Biotic and abiotic factors**

These are the living and the non-living factors that affect production of horticultural crops.

Biotic factors: The biotic factor include, pests, diseases among others including beneficial organisms such as earthworms, rodents.

Abiotic factor: The abiotic factors include, availability of capital, market, transport, extension services and government policy.

Conclusion

This learning outcome covered soil sampling and selection of horticultural crops in detail. That is from, meaning, methods of sampling with different procedures and the importance of carrying out soil sampling. Apart from the guiding principles of selecting horticultural crops in accordance with the farm plans, land and agro ecological zone is also tackled.

Further Reading

1. Soil sampling and methods of analysis. Article in journal of environmental quality 38(1). January 2009.
2. Journal of horticulture and plant research volume5
3. Guidelines for soil description, fourth editing FAO, Rome 2006

8.3.2.3 Self-Assessment

Written assessment

1. Horticulture the study that includes the following, which one is not?
    a) Fruits
    b) Bees
    c) Vegetables
    d) Flowers
2. Which one of the following is a long day plant?
    a) Sweet potato
    b) Potato
    c) Tomato
    d) All of the above

3. The following are examples of macro-nutrients important in horticultural production, which one is not?
    a) Nitrogen
    b) Zinc
    c) Phosphorous
    d) Potassium
4. The following are methods of soil sampling, which one is not?
    a) Random sampling
    b) Benchmark sampling
    c) Directed random sampling
    d) None of the above
5. Which one of the following is not a factor considered in water management?
    a) Root of a pant
    b) Physiological stage of a crop
    c) Cultural practices applied
    d) Furrow irrigation
6. List down three methods of soil sampling?
7. What do you understand by the term bolting?
8. Name three main branches of horticulture?
9. List down three conditions favoring horticultural production?
10. What do you understand by the following terms?
    i. Soil sampling
    ii. Pomoculture
11. Why is soil testing important to a farmer?
12. What do you understand by the procedure carried out n benchmark soil sampling method?

Practical Assessment

1. Practical investigation to examine soil types and component materials.
2. Carry out soil sampling in your school farm using random soil sampling method followed by soil testing in the laboratory.

8.3.2.4 Tools, Equipment, Supplies and Materials

- Land
- Propagation materials
- Pangas
- Fork jembe
- Rakes
- ShovelWatering can Water Horse pipe Drip lines
- Water tank
- Nursery trays
- Pumps
- PPE
- Green house kit
- Harvesting crates
- Harvesting knifes
- Harvesting pails andbaskets
- Packaging materials
- Shade nets
- Soil containers/ poly tubes
- Soil sterilizers
- Soil sampling tools,Media

8.3.2.5 References

Megersa, H. G., Lemma, D. T., & Banjawu, D. T. (2018). Effects of plant growth retardants and pot sizes on the height of potting ornamental plants: A Short Review. *Journal of Horticulture*, *5*(220), 1-5.

Norra, S., Fjer, N., Li, F., Chu, X., Xie, X., & Stüben, D. (2008). The influence of different land uses on mineralogical and chemical composition and horizonation of urban soil profiles in Qingdao, China. *Journal of Soils and Sediments*, *8*(1), 4-16.

Schoeneberger, P. J. (2002). *Field book for describing and sampling soils: Version 2.0* (No. 631.47). National Soil Survey Center, Natural Resources Conservation Service,.

8.3.3 Learning Outcome No 2: Procure Horticultural crop planting materials

8.3.3.1 Learning Activities

Learning Outcome No 2: Procure Horticultural crop planting materials	
Learning Activities	**Special Instructions**
1.1. Identify Sources of horticultural crop planting material in accordance with SOPs 2.2 Select Horticultural crop planting materials as per type of crop, quality.	Field Excursion in demonstrating T-budding and grafting

8.3.3.2 Information Sheet No8/LO2: Procure Horticultural crop planting materials

Introduction

This learning outcome covers, types of propagation materials, propagation method and nursery establishment and management.

Definition of key terms

Propagation: The breeding of specimen of a plant or animal by natural process from the parent stock.

Plant propagation: Producing new plants from a parent plant.

Content/procedures/methods/illustrations

2.1 Sources of horticultural crop planting material are identified in Accordance with SOPs.

The sources of horticultural planting materials include:

- Seeds
- Cuttings
- Other vegetative plant parts

These planting materials are divided into two

- Sexual propagation planting materials
- Asexual propagation planting materials

Sexual propagation

This refers to the multiplication of plant by seeds. In a sexual process which it involves the fusion of male and female gametes to produce seeds. It is known as sexual (seed) propagation since the propagation is through seed and also because sexes are involved.

Advantages of seed propagation (sexual)

- Seedlings trees generally live longer, bear more heavily and are harder than vegetative propagated trees.
- Seed propagation sometimes results in the production of chance seedlings with superior characteristics
- Seeds offer convenient method of storing plants for a longtime
- Plants which are difficult to propagate e.g. pawpaw by vegetative method can only be propagated by seeds.

Disadvantages of seed propagation

- Owing to genetic segregation in heterozygous plants, seedlings trees are not uniform in their growth.
- Seedling trees take more time to come to bearing compared to grafted plants
- Continuous seed propagation results to infertility in the progeny.
- Sexually propagated plants have long preparing period

Asexual propagation

Can also be referred to as vegetative propagation. This is the reproduction by means of vegetative parts of the plant such as roots, shoots and leaves other than seed. Sexes are not involved in this propagation. The vegetative organs of many plants have got the ability to regenerate to produce new individuals.

Advantages of a sexual reproduction

- Propagation by vegetative means is some time easier more rapid and economical than seeds.
- Budding and grafting may be used to make a certain fruit adoptable in unfavorable environmental conditions.
- Vegetative propagated materials are usually less vigorous compared to seed propagated.
- Vegetative propagated plants are more precious in bearing.
- Certain injuries can be repaired by means of bridge grafting

Disadvantages of sexual reproduction

- No new variety can be evolved by means of vegetative method of propagation.
- Its more expensive than seeds propagation in most cases.
- Vegetative propagated plants are comparatively less hardy.
- Transmit viral diseases from plant to plant

Plant propagation by separation and division

Many herbaceous species that die back at the end of the growing season have underground food storage organs that survive the dormancy periods. These organs are also vegetative propagation structures that produce new shoots in growing season. The variety of underground storage organs may be grouped into two classes based on how they are propagated: Plant propagated by separation and plants propagated by division.

Plants propagated by separation

Separation is a method of propagation in which underground structures of plants are divided not by cutting but by breaking along natural lines between segments. Separation

is breaking away of daughter structures from the parent structure to be used to establish new plants. The two specialized underground structures are bulbs and corns.

Bulb: A bulb is a specialized underground organ that consist predominantly of fleshy leaf scales growing on basal plate.

Types of bulbs

There are two types of bulbs:

- **Tunicate bulb**
- **Non-tunicate bulb**

Tunicate bulb: These are bulbs that have outer bulb scale that are dry and membranous. This covering provide protection from drying and mechanical injury to the bulb. Mostly found in onion and tulip among others.

Non-tunicate bulbs: These are bulbs that do not possess the enduring dry covering. The scales are separated and attached to the basal plate.

C**orms:** These are bulbs consisting of predominantly modified leaves. A corm is a modified stem examples of plant with corms include: Amorplallus, colocasia, gladielus.

Plant propagation by division: This is a method of propagation of plants using cut section of a particular part like rhizome, tuber, and tuberous root.

Rhizome: This is a specialized stem structure in which the main axis of the plant grows horizontally just below or on the surface of the ground.

Stolon: Describes various types of horizontally growing stems that produce adventitious roots when they come into contact with the soil. Mostly found in mint, bermuda grass among others.

Runner: This is a specialized stem that develops from the axil of a leaf at the crown of plant. It grows horizontally along the ground and forms a new plant at one of the nodes.

Stem tuber: This is a specialized swollen underground stem which possess eyes in regular order over the surface. Propagation by tubers can be done either by planting the tubers whole or by cutting them into sections. Example of a crop propagated by stem tuber is a potato.

Plant propagation by cuttings

Classification of cuttings

Stem cuttings are usually classified into 3 groups according to the particular part of the plant used as cuttings. They include:

- Stem cuttings
- Root cuttings
- Leaf cuttings

Stem cuttings

Can be divided into 4types based on the degree of maturity and lignification of wood used in cuttings.

- Hardwood stem cuttings
- Semi-hardwood stem cuttings
- Soft wood stem cuttings
- Herbaceous stem cuttings

Propagation by layering

Layering is the developing of roots on a stem while it is still attached to the parent plant.

Advantages of layering

- Do not require much care and arrangement like cutting.
- The mother plant supplies nutrient and other metabolites as it remains attached while rooting.

Disadvantages of layering

- It is a costly method
- It is a slow process
- Limited number of plants can be propagated

Classification of layering

Ground layering

- Tip layering
- Simple layering
- Trench layering
- Stool layering
- Compound layering

Tip layering: Is generally followed in plants which have trailing type f shoots.

Procedure for tip layering

i. Dig a hole 3-4 inches deep

ii. Insert the tip of a current seasons sheet and cover it with soil

iii. The tip grows downward first, then bends sharply and grows upward.

iv. The received tip becomes a new plant

v. Remove the tip layer and plant it in late fall or early springs.

Examples of plants propagated by tip layering include purple and dark raspberries.

Air layering

Roots from an aerial shoot. The rooting medium is tied to the shoot getting root initiation.

Procedure for air layering Air layering

- Select a healthy branch of previous seasons growth
- At point 15-30 cm back from the tip of the shoot, make a girdle just below a node by completely removing a strip of bark 2cm wide all around the shoot.
- Scrape the exposed surface lightly to remove traces of a phloem or cambium to retard healing.
- In difficult to root species, treat the girdle portion with the recommended growth regulator to induce better rooting.
- Cover the girdle portion with moist propagating medium, sphagnum mass, saw dust.
- Tie the medium around the girdled portion using a polythene sheet.
- Tying should be perfect so that no water can enter treated part.
- Separate the root zone and transplant the layer appropriately after observing the fully developed roots through the transparent sheet.

Propagation by grafting and budding

- **Grafting**: This is an art of joining parts of two independent plants in such a manner that they unite and grow together in a single independent plant.
- **Scion:** the part of the graft combination which is to become the upper portion of the new plant.
- **Root stock:** The part which is to become a root system

Methods of grafting

- Approach grafting
- Veneer grafting
- Epicotyl grafting
- Soft wood grafting

Approach grafting

The distinguishing feature of this method of grafting is that two independent plants on their own roots are grafted together. This method provides a means of establishing a successful union between certain plants which are difficult to graft by any other method as the two plants will be on their own roots till the formation of a successful graft e.g. Guava, Mango etc.

Procedure of carrying out approach grafting

i) Select a healthy shoot having a girth 3.5cm girth on the selected mother plant which is to be used as a scion source
ii) Select a rootstock (raised in a pit) having approximately the same size as that of the selected shoot on the mother plant
iii) On the internode region, her the union is to occur, a slice of bark and wood 2.5 to 5cm long is cut from both the selected stock and scion shoots.
iv) The cut to be given on the stock and scion should be of the same size.
v) **NB**: The cuts should be perfectly smooth so that a close contact of the cambial layers of stock and scion is brought about when they are pressed together.
vi) Tie the two cut surfaces together tightly with a string or cloth.

Budding

This is method of grafting where only one bud with a piece of bark and with or without wood is used as the scion material. The plant that grows after union of the stock is called budding.

Methods of budding

- T-budding
- Inverted t-budding
- Patch budding
- Ring budding

Tissue culture

This is the multiplication of true type plant throughout the year in aseptic condition and in artificial growth medium from plant parts of axillary buds, meristem tips among others.

Advantages of tissue culture

- Helps in rapid multiplication of the type plants throughout the year
- A new plant can be regenerated from a miniature plant part.
- Plants raised from tissue culture are free from diseases.

Disadvantages

- The cost involved in setting the laboratory is very high and may not justify their use in horticultural plants ordinarily.
- Tissue culture techniques require skilled manpower.

Methods of tissues culture

- Meristem culture
- Cell culture
- Embryo culture
- Shoot apex culture
- Pollen grain culture

2.2 Horticultural crop planting materials are selected as per type of Crop, quality,

Different types of planting materials are discussed above in the content1.1 with their merits and demerits. Therefore, it is up to the farmers to select all suitable planting material innermost the type of crop and quality.

Factors considered when selecting planting material

- Cost of the planting material
- Labor requirement
- Viability
- Health of the planting material
- Longevity of the planting material

After all these factors have been considered by the farmers, he/she will be able to choose a desirable planting material suitable for the type of horticultural crop to be planted. After the materials have been selected another operation follows immediately that is planting.

Planting of the selected planting materials

There are two methods of planting:

- Direct planting
- Nursery planting

Direct planting: This is the type of planting is mostly applicable to the vegetative crops which are planted directly to the field. This is possible mostly to the big seeded crops

Nursery planting: This is the establishment of seedlings in a nursery before transferring them to the main seedbed.

Advantages of using nursery

- It is easier to apply management practices e.g. weeding, pest and disease control
- Only clean and healthy seedlings are picked from the nursery and transplanted to the nursery bed.
- It easier to break seed dormancy by picking seedlings that have only grown.

- Allows farmer to gap in order to have a uniform stand.
- The environment at the nursery bed is controlled

Disadvantages

- Its labor intensive
- Time consuming

Types of planting

There are different types of horticultural crops:

- Row planting
- Broadcasting

Row planting: Planting of materials in accordance to the depth rate of planting and spacing between rows and within

Broadcasting: Random scattering of seeds /planting materials in a seedbed

Factors affecting depth of planting

- Type of planting material
- Moisture availability
- Size of planting materials

Factors affecting the size of planting

- Leaf structure
- Type of plant to be grown
- Root structure of a plant
- Branching of stem general size of the plant

Factors affecting the time of planting

- Market
- Soil and weather conditions
- Prevalence of disease

Factors affecting planting time

- Maturity of the crop
- Proximity to the market
- Availability of the market

Conclusion

This learning outcome has covered; types of propagation materials, propagation and methods nursery establishment and management. From the above discussed content, it is evident that the type and quality of horticultural crops is influenced by different practices ranging from selection of planting materials to harvesting time. We can also note that farmer plays a larger role in ensuring all this practice are done correctly during the required period of time so as to have crops that are of good quality at the end.

Further Reading

1. Landis,TD, Tinus,R.W.and Barnett,J.P,1999. The container tree nursery manual; seedling propagation. Agriculture hand book,674, Washington DC US department of Agriculture, forst service
2. Beyl,caulaA.andRobert N. Trigianess eds,Plant propagation :concepts and laboratory exercises.Boca Raton,Florida CRCPress,2008.print

8.3.3.3 Self-Assessment

1. *Bryophyllum* I prepared by_____

    a) Root cutting
    b) Stem cutting
    c) Leaf cutting
    d) Seeds
2. Asexually propagated plants_____
    a) Are true to type
    b) Live longer
    c) Bears late fruit
    d) Have large canopy
3. Hardwood cuttings are generally used in_____
    a) One-year old branch
    b) Three-year old branch
    c) Two-year old branch
    d) For-year old branch
4. In _____layering a partial tongue like cut is given on aa branch.
    a) Aerial layering
    b) Tip layering
    c) Trench layering
    d) Compound layering
5. Air layering is also known as _____
    a) Goo tree
    b) Simple layering
    c) Compound layering
    d) No of the above
6. N trench layering, the whole branch buried in the soil is up to _____cm deep .
    a) 1-2
    b) 3-4
    c) 5-10
    d) 12-15

7. Epicotyl grafting is also called _____grafting
    a) Stone
    b) Wedge
    c) Cleft
    d) Whip
8. Rooted plant on which scion is grafted is called___
9. Joining part of plants together so as to enable them function as one is known as ___
10. In _____grafting, two independent self-sustaining plats are grafted together
11. Older and infertile plants can b rejuvenated through__
12. What is budding?
13. Describe the procedure of t-budding?

Practical Assessment

1. Demonstrate T-budding

Materials required; secateurs, budding knife, root stock, scion budding tape.

Procedure

i. Select and prepare a root stock with the help of secateurs
ii. Make a t-shape cut with the help of budding knife
iii. Gently open the bark of the root stock with the help of bud opener
iv. Prepare the bud with budding knife
v. Insert a shield bud into the t-bud
vi. Wrap this portion with a polythene strip

2. Demonstrate simple layering

Materials required: sharp knife, stone pieces, panga, hooks, polythene bags, secateurs and matchstick

Procedure

i. Select one year old healthy and flexible long-unbreakable shoot near the ground level
ii. At a distance of 15-30cm back from tip, make a sharp slanting inward cut and insert a match stick
iii. Blend the shoot gently to the ground so that the cut part can be inserted into soil.
iv. Cover the rooting region with soil
v. Keep a stone on the part covered with soil in order to retain the layer in place
vi. Drive a vertical stake to the soil by the side of the layered branch.
vii. Tie the branch to the stake with gunny thread
viii. Water the layered portion regularly till rooting starts.

3. Prepare hardwood cutting

Materials required: bunch of bougainvillea, secateurs or sharp cutter, rooting hormone IBA nursery bed.

Procedure

i. Select a health bougainvillea plant.
ii. Select a matured branch of the last season growth of the plant and separate it from the plant.
iii. Remove the leaves over it without damaging the bud
iv. Leave one or two petioles at 5-10cm distance on the branch
v. Cut the branch into cuttings of 10-15cm length with at length 3-4 buds at each cutting
vi. Make a slanting sharp cut at the bottom just below the node and avoid crushing the stem
vii. Dip the basal part in a rooting hormone like IBA of requisite concentration
viii. Plant the stem cutting upright o slanting position in rows as well as within the rows
ix. Keep the newly planted cuttings in partial slide until new shoots sprout from the bud
x. Keep the cutting moist in all times by providing them with adequate air circulation and sunlight
xi. After sufficient rooting transfer the cuttings into a polyethene bag or pot

8.3.3.4 Tools, Equipment, Supplies and Materials

- Land
- Propagation materials
- Pangas
- Fork jembe
- Rakes
- Shovel
- Watering can
- Water Horse pipe
- Drip lines
- Water tank
- Nursery trays
- Pumps
- PPEs
- Green house kit
- Harvesting crates
- Harvesting knifes
- Harvesting pails and baskets
- Packaging materials
- Shade nets
- Soil containers/ poly tubes
- Soil sterilizers
- Soil sampling tools
- Media

8.3.3.5 References

Priori, S., L'Abate, G., Fantappiè, M., & Costantini, E. C. (2018). MAPPING SOIL SPATIAL VARIABILITY AT HIGH DETAIL BY PROXIMAL SENSORS FOR A VINEYARD PLANNING. EQA–Environmental quality, 30, 9-15.

Schilling, K. E., Streeter, M. T., Clair, M. S., & Meissen, J. (2018). Subsurface nutrient processing capacity in agricultural roadside ditches. Science of The Total Environment, 637, 470-479.

Schoeneberger, P. J., Wysocki, D. A., Benham, E. C., & Broderson, W. D. (2002). Field book for describing and sampling soils. Version 2.0. National Soil Survey Center. Natural Resources Conservation Services. US Department of Agriculture Lincoln, Nebraska

8.3.4 Learning Outcome No 3: Manage Horticultural crop nursery

8.3.4.1 Learning Activities

Learning Outcome No 3: Manage Horticultural crop nursery	
Learning Activities	**Special Instructions**
3.1. Select Nursery site as per quality of soil, availability of fresh water, landscape, accessibility and wind breaks 3.2 Propagate Horticultural crop in accordance with the kind of plant 3.3Determine Horticultural crop nursery layout per number of seedlings and production system 3.4 Prepare Growing media as per GAPs 3.5 Design Nursery plans as per conveniences in operations 3.6 Clean Horticultural plant nursery area in accordance with horticultural 3.7 Prepare Horticultural crop production schedule is prepared as per requirements	Discussion and brief lecture

4.3.4.2 Information Sheet No8/LO3: Manage Horticultural crop nursery

Introduction

This learning activity covers; nursery cultural practices, crop water requirements and good agricultural practices

Definition of key terms

Nursery bed: A small plot of land specially prepared for raising seedlings or planting materials before transplanting.

Pricking out: Removal of seedlings from a nursery bed to a seedling bed.

Nursery practices: Refers to all activities carried out in a nursery life to raise seedlings.

Seedling bed: A special type of nursery bed used for raising seedlings picked out from the nursery due to overcrowding before they are ready for transplanting.

Content/procedures/methods/illustrations

3.1 Nursery site is selected as per quality of soil, availability of fresh water, landscape, accessibility and wind breaks

Nursery

A small plot land specially prepared for raising seedlings or planting materials before transplanting.

Importance of a nursery bed in crop Production

- Facilitates the production of many seedlings in a small area
- It is easy to carry out management practices in the nursery than in the seed bed
- Excess seedlings from the nursery can be sold to earn income
- It reduces the period taken by the crop in the field
- It ensures transplanting of only healthy and vigorous growing seedlings.

Selection at a nursery site

The following factors are considered when selecting a nursery site;

- Nearness to the water source
- Type of soil; The soil should be well drained, deep and fertile, preferably loamy soil.
- Topography; The topography should be on a gentle slope to prevent flooding and erosion through surface runoff.
- Previous cropping; To avoid buildup of pests and diseases associated with a particular plant family, consider the preceding crops.
- Security; Select site that is protected from theft and destruction by animals
- Protection against wind (strong winds) and heat at the sun; Select a sheltered place to avoid excessive evapotranspiration and uprooting of seedlings.

3.2 Horticultural crop is propagated in accordance with the type of Plant

Propagation

Producing new plants from a planting material.

The types of planting materials are usually propagated (planted) by use of different method depending on the kind of crop to be planted.

There are two main methods of propagation, that is;

- Broadcasting
- Row planting

Broadcasting

This method involves scattering of the seeds all over the field in a random manner. Commonly adapted for light tiny seeds such as those for vegetable crops such as sukumawiki, spinach, cabbages and among others.

Advantages

- It is easier and quicker compared to row planting
- It is cheaper
- Gives a good ground cover

Disadvantages

- Uses more seeds than in row planting
- The seeds are spread unevenly leading to overcrowding of plants in some areas resulting to poor performance due to competition.
- Weeding cannot be mechanized

Row planting

The seeds or any other planting material are placed in holes, drills and furrows in rows. The distance between one row to the other and from one hole to the other is known.

Advantages

- Machines can be used easily between lines
- Easy to carry out cultural practices such as weeding
- Lower seed rates are used
- Easy to establish the correct plant popular

Disadvantages

- Requires some skills in measuring the distance between and within rows
- Does not provide an ample forage cover
- More expensive than broadcasting as it consumes a lot of time

3.3 Horticultural crop nursery layout is determined per number of seedlings and production system

Nursery layout

Refers to different designs used to establish a nursery. There is no standard blueprint for designing a nursery that exists Each nursery will have a unique design based on distinct needs, resources and requirements. Generally, a good nursery should consist of water tank, water pump, pump house, seed and fertilizer, storeroom, implement shade, germination bed areas, seedling raising area, propagation structures among others. A nursery is usually arranged in a series of beds with pathway between them.

The layout should be in a way that enables operations to flow logically through the nursery so as to save labor and time. Reads and paths in the nursery should be carefully

planned. The nursery facilities should be kept clean. Every effort should be made to control weeds in and around the nursery as the weeds may host insects and pathogens.
Inputs used in the nursery include;

- Containers e.g. polythene bags and pots
- Nursery media
- Propagules e.g. seeds, cuttings, rootstock
- Water and fertilizer
- Chemicals and tools

A layout is determined by the farmers preferences according to the number of crops to be grown, capital, labor, tools and equipment, water, planting materials among others. Therefore, if a farmer has got all the named above materials, he/she is able to choose on which nursery layout to put in his/her farm for growing seedlings before transplanting them to the main seed bed.
Examples of beds prepared as nursery include;

- Sunken bed
- Raised bed
- Level bed
- Germination bed
- **The Raised beds**

Prepared by dumping soil about 10-15cm above ground level. They are commonly established in areas with high rainfall to prevent water logging. These beds are good for crop species that do not require more water for germination.

- **Sunken beds**

Prepared by excavating the soil in bed area. These beds are usually 10-15cm deeper than the normal ground level. This bed is mainly used in areas with scarce water as it prevents overflow of water and conserves moisture.

- **Level beds**

The surface of this bed is perfectly flat with stones, woods or a line of bricks placed at the edges of bed to prevent crumbling in dry season.

- **Germination beds**

Transplant bed, storage bed, seedling bed and cutting bed are other types of beds used in nursery for seedling preparation.

3.4 Growing media is prepared as per GAPs

Growth media

This is any material that enables planting materials to grow to seedlings in a nursery.
The growth medium must be sufficiently firm to hold the seedling or propagules during rooting and supply food and water for the successful growth of young seedlings.
Soil is the very common and cheaper medium used in nurseries.
Sandy soil is used generally in mother bed and vegetative plant propagation media.

The other media used in nursery include;

- Peat soil
- Vermiculite
- Perlite
- Coco peat
- Leaf mold
- Sawdust
- Grain husk
- Sphagnum

Vermiculite

Is mostly used for cuttings.

Sphagnum

Used for air layering.

NOTE: The availability of minerals nutrients is affected by the pit at the growing medium.

3.5 Nursery plans are designed as per conveniences in operations

Plan

Activities to be carried out as scheduled in order to meet the set objectives.

Nursery plan

The activities that are carried out in a nursery for a successful establishment of quality seedlings and propagules.

The successful establishment of quality seedlings and propagules depends upon proper planning and timely execution of activities.

Even though seed storage facilities, propagation structures for external environment control are available during the nursery activities as per natural season will enhance the field planting success of the propagules.

Preparation of species level nursery activity calendar will facilitate the seedling production.

Points to be remembered when planning nursery activities

- Mature fruit has to be collected just prior to its falling and subsequent seed extracted without damages to the seeds.
- Planning of planting materials should be carried out early in the morning or late in the evening.
- Transplanting, watering, weeding and shifting operations in a nursery needs to be done at fixed intervals.
- Hardening of vegetative propagules and dispatch of grown up seedlings should be done on time (proper time).
- Engage only the skilled and trained labor in nursery activities to ensure the success.

- Water storage for lean available periods, mother plant maintenance, for seasonal collection of planting material is some important resource management activity.
- Timely availability of nursery inputs (soil, sand, FYM, biofertilizer, chemical etc.) and their collection in cheap cost period can reduce seedling production cost.
- Each plant species has its own season of establishment.

General scheduling of seedling production in a nursery

Seed collection

Fresh and matured seedlings are collected at its available season.

Propagule collection

This is done as per standard season and method of scion, bud collection specific to the species.

Seed planting and transplanting

This is done during the physiological active period that is rainy seasons.

Seedling dispatch

Starts with the onset of winds (monsoon).

Available periods

Severe drought period, heavy rains, labor shortage, pest and disease outbreak seasons.

3.6 Horticultural plant nursery area is cleaned in accordance with Horticultural Production manual

Nursery is made clean by carrying out various routine managements in the nursery and around the nursery. Some of the routine management practices carried out include;

- Shading
- Thinning
- Watering
- Weeding
- Mulching
- Staking
- Pest and disease control

- **Shading**

Newly established propagation materials must be protected from adverse weather conditions.

The shade can be provided by using shade nest or polythene sheets.

The shading poles should be strong enough to accommodate the sheets that could fall to the beds making it look untidy and hindering growth due to direct contact with the growth medium.

- **Thinning**

This is an important operation that maintains plant density in rows so as to ensure adequate light and air to the plants.

Weak and diseased or damaged plants are pulled out, allowing the growth of healthy and clean seedlings.

- **Watering**

Nursery beds must be watered carefully with the help of fine rose can. (watering can)
After the establishment of plants, watering must be one as per the requirement of individual plants in order to avoid flooding of the bed and areas around the bed which makes it difficult to continue doing the other operations.

- **Weeding**

This is the removal of unwanted plants from the nursery. This is beneficial for the growth and development of seedlings as it prevents competition with the main plants for sunlight, water and nutrients.
The nursery area must therefore be kept free from weeds.
Hand weeding and hoeing are the most common practices used to remove weeds

- **Staking**

This is the practice to support plants growing straight and saving them from bending or lodging. This saves the plants from being blown over due to wind and rain also because of the weight of the stems when in bloom.
Useful in potted plants, as well as grafted and budded plants.

- **De-shooting**

Refers to the removal of all side shoots charging from the base of a plant. The main purpose is to divert the energy of the plant towards the development of its shoots or buds. This is important because it also helps to make the area around the medium of growth clean because there are no leaves overlapping in the soil.
Apart from these, the paths and ways should also be kept clean by clearing the vegetable around for easier movements in between and within the nursery beds. This is done by slashing.

3.7 Horticultural crop production schedule is prepared as per requirements

Horticultural production schedule is prepared as per different plant species requirements and also farmers choice and needs.
Horticultural production schedules start from selection of propagation materials to planting.
What factors are to be considered by a farmer before engaging in horticultural production?
The following are the factors to be considered;

- Cost of production
- Viability of the planting materials
- Availability of labor
- Extension services
- Market
- Good infrastructure
- Government policy
- Availability of materials (resources)

After having all these factors considered, the farmer now comes up with a plan that has to meet the set objectives at the end of the production system.
The plan consists of the following;

- The type of crops to be planted in different seasons
- The type of planting materials available
- The methods to be used for propagation
- The type of resources required for production
- The time required for the crops to grow and mature to meet the market demand
- Skilled labor required in the production process i.e. when carrying out management practices.

NOTE: The schedule is prepared as per the requirements of the crops to be planted in different seasons. So, it is upon the farmer to know what he/she requires before planting a particular horticultural crop for ease of production.

Conclusion

This learning outcome covered; Nursery cultural practices, crop water requirements, good agricultural practices in horticultural production that boosts on its productivity by reducing the chances of crop pests and diseases and also having healthy seedling growing.

Further Reading

1. Kevyn E. Wightman, 1999. Good tree nursery practices: Practical guidelines for community nurseries. Nairobi, Kenya. The world agroforestry center.
2. Kumar, V. 2011. Nursery and plantation practices in forestry. Scientific publisher. India, January 2007, page 420.

8.3.4.3 Self-Assessment

Written assessment

1. Removal of plants from pots for planting is called
    a) Re-potting
    b) De-potting
    c) Potting
    d) None of the above
2. Application of fertilizers through irrigation water is known as
    a) Surface application
    b) Top dressing
    c) Fertigation
    d) Sub-surface irrigation

3. The common growing medium in plug trays is
    a) Cocopeat
    b) Vermiculite
    c) Sand
    d) Soil
4. Sphagnum is commercially used in rooting medium in
    a) air layering
    b) grafting
    c) budding
    d) cutting
5. The nursery must be free from
    a) Water logging
    b) Fertilizer
    c) Organic matter
    d) Irrigation water
6. The type of nursery bed prepared during the rainy season is
    a) Sunken
    b) Raised
    c) Flat
    d) Furrow
7. Nursery is a practice where planting is raised. (True or False)
8. Are sunken beds are prepared in low from the ground level?
9. When should watering the plant be done?
10. Generally, is seed rate required if seeds are sown by broadcast method? Give reason.
11. What is Hardening?

Oral Assessment

1. What is the common insect-pests in a nursery?
2. What criteria will you follow while selecting a nursery site

Practical Assessment

1. Prepare a raised nursery bed

Material required;

Seed bed, spade, seeds, farmyard manure, watering can, mulching material.

Procedure

i. Select a plot of land which is sterilized
ii. Level the land and make it free from weeds, stumps, stones etc.
iii. The soil of the nursery bed is thoroughly mixed with 5-10kg per sqm of rotten FYM
iv. Prepare drainage channels to drain out excess water
v. Prepare seed bed about 15cm high from the ground level. The width is 1m-1.5m and length of your own desire.

vi. A space of 30-40cm is left between the beds in order to carry out cultural practices smoothly.
vii. Cover the seed bed with mulches and water them slightly using watering can after placing the seeds.

2. Identify different types of growing medium.

Material required;

Sand, compost, coco peat, vermiculite, sawdust, practical file etc.

Procedure

i. Collect different type of growing media available nearby
ii. Identify and label them
iii. Write the use of each type of growing media

8.3.4.4 Tools, Equipment, Supplies and Materials

- Land
- Propagation materials
- Pangas, Fork jembe
- Rakes
- Shovel
- Watering can
- Water Horse pipe
- Drip lines
- Water tank
- Nursery trays
- Pumps
- PPEs
- Green house kit
- Harvesting crates
- Harvesting knifes
- Harvesting pails and baskets
- Packaging materials
- Shade nets
- Soil containers/ poly tubes
- Soil sterilizers
- Soil sampling tools
- Media

8.3.4.5 References

Bhimraj, Bhujbal (Ed). 2012. Resource book on horticulture nursery management, TCMOU, NAIP, ICAR, P 264.

Ratha Krishnan, P. 2008. Nursery management and quality plant propagation in Training manual on "Advances in Agroforestry research and development". 24th November-5th December 2008, NRCAF, Jhansi, PP 85-91.

www. World agroforesty.org.

8.3.5Learning Outcome No 4: Manage Horticultural Green Houses

8.3.5.1 Learning Activities

Learning Outcome No 4: Manage Horticulture Green Houses	
Learning Activities	**Special Instructions**
4.1. Select Green house in accordance with crop variety and value, wind, security and GAP 4.2 Design Greenhouse structure as per farm plan 4.3 Determine Greenhouse working tools as per GAP 4.4 Carry out Greenhouse crop selection in accordance with GAPs 4.5 Undertake Greenhouse nursery propagation in accordance with GAPs 4.6 Undertake Greenhouse field preparation in accordance to GAP 4.7 Carry out Greenhouse irrigation as per Operations and Maintenance Manual 4.8Maintain Greenhouse crop water requirement per Crop Water Requirement Manual	Group discussion on how to select and design green houses Demonstration on the field Field excursion

8.3.5.2 Information Sheet No3/LO4: Manage Horticulture Green Houses

Introduction

This learning outcome covers; greenhouse installation, types of media and preparation, seedbed layout, crop establishment, pest and disease control, watering techniques and PPE.

Definition of key terms

Greenhouse installation: is a structure with walls and root made chiefly of transport material such as glass in which plants requiring regulated condition are grown.

Installation: Putting something into place

Seedbed: A prepared piece of land ready to receive planting materials for growth upto maturity.

Content/procedures/methods/illustrations

4.1 Green house site is selected in accordance with crop variety and Value, wind, security and GAP

i. Research of the size of your local market
   This helps you determine if the market can accommodate additional greenhouse business; it also helps you determine the level of composition.
ii. Determine the crops you prefer and the size of your operation
   Consider the crops that are in limited supply so that you can capitalize on the demand.
iii. Learn the legislation surrounding this farm of agriculture
   This will allow you to rest assured that no one will be any out.
iv. Design the greenhouse
   Pay close attention to solar green houses as they are cost effective.

Factors considered when selecting a site for greenhouse

When selecting a proper site for the greenhouse a number of location factors must be considered before making a final decision on the greenhouse site.

The factors are discussed below:

- **Availability and quality of water**
  Water is one of the most factors looked resource in the establishment of a greenhouse. A sufficient quality and high-quality water is important for the production of greenhouse crops. The need for frequent irrigation requires careful planning and management to ensure that operations have sufficient water to maintain adequate supplies for crop production.
- **Topography**
  The topography of the site affects where a growing structure is built. The surface at ground of the greenhouse should be level. Flat surface is efficient for placing the structure because it facilitates easy adjustments to various mechanical controls in the greenhouse which is economical. The site should also be well drained.
- **Wind breaks**
  This is important because wind breaks reduce infiltration of cold air and convection at heat away from the greenhouse. Wind breaks also reduce the speed at wind that can cause damages to the greenhouse.
- **Climate**
  Climatic conditions have dictated geographical shift in horticulture. The primary limiting factor to crop production in greenhouses is low light intensity during cold seasons.
- **Room expansion**
  A parcel of land larger than the graver's immediate needs should be acquired the ultimate size of the range should be predicted. Area should therefore be predicted figure to accommodate service building, storage, access drives, and additionally extra space should be allotted to cover unforeseen needs.

- **Availability of labor**
  Present and future labor needs should be assessed and should be in accord with labor supply in the area. The greenhouse owner must determine if labor is available to perform both routine and harvest time duties.
- **Infrastructure**
  Proximity to transport network e.g. roads railways access to communication systems and availability of energy must be considered. Greenhouses also need convenient access to materials for growing plants. Transportation requirements to the greenhouse site relate directly to the intended operations size and marketing arrangements.
- **Market accessibility**
  Locating new market is very important for retail growers who rely on customers getting to the greenhouse. The market potential should be explored before building.
- **Legal cogenerations**
  Site selection involves various legal consideration permits, licenses and zoning regulations govern where a greenhouse may be built and even offer dictate what type of building materials to be used. Selecting an appropriate site also involves how the greenhouse operates affects its neighbors
- **Greenhouse orientation**
  Growers optimizing for winter growing should orient their free-standing greenhouse in an east-west orientation meaning the longer glazed side of the green house to face south with the shorter ends facing east and west.

4.2 Green house structure is designed as per farm plan

Greenhouses are used to provide optimal environment for plant growth and development. The greenhouse design must deal with the local outdoor circumstances like; Temperature, humidity, solar radiation, clearance of the sky, precipitation speed of wind and direction of wind.

Components of greenhouse design

Some of the components of greenhouse design include;

- Location
- Orientation
- Site selection
- Structure
- Foundation
- Flooring
- Glazing
- Ventilation facilitates
- Technical equipment

The location and orientation of a greenhouse determine the amount of light that enters it. Determining the best location to put up the greenhouse is important decision.

A suitable greenhouse location will include a spot where the sun hits the greenhouse all day long and the shadows are cast on the greenhouse.

Classification of green houses

1. Free standing greenhouse
2. Gutter connected greenhouse

Free standing greenhouse

Can have different shapes of the roof ranging from gothic, gable and quivered roof shapes.

Gutter connected greenhouse

This is a series of bays with gable of queries arches connected together at the gutter level. Structural materials used for the greenhouse "skeleton" should be strong enough to prevent structural failure during adverse weather condition but kept to a minimum size and number to reduce the amount of shading and to provide for maximum light transmission.

Advantages and disadvantages of free-standing greenhouses.

Advantages

- Easier to programme and maintain the temperature to meet specific crop requirements
- It is easier to ventilate without exposing the plants to blasts of cold air
- Light is uniformly distributed over the entire growing area

Disadvantages

- Occupies more spaces
- More materials are needed to construct side walls
- Limited interior space

Advantages and disadvantages of gutter connected greenhouses

Advantages

i. Occupy less space and have no side walls.
ii. Less material is used in construction due to lack of side walls.
iii. More interior space is available due to lack of side walls compared to most free-standing greenhouses.
iv. Less energy is required to heat and cool the greenhouse because the exposed surface area is reduced.
v. It is a cheaper and therefore more feasible to automate the single consolidated space inside the greenhouse

Disadvantages

i. Difficult to program and maintain temperature to meet specific crop requirement.
ii. Light is not evenly distributed over the entire growing area.

4.3 Green house working tools are determined as per GAP

Tools: materials used to make work easier. Some of the tools commonly used by people with greenhouses include;

- Trowels
- Rakes
- Potting tools among others

These tools perform different functions.

Functions of different tools and equipment insertion the green house.

1. Hand trowel: Transferring dart into pots or planting seedlings and bulks.
2. Garden gloves: Protects the hand from being pricked by thorny plants causing injuries.
3. Hose = spray nozzles: For watering purposes.
4. Rake: leveling of beds, removal of trash from beds.
5. Pruning shears: cutting and trimming of plant parts. Can also be used in harvesting herbs fruits and vegetables.
6. Digging shovel: slight digging of beds.

N/B: Apart from the above mentioned some of the tools used in the greenhouse include;

- Hoes
- Weeder
- Edger
- Wheelbarrow
- Pruning saw
- Watering among others

4.4 Green house crop selection is done in accordance with GAPs

Choice of species and planting materials for greenhouse production should not rely on single farmer initiatives but should be the outcomes of a coordinated programme that for a given area takes into consideration agro environmental constraints technology development and social- economic opportunities. Before selecting crops to be grown in the greenhouse, some fundamental questions need to be answered e.g.

- What to produce
- When to produce
- How to produce
- Where to sell the product

There are two basic options available for farmers that is.

1. Choose a crop species for its high economic potential and develop the most suitable protective growing systems and technology
2. Choose a crop suitable for existing structure within the farm and capitalize on these.

Choice of the crop

Under mild winter climatic conditions greenhouses and protected cultivars concentrate on vegetable productions belonging to the substance family e.g. (tomatoes, pepper,

eggplant) and Cucurbitaceae family e.g. melon, squash, cucumber. These crops suit cold greenhouses conditions and meet market requirements

Their success in protected cultivation is due to

- Wide consumption
- Good adaptation to unsteady climatic conditions
- Long cultivation cycles

Crop choice must consider species and genotypes capable of providing specific produce typologies taking account of market and economic conditions crop characteristics and requirements, compatibility between crop and micro climate and soil characteristics and soil borne diseases. All these are summarized below specifically;

- Market requirement
- Economic convenience
- Labour requirements
- Characteristics of protective means
- Possibility of active climate means
- Distance from markets
- Plant dimensions
- Crop requirements
- Soil characteristic and soil borne diseases
- Economic and social context

Choice of the planting material

Green house production is a very dynamic economic sector and must cope with rapid changes in market trends and customer preferences. Planting material choice is important for each crop and specific produce typology. Cultivars proceeding fruits with varying characteristic are not valid alternatives for green house production system which must respond to strict production and market requirements. Cultivates used for greenhouse production differs from these used in open field productions in that they are less exposed to environmental constraints and can express their yield potential better.

Factors considered when selecting a planting material in green house for both growers and traders.

- Potential yield
- Extended harvesting time with constant product
- Quality
- Resistant to biotic and a biotic stress
- Shelf life shield be long.

It is important to choose cultivars that in specific areas adapt to the environmental conditions and technical factors involved in the production process. While the above-mentioned traits are important in green house production it is fundamental to assess their responsiveness under different conditions in the specific growing areas. At global level more than 1000 species are consumed as vegetable. There are several sources of new crops introduced in green house production;

- Species introduced from other countries
- Wild species eaten as vegetables

- Species to date cultivated only in the open air among others

In summary: new crops should:

- Adopt to agro climatic and social/ condition
- Meet consumer requirements
- Be makeable and profitable

4.5 Green house nursery propagation is undertaken in accordance With GAPs

Nursery propagation: this is the planting of cultivars in nursery beds.

Proportion structure: Are structures required for propagating planting materials.

Types of propagating structures

A structure with temperature and ample light such as greenhouse, where seeds can be germinated, cutting are rooted or tissues culture acclimatized.

The unit which the younger tender plants can be moved for hardening off preparatory to transplanting outdoors.

Greenhouses

Greenhouses have been used long back by horticulturists' as a mean for rapid growth of plants and extending the growing seasons particularly in the colder areas. They are also used for whole sale production of floricultural plants, nursery stock of fruit crops and vegetable crops. Most greenhouses are used for propagation but the most suitable type is the one that admits the maximum amount of light. Green houses that run from east- west is the best for better light penetration and consequently preferred in raising seedlings. The greenhouse should be away from shade. Modern greenhouses are well equipped with elaborate structures and have precise control on temperature. Light intensity and humidity. The size of plant of greenhouse depends upon the need of plant propagation

Role of nurseries in horticulture development

- Production of genetically pure nursery stock.
- Expert of nursery stock
- Employment creation.

Types of plant propagation nurseries according to sale

- Retail nurseries: Soil to general public
- Wholesale nurseries: Sell only to business such as commercial gardeners.
- Private nurseries: Produces seedlings according to the needs at institutions or private companies.

According to type of plant grown

- **Fruit plant nurseries**

Fruit crops are mainly propagated vegetable and nee special techniques for propagating as well as maintenance. Fruit nurseries are essential for production of grafts as well as the mother plant aecia and rootstocks.

- **Vegetable nurseries**

All vegetable except from few like potatoes sweet potato, bulbous vegetables and some other are raised by seedlings some are perennial and others are annuals.

- **Ornamental nurseries**
  Ornamental and floricultural crops are nurseries and are propagated vegetative like roses lilies etc.
- **Forest plant nurseries**
  Forest plants are essential for synthesis of gums, honey, timber and fuel and there is lack of forest plant nurseries. Therefore, to save and multiply, the entire lot of valuable forest plants is very essential to preserve and multiply these plants for which a special type of nursery is established.
- **Hi- tech nurseries**
  There is sudden increase in demand for certain commercial plants for example tissue cultured banana. It is not possible to fulfill this requirement by ordinary nurseries practices. There is necessity to have special techniques and methods to meet the demand and only Hi-tech nurseries can satisfy this type of demand.

Physical and financial resources for nursery

Nursery is the base for future horticultural development. The physical resources include: land, water and labour. Transport, market communication facilities and the availability of technical skills. Capital requirement of a nursery should be fulfilled sufficiently and timely.

Types of plant nursery soil

Nurseries grow plants for resale to landscape and to the general public. A nursery can be a field nursery where plants are grown in the soil or a container nursery where plants are grown in different types of growth media. The type of soil required in a nursery depends on the type of crop one needs to grow:

a) **Field nursery soil**
   Mainly produce ornamental shrubs, fruits, trees and perennial flowering plants. The type of soil needed should be fertile and well drains. The soil should cling to the roots of the plant well when the seedlings are transplanted.
b) **Container nursery soil**
   A mixture of sand, peat moss and aged hard wood bark is commonly used for pot mixture line need to be added to the non-soil growth media to balance its pit
c) **Green house soil**
   Sand and organic growth media such as hammered bark and sphagnum peat moss provide a good support for young plants without exposing them to the disease and pest risks found in top soil.

4.6 Green house field preparation is undertaken in accordance to GAP

Green house field preparation: These are the activities carried out in the green house before planting.

The activities are discussed below;

1. **Soil treatment**

   There are various ways of soil treatment before transplanting especially when the soil becomes prone to soil borne pests and diseases. Soil treatment includes the following;

i. Bioxx 5000 = cover the soil for 3-5 day as after application.
ii. Application of methane sodium covers for 14 days.

Procedure for (ii)

Double dig the land and soak with water until 2 feet deep, mix the top soil and subsoil well, let open for 10 days for weeds to germinate and then cover with plastic. Fumigate in the tank and let flow to the field. Allow further flow until completely wet. Leave covered for 21 days, wet again with water and leave open for another 7 days.

iii) Bacmid

Procedure

i. Double dig the land
ii. Incorporate bacmid and mix the soil thoroughly
iii. Cover with polythene
iv. Soak thoroughly and leave covered for 21-28 days
v. Wet again and leave open for 7 days of planting is done immediately it will kill the crops.

N/B: Sunlight raises the temperatures therefore weeds starve by being denied oxygen by covering with polythene.

i. Soil should be well prepared, thoroughly and dug up to 1.5 feet deep to loosen the soil.
ii. Apply one wheelbarrow of manure and mix well with soil to a fine tilth.
iii. The land is then divided into beds of 1m wide compact beds for better water dispersion after which fertilizer such as DAP and NPK are applied to the surface of each bed by sprinkling sparingly.
iv. Raise the bed to 20-30cm high with bottom width of 1m and the top to be 50cm wide.
v. Place the drip time 14cm on either side leaving 52cm in the middle of the top bed.
vi. Do not step on the bed to avoid compaction.
vii. Make holes on the bed top with depth depending on the type of crop to be planted and 4cm from the drip line.
viii. Add Aurum smart fertilizer at a rate of 6gm per hole and mix well before planting the seedlings outside the drip lines at recommended spacing.
ix. Every bed should have 4 wires for support at the bottom and the top tied along the posts.

x. There should be six rows of beds in the greenhouse with a walking path of 30cm wide.

xi. Irrigate at short intervals 6-8 times daily for 15mins for 1 -$1^{1}/_{2}$ weeks, long then at intervals to allow for deep rooting.

xii. During rainy season, it is important to continue with irrigation.

Transplanting

Transplant in the morning from 7-9 a.m. and late in the evening when the seedlings are pencil thick. Seedlings are transplanted at a recommended spacing at different types of greenhouse crops. Single stands are recommended for wider spacing but depend on the crop.

Hygiene

Keep the green house clean from dead plant debris papers overripe fruits. Tools to be kept in a central place not scattered. There should be a footbath at the entrance of the greenhouse.

Training in same crops e.g. tomatoes.

This is done early enough to avoid bending. Usually done when the crop is half foot high. Plastic stringer is more recommended and should not be too tight to allow the plot space to expand.

Pruning

DE sucking

Suckers are removed by hand as soon as they appear; hence frequent surveys around the greenhouse are necessary.

Defoliation

Too many leaves increase canopy cover which may be resulting due to high relative humidity hence prone to diseases, therefore old leaves should be removed.

Top pressing

CAN or urea is used to enhance vigor after first harvesting. Trenches are made between rows and the fertilizer is applied, covered and irrigated. Shallow digging is also carried out in order to accrete the soil.

Watering

This is made possible by the use of drip irrigation system and its usually down in the morning and evening.

Harvesting

Starts from the 10^{th} week after transplanting. This also depends on the type of crop planted.

4.7 Greenhouse irrigation is carried out as per operations and maintenance Manual

Artificial application of water to crops

Green house crops are irrigated by means of applying water to the media surface through drop tubes or tapes by hand using a hose pipe, overhead sprinklers and booms or by applying water through the bottom container through sub irrigation. Drip and sub

irrigation systems are the most commonly used as it provides greater control over the amount of water applied. There is also reduced potential for diseases and injury since the foliage does not become wet.

Different irrigation systems used in the green house

Drip irrigation

This can be a valuable tool for accurate growing medium moisture control.

Advantages

- Saves water and labor
- Reduces the potential for ground water pollution
- Controls weed growth
- No soil erosion
- Improves fertilizer application efficiency
- Fustigation is carried out easily

Disadvantages

- High installation costs
- High skill in design installation and subsequent operations.
- Clogging of openings may occur as a result of chemical debtor's clay thus hindering watering of crops. Drip irrigation systems eliminations runoff of water missing the pot during overhead irrigation and the volume of water applied controlled.

Water trays and saucers

Water is applied to the surface and is collected under the container through collection trays. Water trays depending on their shape and spacing on the bench can greatly reduce runoff and leaching by containing. The water draining from pots and holding water which misses the pot during overhead irrigation.

Advantage

- They are in expensive and reusable.

Sub irrigation

Sub irrigation systems are an environmentally responsible alternative that conserves water and fertilizer. They are being installed by greenhouse growers to improve product quality to achieve this uniform growth and increase production efficiency. In sub irrigation systems, water and nutrient solution provided at the base of the container rises by capillary actuation through holes in the bottom absorbed by the growing medium.

Advantages

- Water nutrient solutions are contained and recycled.
- Foliage remains dry
- Labor input is reduced
- Uniform watering of all containers
- Pot size and placement can be changed easily
- More vigorous plant growth.

Examples of sub irrigation systems

Capillary that systems

The pots are set on a mat that is kept constantly wet with a nutrient solution. The pots take up the solution through holes at the bottom. The mat is placed on a level bench over a layer at plastic.

Trough system

Plastic or metal troughs are place on existing benches or supported overhead from the green house structure, apart from the mentioned other examples of sub irrigation method include; flood floors, Ebb and flood benches and even lable trays. The choice of an irrigation system is up to the preference of the farmers depending on the types beds found in the green house.

Aspects that should be considered during irrigation of crops in the green house.

- Crop water requirement
- Characterization of the amounts of water used and current irrigation practices.
- Irrigation scheduling of soil grown crops
- Water use efficiency

4.8 Greenhouse crop water requirement is maintained as per Crop Water Requirement Manual

Crop water requirement: This is the quantity of water regardless of its source required by crop or diversified pattern of crops in a given period at its normal growth under field conditions at a given place.

Water requirements for crops in the green house.

Water is essential for the growth and development of living organisms; plant requires certain quantities of water during their life cycle. In shortage of this, the life cycle of a plant will be adversely affected. Data of accurate crop requirement of water is very important for the irrigated agriculture. The knowledge of crop water requirements is also needed for efficient use of limited irrigation water. Water is primarily needed to meet the demand of evapotranspiration (ET) and metabolic needs of the plant. These demands are known as consumptive use (CU)

The evapotranspiration (ET)

It is the amount of water that is lost to the atmosphere through the leaves of the plant as well as the soil surface while consumptive use (CU) is the amount of water used by the growing plant in transpiration and building of plant tissue and that evaporated from adjacent soil or from intercepted precipitation on the plant foliage in any specified time It is expressed in mm or cm.

So, CU= ET = water required for plant metabolic purposes/usually water required for metabolic activities is very small (< 1% of the total water passing through the plant) the CU is generally considered as equal to ET.

Water requirement includes the application losses and water for special purposes e.g. for leaching of excess sales due to irrigation.
So, CU=ET= application losses = water for special purposes.
WR= ET or CU= application= special need.
The formula
WR= IR= ER=S where:
IR= irrigation requirement
ER= effective Rainfall
S= soil
Water requirement for special needs include deep percolation which includes separate and percolation and leaching requirement if soil is saline.

Factors influencing crop water requirement

These includes: crop factors, soil factors, climate factors and crop management practices.

Crop factors

Water requirement differs in different stages or phases of the crop and also with the crop varieties. The flowering requires more water than the seedling stage and even that of maturing stage. The consumptive use also differs due to the differences in height number and size of leaves of different crops.

Soil factors

Evaporation from soils differs owing to the differences in hydraulic conductivity, reflectivity and thermal conductivity. Soil temperature has direct impact on the evaporation, which is affected by the soil color. Reduction in evaporation reduces the water requirement of the crop.

Climatic factors

Evapotranspiration is greatly affected by climatic parameters for example solar radiation, wind, velocity, atmospheric temperatures and humidity. These parameters according to their intensities increase the need of water of a crop.

Management practices

The management factors that are adopted for improving soil productivity with increasing evapotranspiration. This increases the water requirement at a crop. Weeding reduces competition for moisture and increases irrigational interval.

Determination of water requirement for crops

There are several methods of determining crop water requirement. These methods require high level of accuracy availability of equipment and technical knowledge. These methods include;

- Transpiration ratio method
- Depth interval yield approach
- Soil moisture depletion studies
- Water balance method
- Climatologic approaches
- Lysimeter method

Conclusion

This learning outcome covered; Greenhouse installation, types of media and preparation, seedbed layout, crop establishment pest and disease control. It also covered watering technique and PPE. Apart from the above-mentioned field operations carried out in the greenhouse is also tacked under irrigation we can see that the sub irrigation system is mostly preferred compared to the other systems. Crop water requirement is also tackled in details.

Further Reading

1. La malfa, G and Leonard, C. 2001, crop practices and techniques; trends and needs. Acta Hart, 559: 31-42
2. Castilla, N, Hernandez, J and Abou Hadid, A,F, 2004. Strategic crop and greenhouse management in mild winter climate areas. Acta Hart, 633: 183-196

4.3.5.3 Self-Assessment

Written assessment

1) The following are example of tools which one of them is specific to greenhouse
    a) Hand trowel
    b) Trocar and canula
    c) Cutting saw
2) The following are advantages of drip irrigation method which one is not?
    a) There is soil erosion
    b) Saves labor
    c) Improves fertilizer efficiency
3) The following are systems of irrigation used in a greenhouse which one is not the most advantageous compared to the others.
    a) Drip irrigation
    b) Water sources its and trays
    c) Sub irrigation system
4) Which one of the following is an example of sub irrigation?
    a) Furrow irrigation
    b) Capillary neat system
    c) Overhead irrigation
5) The following are factors affecting crop water requirements which one is not.
    a) Availability of labor
    b) Management practices
    c) Crop factors
    d) Climate

6) Identify one of the field preparations undertaken in the greenhouse.
    a) Molting
    b) Hygiene
    c) Bolting
7) A rake as a greenhouse tool is used to?
8) Choices of species and planting materials of greenhouse production should not rely on.
9) Crop choice must consider and capable of providing specific produce typologies.
10) Cultivates producing fruits with varying characteristics are not…….
11) The most suitable type of greenhouse used for propagation is?

Oral Assessment

1. Describe the steps followed before starting a green house.
2. State the advantages and disadvantages of free-standing greenhouse.

Case Study Assessment

Imagine you are an extension officer of a particular area and a farmer comes to you to advise him/her on production by greenhouse, what steps and guidelines followed would you advise him to follow before setting up a green house.

Practical Assessment

1. Design a capillary irrigation system as form of sub irrigation;
   Materials;
   - Wick
   - Containers
   - Water etc.
2. Prepare one nursery bed of your choice for green house.
3. Prepare container nurseries using different growth media available in your area apartment soil.

8.3.5.4 Tools, Equipment, Supplies and Materials

- Land
- Propagation materials

- Pangas
- Fork jembe
- Rakes
- Shovel
- Watering can
- Water Horse pipe
- Drip lines
- Water tank
- Nursery trays
- Pumps
- PPEs
- Green house kit
- Harvesting crates
- Harvesting knifes
- Harvesting pails and baskets
- Packaging materials
- Shade nets
- Soil containers/ poly tubes
- Soil sterilizers
- Soil sampling tools
- Media

8.3.5.5 References

Castilla. N. and Hernandez J and Abcu Hadid, A.F. 2004. Strategic crop and greenhouse management in mild winter climate areas. Acta, Hart 633:183-196

Castilla, N., Hernandez, J., & Abou-Hadid, A. F. (2004). Strategic crop and greenhouse management in mild winter climate areas. *Acta horticulturae*.

Castilla, N. (2000, October). Current situation and future prospects of protected crops in the Mediterranean region. In *International Symposium on Mediterranean Horticulture: Issues and Prospects 582* (pp. 135-147).

Castilla, N., Hernández, J., & Abou-Hadid, A. F. (2002, August). Strategic crop and greenhouse management in mild winter climate areas. In *XXVI International Horticultural Congress: Protected Cultivation 2002: In Search of Structures, Systems and Plant Materials for 633* (pp. 183-196).

8.3.6 Learning Outcome No 5: Establish drip irrigation system

8.3.6.1 Learning Activities

Learning Outcome No 5: Establish drip irrigation system	
Learning Activities	**Special Instructions**
5.1 Design Drip irrigation as per client specifications 5.2 Set out Lay out of the drip irrigation is set out in accordance with Operations Manual 5.3 Project Greenhouse crop market as per consumer needs 5.4 Establish Drip irrigation as per Operations Manual 5.5 Plan coordinate and control Drip irrigation activities as per farm requirements and SOPs 5.6 Maintain Drip irrigation system as per the Operations Manual 5.7 Use Drip irrigation materials, tools and equipment as per Operations Manual activities 5.8 Monitor and evaluate Drip irrigation is as per the Operational Manual 5.9 Prepare and implement Training programmes are prepared and implemented as per SOPs 5.10 Prepare and share Drip irrigation reports as per SOPs 5.11 Time Greenhouse crop harvest with peak seasons	Illustrations of drip irrigations Discussions Field Excursion

8.3.6.2 Information Sheet No8/LO5: Establish drip irrigation system

Introduction

Drip irrigation is a type of localized irrigation in which drops of water are delivered at or near the root of plants by very low pressure. This chapter covers all the activities involved in drip irrigation from installation to operation and maintenance.

Definition of key terms

Evaluation: Assessing systematically the objectives and possibly a completed project of a program.

Maintenance: The systematic and routine collection of information from project for different purposes

Content/procedures/methods/illustrations

5.1Drip irrigation is designed as per client specifications

Drip irrigation is manly applied in intensive cultivations.

The concept of drip irrigation is to target the roots of the crop rather than the entire cropland area the crop covers. Water is able to reach the deepest roots of the crops through capillarity and gravity. According to EPA drip irrigation uses 20-50% less water compared pop up systems.

Drip design

Before setting up drip irrigation, there are some factors to consider in order to have a successful drip irrigation system. The main purpose of the design of drip irrigation system is to decide the dimensions of the various components of the systems such that, the system provides the required quantity of water at desired uniformity in application while keeping the cost of the system to minimum. To apply the desired amount of water at nearly uniform rate to all the plants in the field. It is essential to design irrigation system that maintains a desired hydraulic pressure in the pipe network and provide the desired operating pressure at the emitter.

The design of the drip irrigation system consists of;

- Selection of emission devices
- Size of laterals
- Manifolds
- Main pipeline
- Filter
- Pump

The design depends on many factors, but will be constrained by several economic factors such as; feasibility, initial investment, labor, return on investment and performance parameters such as the flow rate and desired emission uniformity.

Steps followed for designing the drip irrigation system

i. Inventory of the resources and data collection
ii. Computing of peak crop water requirement
iii. Designing appropriate layout of drip irrigation system
iv. Selection of embitters
v. Hydraulic design of the system in terms of lateral, sub main and main
vi. Horse power of pump

I) Inventory of the resources and data collection

This step involves preparation of inventory of all the available resources and operating conditions. The resources involved include: water resources, land resources, climate.

Water resources: This includes, the quality and quantity of water, the type of water resources i.e. borehole and, tank etc. and also location of water resources is known.

Land resource: This covers the size and the shape of the area to be irrigated. The type of texture and irrigation properties (field capacity, wilting point, bulk density and allowable depletion level). The infiltration rates and topography of the land.

Climate: The climate data is required for computation of crop water requirement.

Crop to be grown: Crop type, planting and harvesting period, crop co-efficient, fertilizer requirement and crop geometry.

In general, the above guidelines can be used to ensure adequate quality of available water for irrigation to fruits and vegetable. However, the area to be irrigated can be decided on basis of water availability and the crop water demand.

ii) Peak crop water requirement

The designing of irrigation system needs the information on the peak water requirement. However, while the system is in operation, the water requirement during specified irrigation interval is required. Peak crop water requirement section describes the method to estimate the crop water requirement. Water requirement is a function of plant, surface area covered by the plant and evaporation rate. The water requirement of the whole area is estimated based on the water requirement per plant and the total number of plants. The crop water requirement, which is maximum during any one of the seasons, is adopted for the system

iii) Layout out of the drip irrigation system

It is possible to apply water to the whole field by drip irrigation method at the same. However, this may result in the requirement of high discharge which may not be available. Therefore, the whole field needs be divided into convenient number of sub units. Each sub unit is the designed separately and operates separately but having a valve at the head of each sub unit.

Number of sub units=total time available for irrigation

Total time of irrigation depends on the hours of electricity available in the region and capacity of farmers to supplement the electricity by other means

The system requirement for each sub units is computed

The layout of the drip system is done considering the shape, size and slope of the land

iv) Selection of emitters

The emitters are to be selected for its discharge. operating pressure compensating non pressure, point source, exit and surface

The selection of a particular emitter depends on;

- Topography
- Desired emission uniformity
- Available discharge
- Source of power e.g. electricity
- Water quality
- Water use efficiency
- Cost
- Type of soil

v) Hydraulic design of the pipe

The pipe network in drip irrigation system consists of lateral, sub main and main.

Water under pressure flows through these pipes and as a result reduces creating the variation.

The emitter discharge depends on the operating pressure available in the pipe, at the emitter connection and this reduces with reducing pressure.

The process of hydraulic design

- Know the operating pressure of the emitters
- Find out the available head loss in lateral and sub main
- Find the lateral and sub main discharge
- Find out the diameter and length of the lateral such that head loose is within allowable limits for the given layout.
- Repeat the procedure for the sub main
- Find out the diameter of the main so that the velocity is within allowable limit

Horsepower requirement of pump

Horsepower (hp)

$$\left(\frac{\text{The formula}}{\text{Horsepowernrequired(hp)}}\right) = \frac{\text{H} \times \text{Qm}}{75\text{xmpxnm}}$$

Where

H= total pumping head (HF+He+H3) M

H_f =total head loss due to friction. Friction head loss in the main + friction head loss in the laterals +friction head loss in accessories, filters and fustigation unit.

H_c=operating pressure head required at the emitter

H_s=total static head

Q_m=discharge of main

H_p=efficiency of the pump

H_m=efficiency of motor

5.2 Lay out of the drip irrigation is set out in accordance with Operations Manual

Much of the lay out has been discussed in the design of the irrigation system

Once the layout is finalized as discussed in the content above (5.1) the diameter and length of the sub main and the lateral for each subunit is decided on the basis of the hydraulic system design. The spacing between the lateral depends on the crop geometry for the row crops for the plantation.eg overhead crops. The spacing between the lateral is equal to the row spacing. However, depending on the age of the tree, tree spacing and the soil type. Two layers per row of a tree may be needed. The spacing between the emitter and the on the laterals for row crops is governed by spacing, age and soil type.

5.3 Green house crop market is determined as per consumer projected Needs

Consumer: A person who purchases a product from a buyer

To be able to market the horticultural crops, you should ask yourself what the consumer wants. As a farmer, you should be able to understand different techniques of finding a suitable market for your product. The techniques are discussed below

Crop calendar to show seasonality

This will enable the consumer to know when to expect the produce and off-season period. This calendar can be used to compare these periods when an area is able to supply the produce with the periods when market prices are likely to be high. It can also be used to compare seasonality of areas production with that of the competing area.

Cost of production calculation

Cost of production data and figures of the sales can be used to draw up crop budgets. These can be used by the farmer to predict the potential profits of different crops.

Production location maps

Maps of the production location help farmers to understand whether to re-clusters where particular products are produced. This can also help the farmer to produce when others are producing crops off the season. These maps are also useful for discussion with traders and can be used to identify locations where the farmers could group together in order to sell to traders' diagram to describe marketing channels, providing information about traders' price trends over the year understanding your marketing. Information about the demand for different products

All these techniques when used and followed by horticultural farmers will enable them to have reliable market for their products. Apart from this the farmer also know the consumers choices and preferences of the produce. Value chain followed by the farmer also affects the market prices.

Before you market your produce, you should ensure that they are safe for consumption. This is by involving the standardize boards so that consumer health is assured.

The products should have the following consumption information to enable the consumer buy without question

- Varieties appearance and taste
- Grading and quality standards
- Seasonality and supply patterns
- Typical prices and price patterns
- Packaging
- Sales trend

Farmers always complain about poor prices and this is predictable finding at any field season. Inadequate prices may reflect high marketing cost a lack of demand. It may be possible to improve prices by lowering the unit cost of marketing and promoting more

competition between buyers by improving negotiating by farmers and by organizing access to new market opportunities.

5.4 Drip irrigation is established as per Operations Manual

Before establishing drip irrigation system, the farmer should be able to plan for design and layout of drip irrigation system.

The design of drip irrigation follows the following steps

i. Inventory of the resource and data collection
ii. Computing of peak crop water requirement
iii. Designing appropriate layout of drip irrigation system
iv. Selection of emitters
v. Hydraulic design of the system in terms of lateral, sub main and main
vi. Horse power of pump

After designing drip irrigation system, then setting up the layout then follows.

It is possible to water the whole field though it may in the requirement of high requirement of high discharge, which may not be applicable. Therefore, the whole field is sub-divided into convenient subunits. Each sub unit is then designed and operated separately by having a valve at the head of the sub-unit.

After laying out the drip irrigation system one is supposed to select emitters suitable for irrigation, this depends on the design of the emitter and the choice of the farmer. Choose the hydraulic design of the pipe network, in the main and the sub main. Where water from the tank flows in them under pressure available in the pipe at the emitter connection. After selecting the hydraulic design, a computation of the pump is then done to enable water flow in the pump to the pipes with easy of irrigation purposes.

5.5 Drip irrigation activities are planned, coordinated and controlled as per farm requirements and SOPs

Drip irrigation system consists of various components, which are designed properly as per the specifications. After designing the components, they are to be installed properly. Many of the problems of drip irrigation occur because of poor installation. The system needs to be maintained and operated properly for obtaining longer life of different components of the system and trouble-free operation.

The drip irrigation activities include the following

Installation

The main item in the installation of the system include; installation of control head, comprising of the pumping set, non-return valve, water meters, filters, fertigation equipment, flow control and release valve. The other items of installation include the mains, submains and laying out drip tape or lateral with drippers. While installing the control head or the network, the minimum number of accessories such as elbows, reducers and others should be used f or proper maintenance of the system and to reduce unnecessary head loss in the system due to the connections.

Installation of filters and fertigation equipment

i. A support in the form of hard base along with fittings should be used for the installation of the and hydro-cyclone fitters to avoid any vibrations due to load
ii. The fitter size should be in accordance to the capacity of the system and should match with the pump discharge as undersize will lead to loss.
iii. The delivery pipe of the pump should be connected directly to the hydro clone or sand fitters followed by the fertilizer equipment and the screen fitter, all the equipment should be installed to the main pipe
iv. Once the sand fitter is connected to the essential requirement. suitable arrangement to collect and dispose of the bypass material should be made.
v. In pressurized irrigation system the fertilizer injections units are located between the sand filter if required and the screen filter.

Installation of mains and sub mains

Except for fully portable system, both mains and sub mains made from PVC must be installed underground at minimum depth of about 0.5 m such that they are unaffected by cultivation or by heavy harvesting machinery.

- Compute the time of operation of different sub units, based on the climatological data of the previous days or from the average historical data.
- Prepare the time schedule for various valves and operate accordingly to release the desired quantity of water.
- Compute the volume of water to be applied for each subunit and ensure that the desired quantity of water is applied.
- Check the pressure of the pressure gauges regularly.
- For the system involving the operation of the valves hydraulically, ensure proper setting of the hydraulic water valve.
- Operate the heading valve to begin irrigation.
- Checking the system components for proper operation randomly for the discharge
- Measure the emission uniformity to the system at least at the start of the irrigation season.
- The chemical and fertilizer injection season equipment to ensure the application of the desired quantity and concentration.
- Installation

Maintenance of drip irrigation

Periodic preventive maintenance of all the components of the drip irrigation system is required for successful operation of drip irrigation system. The emitter functioning, welting pattern and leakage of pipes valves and fittings should be checked regularly
Placement of the emitters should be done on broken ones. If the mains and sub mains are made out of materials other than PVC such as HDPE or GI
These may not need to install them below the ground surface; however, it is advisable to install them underground. It is importance to remove mud and other impurities in the pipe before fitting out mains and sub mains and get valves. A ball is provided at the

inlet and of the sub main, after the ball valve the air release valve is provided. A flush facing the slope of the sub main to facilitate sub main flushing. After installation of the main and the sub main and sub mains layering of lateral is done. Punching of the lateral and fixing the emitter follows later.

Operation of drip irrigation system

When the system is in use, it is required to operate properly for long and trouble-free use of the system.

Guidelines of the drip irrigation system

Keep the design, evaluation and testing information from the designer, installer and clean the clogged emitters to allow for of flow of water in drip

Clean the filter of the drip to prevent clogging of the emitters which reduces on performance

Clean water though venture or other injectors for 10-15 mins before and after fertilizer application

Types of treatment drips

- Flushing
- Chemical treatments- further divided into
- Acid treatment
- Chlorine treatment

5.6 Drip irrigation system is maintained as per the Operations Manual

Drip irrigation should be maintained for proper efficiency. Some of the maintenance and operation carried out in drip irrigation includes;

For perennial crops: The drip horse should be lifted periodically if the drip is used on the surface. So that leaves, soils and debris do not cover the hose. If the house is not lifted root can grow over the horse affecting the flow of water to crops. Leaks can occur unexpectedly due to damage by insects, animals or farming tools. Systematically monitor the lines for physical damage. It is so important to fix holes as soon as possible to prevent uneven irrigation. If the rate of the water flow declines progressively during the season the pipes may be slowly plugging resulting in severe damage of the crop. Therefore, once a month, flush the drip lines by opening the far ends of the portion of the types at time and allowing the higher velocity water to flush out the sediments.

5.7 Drip irrigation materials, tools and equipment are used as per Operations Manual activities system

Components for a drip irrigation system

Hose connector with short valves

This connector allows drip system connected at all to keep the system connected at all times. You can still use the regular garden hose without removing the drip system.

Timers

Turns the water on and off. This offers more proof means of controlling the system, rather than simply turning the facet manual.

Back low preventer
This is required to prevent water from your water supply when the system is turned off
Fitter
Screens out particles that could clog the holes in the drip system
Pressure regulator
This reduces the pressure to lower pressure required by the drip system
Hose fitting
Connects the pressure regulator to the tubing

Tubing
There are two different types of tubing
Blanks tube – has no holes
Emitter tubing –has holes

Emitters
These are drippers, sprayers or drip line
They are available with different floe rates to accumulate the need of the plant
Types
Dripper
Used to water individual plant
Bubblers
Often used for larger plants e.g. roses, tomatoes, because it delivers more water in less time
Sprayer
Use sprayer to water ground cover or densely planted beds
Soaker drip line
Tubing with build in drippers, great for vegetable gardens and row of plants
Tubing stake
Prevents emitters from clogging
Riser stake. Allows emitters to be placed above the plants
Common tools used are pipe cutters, which cuts the desire length
Hole punch Punch holes in tubing wherever you want to install emitters. These are the things /apparatus making up the drip.

5.8 Drip irrigation is monitored and evaluated as per the Operational Manual
Evaluation: Assessment of efficient impact relevance and sustainability of a project
Monitoring: Ongoing analysis of project progress towards achieving planned results with the purpose of improving management decision making
Objective of irrigation system
To learn a layout sketch of an operation is invisible for making notes during evaluation. Pressure is an important measure of application uniformity; a portable pressure gauges can be used. A relatively simple way to measure application uniformity is by using cater

cans. To understand methods by which an irrigation system can be evaluated. The irrigation system can be evaluated each year to check uniformity of pressure and water application.

Purpose of evaluating and monitoring

- To provide accountability to the partners, according to the set objectives that is improved reliable and equitable distribution of irrigation water
- Evaluated to check on clogging pipes and unclog them
- Also, to find if the water being used for the irrigation purposes is healthy or it requires some treatment

5.9 Training programs are prepared and implemented as per SOPs

Training: Passage of knowledge and skills to you group of people using different methods.

Training programs: Activities designed for training a group of people in specific skills. Training programs for irrigation allows farmers to be conversant with the type of irrigation, the irrigation system to adopt in this case drip irrigation, people are taken through the training in order to understand;

- Basic equipment for proper irrigation
- How much water should be applied?
- How to prevent leaching
- Use an irrigation schedule program
- Use of soil moister sensors
- Well testing to estimate energies efficiency of the system
- Basics of drip irrigation

From the training the farmer will come up with knowledge and skills concerning, component, management and maintenance of drip irrigation system. Explaining to them on what is expected to be done on the farm because they have the knowledge.

5.10. Drip irrigation reports prepared and shared as per SOPs

Report: This is a summarized information about a project. After using the drip irrigation system, a farmer, needs to write a report on how efficient the system is. The report should contain the efficiency and the challenges of using drip irrigation system. Any other information concerning the system can also be noted down for further improvement. The report written should be shared to people concerned and solutions made to the system, which in return boasts productivity thus, profitability.

5.11. Greenhouse crop harvest is timed with peak seasons

Harvesting can be done due to many reasons in order to meet market demand. The timing, techniques and conditions of harvesting can significantly affect prices. Most horticultural crops are grown in the green houses therefore production is done off season. This is important to a farmer because at this time the market demand is high the key issues to be looked at include;

- Maintain quality

- Maximizing shelf life
- Supplying produce when and as the market demand

Harvesting and prices

Harvesting early in the season can be carried out to take advantage of the opportunities for high prices. Taking advantage of the short term marked opportunities require close links with the market.

Harvesting and crop maturity

The life of the crop and its suitability for long-term storage is affected by the maturity of the crop at the harvest. The optimum harvesting for most crops depends not only on the climate and distance of the market but also the variety and the growing conditions. Crops with larger shelf life are most preferred by consumers therefore famers should harvest crops that are mature and fort the market.

Harvest quality

Growers often do not understand the handling on the quality of the produce when it reaches the market. Harvesting should take place when the crop and the climate is coolers and the plant has the highest moisture content. If the transport is a problem the harvest should be rescheduled to avoid produce being left for too long. Harvest a specific crop in the ideal times depending on the variety. When the crops have reached the season when farmers have produced the same type of crop it is advisable to carry out value addition through processing of the produce into different produce so that they do not go on a loss of high supplies and demand.

Conclusion

This learning outcome covered; Installation, operation and maintenance of drip irrigation system. From this we come to know the tools materials and equipment required in the process and which skills to be used in managing and maintaining the drip irrigation system.

Further Reading

1. Jonson.M,E. 1983. Design and opetation of farm irrigation systems. revise printing,Agr.Mone ,no,3. St josephs .
2. Nakayoma.F,S. AND Bucks . D.A.1986.Trickle irrigation of crop production, Design Operatiom and management. New York

4.3.6.3 Self-Assessment

Written assessment

1. In which one of the following systems, the waterfalls drop just at the position of the root crop?
    a) Sprinkler
    b) Drip irrigation
    c) Sip irrigation
    d) All of the above
2. What type of crops cannot be cultivated with drip irrigation?
    a) Rice
    b) Sukuma wiki
    c) Banana
3. The following are the types of emitter used in drip irrigation which one is not?
    a) Drippers
    b) Bubblers
    c) Hoop stake
    d) Mister
4. The following are the method of cleaning the emitter, which one is not?
    a) Flushing
    b) Chlorination
    c) Acid treatment
    d) Sipping
5. One of the following is performance parameter that is evaluated in the field, which one is it?
    a) Field application efficiency
    b) Type of crop
    c) Climatic factor of the area
6. Drip irrigation is the
7. The concept of drip irrigation is to target ……of the crops
8. It is essential to design irrigation system that maintains a……in the pipe network
9. The emitter discharge depends on …….in the pipe at emitter connection
10. The pipe network in drip irrigation system consists of?

Oral Assessment

1. What are the factors to consider when selecting a particular emitter?
2. Describe the maintenance of drip irrigation

Case Study Assessment

1. Imagine you are working with irrigation system Installation Company. Formulate guidelines that will help you to know the type of system to be installed for your client.

Practical Assessment

1. Demonstrate drip irrigation materials
2. Use it to construct drip irrigation system on different crops and show how long it takes for the water to get finished in the container

4.3.6.4 Tools, Equipment, Supplies and Materials

- Land
- Propagation materials
- Pangas
- Fork jembe
- Rakes
- Shovel
- Watering can
- Water Horse pipe
- Drip lines
- Water tank,
- Nursery trays
- PumpPPEs
- Green house kit
- Harvesting crates
- Harvesting knifes
- Harvesting pails
- baskets, Packaging materials
- Shade nets
- Soil containers/ poly tubes
- Soil sterilizers
- Soil sampling tools

8.3.6.5 References

Burt.C.m and .W.S. 2011. Drip and micro irrigatiom design and manage trees, field crops 4 TH ed, Irrigation trainning and research

Clerk, G .W. Lanmon.J.R. D.Rogers,1996. Maintaining drip irrigation systems. MF2178. Kamsas state.

Sanford.s and J . PANUSKA.2019. irrigation management in wiscosi, bulleting. A4119. university os Wisconsin- extension

8.3.7 Learning Outcome No 6: Manage Horticultural field

8.3.7.1 Learning Activities

Learning Outcome No 6: Manage Horticultural field	
Learning Activities	**Special Instructions**
6.1 Establish Horticultural farm in accordance with Horticultural Crop Production Manual 6.2Determine Soil nutrition requirement for horticultural crop and enhanced 6.3Establish Horticultural crops as per crop extension handbook 6.4Undertake Horticultural crop husbandry as per Crop Extension Manual and GAPs 6.5 Harvest Horticultural crop in accordance with GAPs 6.6 Undertake Horticultural crop post harvesting management as per Post Harvest Handling Manual	Discussions and group presentations. Field excursion

8.3.7.2 Information Sheet No8/LO6: Manage Horticultural field

Introduction

This learning outcome covers; crop rotation program, land preparation, soil fertility management, pest and disease control, harvesting, safe use of pesticides and security measures. In management of agricultural field same of the main areas to be covered include the following practices: establishment soil nutrition requirement, establishment of horticultural crops, crop husbandry and harvesting of the horticultural crops.

Definition of key terms

Crop rotation: Practice of growing a series of different types in the same area in sequenced seasons.

Soil fertility management: Practices carried out in the soil in order to improve on its fertility.

Crop husbandry: This is aspects of crops from seed planting, field operations, harvesting and past harvest operations and marketing of products.

Content/procedures/methods/illustrations

6.3Horticultural farm is established in accordance with Horticultural Crop Production Manual

Establishment of a horticultural farm is the coming up with a horticultural farm following different guidelines.

Before setting up a farm there are some guides that must be followed that will help in understanding a successful horticultural.

Factors considered when establishing a horticultural farm

The factors to be considered before starting up an agricultural farm include:

- Soil factor
- Choice of land
- Ecological potential
- Proximity to the market
- Adequate water supply
- Planting system

Soil factor

The type of soil determines the type of crop that can be grown in that particular area. Soil analysis should be done so that you have information on the type of soil, its fertility, its depth among other characteristics.

Climate

The climate of the locality should be suited for the growth of fruits and vegetables. Carry out extension services to require the types of crops suited for different climatic conditions.

Irrigation facilities

Most of the horticultural crops are raised under irrigation. So, the water facilities should also be taken into consideration.

Nearness to the market

This factor saves the overhead charges in transport and gives close touch with market tastes.

Availability of labor

Large horticultural farms are usually situated away from the population. Therefore, it will be necessary to ensure that adequate labor is available for the operations.

Cost of the land

This comes about after listing all the requirements and has been satisfied. This should never be the prime consideration in the extra cost paid for the foregoing amenities in more than repaid in the long run.

Availability of land

This is one of the important considerations in horticultural establishment as it is the basic to all the other practices.

Availability of infrastructure

Infrastructure in terms of transport and communication network is an important factor to consider as this will help in accessing the required materials into and out of the market.

Steps in establishment of a horticultural farm

i. **Cleaning of the land**

Preparation of the soil depends largely on the condition, previously grown crops and growers plan. If the land has been under cultivation and has been well maintained, nothing further may be required.

ii. **Leveling**

This is important for efficient irrigation, drainage to check soil erosion and to improve appearance.

iii. **Fencing**

This is necessary for protection of the crops from stray animals, human trespassing and also for security purposes.

iv. **Wind break plants**

This is provided to reduce velocity of wind which causes loss of bloom, wind erosion and evaporation of moisture and keep arch and warm.

v. **Roads and drains**

This are laid out according to the plan prepared in advance taking convenient levels into consideration. Main irrigation channels also have to be glutted.

vi. **Tillage**

This including subsoil should be done thoroughly since it cannot be done after planting without disturbing the roots of the trees.

vii. **Selection of plants from the nursery**

Healthy crops are the ones selected to be grown on the main seed bed.

viii. **Planting**

Done after all the activities have been successfully done. The method of planting largely depends on the farmer.

6.2 Soil nutrition requirement for horticultural crop is determined And enhanced

Soil nutrition requirements

This is the nutrients that a soil has that can accommodate crop production. Soil nutrients are important for healthy plant growth.

The nutrients are classified into two

a) Macro nutrients
b) Micro nutrients

Macro nutrients are required by plants in large quantities and they include (N.P.K).

Micro nutrients are required by plants in small quantities i.e. zinc, Tin. Etc.
Nutrient management is crucial in order to increase or maintain crop yields on an agricultural land. To most crop needs throughout the year growing season. Soil fertility must be constantly high.
Deficiencies of the nutrients will impact crop quality and knowing these will assist in determining the amount and type of fertilizer required. This means that the soil testing should be carried out. Plant tissue analysis may also be used as a method for measuring nutrients levels of plant during their growth. This analysis is a useful tool for growers looking to understand the effectiveness of their fertilization practices. Beyond accounting for adequate amounts of essential plant nutrients, growers should be aware of a variety of other factors that will impact nutrient uptake and availability. Soil chemical and physical properties, such as parent material, texture, organic matter content or permeability will greatly impact the accessibility of certain nutrients for plant uptake, water content is also important because nutrients available to plants are dissolved in the soil solution. Excess water may however deplete soil oxygen leading to an increased concentration of carbon dioxide.
The pH of soil also affects concentration of certain mineral elements or their availability for crop intake. Soil acidification or a decrease in the pH may be caused by long-term fertilizer applications and other crop management practices. To account for this, farmers may consider applying lime or other amendments to increase on pH. For most crops, a neutral pH is required as it allows for the accessibility of nutrients. Lack of accessibility to nutrients can also be caused by environmental or soil conditions. Some nutrients may be lost from a system due to leaching, volatilization or runoff. Nitrogen may be leached from the agricultural system. These losses occur often with drainage after rain or irrigation events. All the macro and micro nutrients are susceptible to the effects of runoff and erosion.

6.3 Horticultural crops are established as per crop extension hand Book

Horticultural crops such as fruits and vegetables are established as per different considerations. Before establishing horticultural crops. One should first select the site.

Selection of site of horticultural crops.

The following are factors to be considered before selecting a site for an orchard.

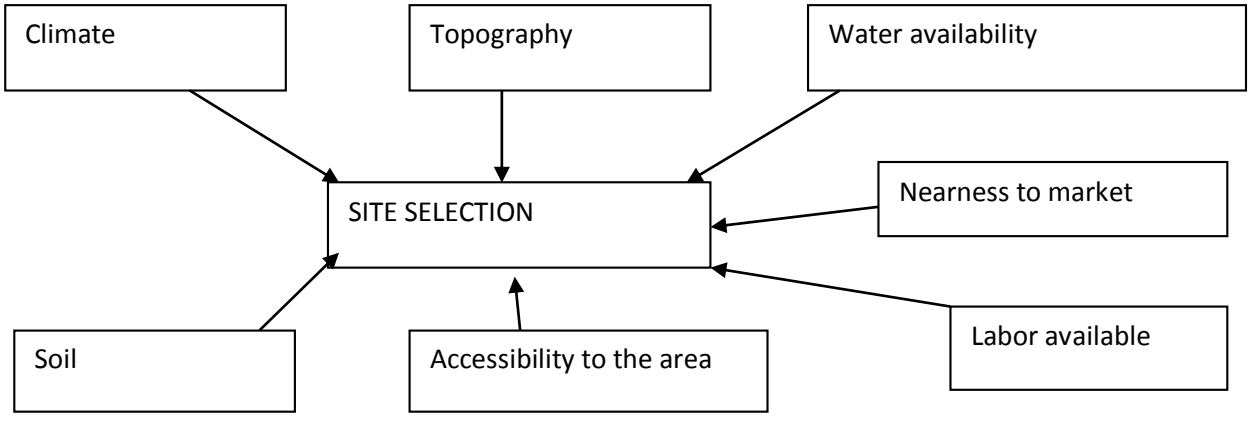

Figure 46:Selection of site of horticultural crops

Climate: The climate of the area should be suited to the horticultural crops chosen.
Soil: Few prospective sites should be examined for both physical and chemical

Properties: This means that one should carry out soil testing.
Nearness to the market: This one will save on transportation cost of produce to the market and materials from the market.
Availability of labor: Establishment do crops require labor in different farm operations such as nursery management, planting and other field practices.
N/B: With all these factors considered, a farmer is now able to establish his/her crops of choice in a particular area.

6.4 Horticultural crop husbandry is undertaken as per Crop Extension Manual and GAPs

Crop husbandry: Deals with the various aspects of crops from seed sowing, on field and off field operations, harvesting, threshing, storage and marketing of the products.

Subdivisions of crop husbandry

Crop husbandry is sub-divided into:

- Agronomy
- Horticulture
- Forestry

In our case we are going to discuss on horticulture as this is our area of interest.
Horticulture deals with various aspects of vegetable, fruits and ornaments. Horticulture is further subdivided into different branches which include:

- Floriculture
- Olericulture
- Pomiculture
- Land scaping

Olericulture: This is the production of vegetables.
Pomiculture/pomology: Deals with fruit production, orchard layering and their management.
Floriculture: Deals with growing and maintenance of flower plants for cut flowers industry and aesthetic purposes.
Landscaping: Application of horticulture towards beautification of land through lawn layering and maintenance.

6.5 Horticultural crop is harvested in accordance with GAPs

Harvesting

Principal of harvesting

Harvesting should be completed during the coolest time of the day, which is usually early in the morning. The harvested produce should be kept under a shade. The produce should be handled gently. Crops destined for storage should be as free as possible from skin breaks, bruises, spots, rots, decay and other deteriorations. Bruises and other mechanical damage not only affect appearance but also provide entrance to decay organism as well.

Packaging of Horticultural crops after harvesting

Packaging in situ

This is packaging done from where the crops are grown. This is done to prevent physical damage to produce and be easy to handle.

Packaging in a packaging house

This is done away from where the crops are planted. Possibly in a warehouse or store.

Grading of horticultural crops

This is done according to different characteristics which include:

- Quality
- Size
- Appearance

6.6 Horticultural crop post harvesting management is undertaken as

Per Post Harvest Handling Manual

Fruits and vegetables are marketable so long as they maintain their quality to a level that is acceptable by consumers. The post-harvest storage technologies are aimed at maintaining the quality of vegetable as long as possible

Impact of temperature on post-harvest life of horticultural crops

Temperature is the single most important factor in maintaining quality after harvest. Refrigerated storage retards the following elements of deuteriation in perishable crops.

- Aging due to ripening, softening and textual and color changes
- Undesirable metabolic changes and respiratory heat production
- Moisture loss and the resultant wilting
- Spoilage due to invasion by bacteria, fungi and yeasts
- Undesirable growth such as potato sprouting

Impact of storage temperature on respiration rate

- One of the most important functions of refrigeration is to control the crops respiration rate
- Respiration generates heat as sugars, fats and proteins in the cells of the crop are oxidized

- The loss of these stored food reserves through respiration means decreased food value, less of flavor, less of salable weight and more rapid deterioration
- The respiration rate of a product strongly determines its transit and past harvest life
- The higher the storage temperature, the higher the respiration rate

Pre-cooling

This is the first step in good temperature management. The field heat of freshly harvested crop is usually high and should be removed as quickly as possible before shipping, processing and storage.

Methods of pre-cooling

i. **Room cooling:** This is where produce is placed in an insulated room equipped with refrigeration units. This method can be used with all commodities but it is slow compared to other methods.

ii. **Forced air cooling:** Fans are used in conjunction with a cooling room to pull cool air through packages of produce.

iii. **Hydro-cooling:** Dumping produce into cold water or running cold water over produce is an efficient way to remove heat and can serve as a means of cleaning at the same time.

iv. **Top or liquid icing:** This is particularly effective on dense products and palletized packages that are difficult to cool with forced air. Icing method works well with high respiration commodities e.g. broccoli and sweet corn.

v. **Vacuum cooling:** Produce is enclosed in a chamber in which a vacuum is created. This system works best with leafy crops such as lettuce which has high surface area to volume ratio.

Other aspects related to post harvesting management of horticultural crops include:

i. Sanitation: this important to avoid infections by pathogens.

ii. Ethylene: a plant hormone that accelerates the ripening process thereby reducing post-harvest life.

iii. Modified atmosphere: Reduction of CO2 and increasing on CO2 concentration in the storage room.

iv. Controlled atmosphere: Controlled modification of oxygen and carbon dioxide in the atmosphere.

Conclusion

This learning activity covered; crop rotation program, land preparation, soil fertility management, pest and disease control, harvesting, safe use of pesticides, security measures as activities carried out in horticulture production in order to increase on productivity.

Further Reading

1. FAO, 1986. Improvement of postharvest fresh fruits and vegetables handling. Regional office for Asia and pacific. Maliwan Mansia, Phra Atot road, Bangkok, 10200, Thailand.

8.3.7.3 Self-Assessment

Written assessment

1. The following are the factors to be considered when starting up horticultural farm, which one is not?
    a) Soil factor
    b) Climate
    c) Rainfall reliability
2. One of the following is a step in establishing a horticultural farm which one is it?
    a) Wind break plants provision
    b) Marketing
    c) Availability of land
3. Selected plants from a nursery to be planted in the horticultural farm have got the following characteristics apart from?
    a) Healthy
    b) Attacked by pests
    c) Viable
4. The following are examples of nutrients that are used by plants for growth. Which one of them is a micronutrient?
    a) Nitrogen.
    b) Phosphorus.
    c) Zinc.
5. The following are factors that affect nutrient uptake in plants which one is not.
    a) PH concentration
    b) Type of soil
    c) Water content of the soil
    d) Nutrition requirement
6. The following are subdivisions of crop husbandry, Horticulture, Agronomy and Forestry. Olericulture falls under which type of husbandry.
    a) Horticulture
    b) Agronomy
    c) Forestry
7. Amongst the following which one is not a pre-cooling method?

a) Room cooling
b) Forced air cooling
c) Open air cooling
d) Hydro cooling

8. Harvesting sound is completed during the time of the day.
9. What are the types of packaging in horticultural crop production?
10. Bruises and mechanical damage not only affect appearance but also?
11. Why is infrastructure important in horticultural production?
12. Pomiculture is the production of?

Oral Assessment

1. Discuss the factors considered when establishing a horticultural farm?
2. Discuss on storage of horticultural crops.

Case Study Assessment

Visit a horticultural farm around your area and note done the post-harvest practices done to the produce. Ask questions on why certain practices are being done.

Practical Assessment

1. Practice post harvesting management of horticultural crops under the following sub headings.
   a) Sanitation.
   b) Ethylene.
2. Carry out hydro cooling method of pre-cooling in harvested horticultural crops in your areas.

8.3.7.4 Tools, Equipment, Supplies and Materials

- Land
- Propagation materials
- Pangas
- Fork jembe
- Rakes
- ShovelWatering can Water Horse pipe Drip lines
- Water tank
- Nursery trays
- Pumps
- PPEs
- Green house kit
- Harvesting crates
- Harvesting knifes
- Harvesting pails and baskets
- Packaging materials
- Shade nets
- Soil containers/ poly tubes
- Soil sterilizers
- Soil sampling tools,Media.

8.3.7.5 References

Bernard, D. (1998). Developing and implementing HACCP in the USA. *Food control*, *9*(2-3), 91-95.

Buntain, B., & Bickerton, G. (1999). The US Department of Agriculture Food Safety and Inspection Service's Activities in Assuring Biosecurity and Public Health Protection. *Annals of the New York Academy of Sciences*, *894*(1), 44-47.

Kader, A. A. (2004, June). Increasing food availability by reducing postharvest losses of fresh produce. In *V International Postharvest Symposium 682* (pp. 2169-2176).

Ofor, M. O., & Ibeawuchi, I. I. (2010). Sun-drying—a low cost technology for reducing postharvest losses. *Academia Arena*, *2*(1), 56-59.

8.3.8 Learning Outcome No 7: Horticulture postharvest management

8.3.8.1 Learning Activities

Learning Outcome No 7: Horticulture postharvest management	
Learning Activities	**Special Instructions**
7.1 Adhere Horticultural crop safety and quality to as per Post harvest Manual 7.2 Undertake Pest control Manual 7.3 Undertake Horticulture crop storage in accordance with Post harvest Manual 7.4 Determine Marketing opportunities as per farm marketing strategy	Group discussion Field excursions

8.3.8.2 Information Sheet No8/LO7: Horticulture postharvest management

Introduction

This learning activity covers; Post-harvest handling, packaging, processing, transportation, pack house operations, storage and marketing.

Definition of key terms

Packaging: The science art and technology of enhancing or protecting products for distribution, storage and sale use.

Post-harvest: This are the activities carried out after harvesting the agricultural crops.

Content/procedures/methods/illustrations

7.1 Horticultural crop safety and quality is adhered to as per Post Harvest Manual

- Horticultural crops such as fruits and vegetables play significant role in human nutrition, in terms of vitamins, minerals among other nutrients.
- Increased consumption of a variety of agricultural products on daily basis is recommended because of associated health benefits.

Both qualitative and quantitative losses occur in horticultural commodities between the harvest and consumption.

The qualitative losses include:

- Loss of edibility
- Nutrition quality loss
- Caloric value loss
- Loss consumer acceptability of fresh produce

These losses are much difficult to assess than the quantitative losses. Quality standards consumer preferences and purchase ng power vary greatly across countries and culture and this difference influence marketing and magnitude of post-harvest losses. Quality and degree of excellence is a combination of attributes, properties or characteristics that gives value in terms of the intended use. The relative importance given to a specific quality attribute varies in accordance with the commodity concerned with quality assessment.

Important quality attributes to different individuals

Producers

Producers are concerned with qualities such as:

- High yield
- Good appearance
- Ease of harvest
- Ability to withstand long distance shipping to markets

Wholesalers and retail market.

the qualities looked by wholesalers and retail market include:

- appearance
- firmness
- shelf life

Consumers

Consumers on the other hand classify horticultural product on the basis of:

- Appearance on the time of I natal purchase.
- Subsequent purchase depends upon consumers satisfaction in terms of flavor and quality of the edible parts.

Factors that contribute to various qualities of agricultural products

1. **Appearance quality factor**
   These may include shape, size, color, glass with no decays or defects. Defects come about as a result of damage by insects, deceases, birds etc.
2. **Texture quality factor**
   These includes firmness, crispiness, and toughness depending on the commodity. Textural qualities of horticultural crops are not only important for their eating and cooking quality but also for their shipping ability.
3. **Flavor**
   These include sweetness, sourness, bitterness, aroma, and off flavors.
   Flavor quality involves perception of the tastes and aromas of many compounds.
4. **Nutritional quality factors**
   Fresh fruits and vegetables play a significant role in human nutrition, especially as a source of vitamins and minerals.

Safety factors

A number of factors threaten the safety of fruits and vegetables.

The factors include:

- Naturally occurring toxicants e.g. glycoalkaloids.
- Natural contaminants such as fungal toxins.
- Heavy metal e.g. mercury.
- Environmental pollutants e.g. pesticide, insecticides.
- Microbial contamination.

N/B: Microbial contamination is a number one safety concern but most consumers rank pesticides as the most important safety concern. Organic fertilizers such as chicken manure should be sterilized prior to their application to fruits and vegetables so that to avoid the risk of contaminating fresh produce with Salmonella listeria and other pathogens. Commodities that tough soil are more likely to be contaminated than those that do not come into contact with the soil. The best approach to achieving and maintaining the safety of fresh fruits and vegetables is to focus on limiting potential contamination during growth, harvesting, handling, treatment ,packaging and storage, strict adherence to agricultural practices, good hygiene practices, careful handling and washing of all produce to be consumed raw and the strict observance of proper sanitary measures.

7.2 Pest control is undertaken in accordance with Post Harvest Manual

This learning outcome reviews some of the post-harvest technologies related to pest control and outlines the recommended practices for pest management.

The post-harvest pest control techniques

Post-harvest pest can be controlled by different methods which include:

- Heat and cold
- Sanitation
- Use of pesticides
- Controlled modified atmospheric treatment

a. Heat and cold

- Certain fungi and bacteria in their germination phase are susceptible to cold, infections can be reduced by treating produce with a few days of storage at the coldest temperatures. The commodity can withstand without incurring damage.
- On the other hand, brief hot water dip can also be effective especially for reducing the microbial load for crops such as plums.
- Cold treatment can control some insects, pests and are currently used to control fruit flies.
- For produce packed before cold storage treatment, package vents should be screened to prevent the spread of insects during handling.

- Hot water dips can be used for direct control of insects. Fruits should not be handled immediately after heat treatment.
- Whenever heat is used with fresh produce, clean cold-water showers should be provided to help return the fruits to their optimum temperatures as soon as possible.

b. Sanitation

Washing with chlorinated water can prevent decay caused by bacteria, mould, and yeast on the surface of the produce. Calcium hydrochloride and sodium hypochlorite are commonly used. The effectiveness of chlorine increases as pH is reduced from pH 1+0 pH8 but lower pH chlorine becomes unstable.

c. Pesticides

A wide variety of chemicals can be used to control pests after harvesting of the produce.

Ways which chemicals are used.

- Dips
- Sprays
- Dust
- Applied on pad of absorbent paper

N/B: Always follow the instructions and be aware of the recommendation for use. It may differ by state and commodity.

What to consider when using chemical cost control

- Cost
- Availability
- Regulations for proper use
- Residue tolerance

It is recommended to try and avoid or reduce on chemicals for pests' control.

d. Controlled modified atmospheric treatment

For commodities that tolerate high levels of carbon (IV) oxide (CO_2), carbon (IV) oxide enriched in air can be used to control decay-causing pathogens such as Botrytis cinereal. The effectiveness of insecticides' atmospheres depends on the temperatures, relative humidity duration of exposure and life stage of the insect.

7.3 Horticulture crop storage is undertaken in accordance with Post Harvest Manual

Storage is an essential and unavoidable part of the crop production process.

Importance of storage

- Protects the produce from insects and pests.
- To be consumed and stored for large period of times.

Fruits and vegetables grocers work diligently to ensure that they bring the best quality products to the market.

Methods of storage of agricultural products.

i. **Cold storage**

Storage where temperatures are lower than ambient temperatures. The fruits stored under cold storage allow more shelf life than those stored in ambient temperatures.

ii. **Controlled atmospheric storage**

In this type of storage carbon (IV) oxide is higher than oxygen levels.

iii. **Modified atmospheric storage system**

This is the practice of modifying the composition of the internal atmosphere of package in order to improve the shelf life.

iv. **Hypobaric storage**

In this type of storage life of several fruits and vegetables is increased significantly by reducing pressure under refrigeration. Apart from the above-mentioned other methods of storage include; can, drying, curing and salting, freezing and common storage.

7.4 Marketing opportunities are determined as per farm marketing strategy

- Marketing is a very important aspect in Agricultural production.
- Marketing is the process by which the space between the producers and the consumers is bridged.
- The process involves transport and techniques for minimizing crop loses. An effective distribution system will also require the establishment of rural business such as truck drivers and packaging manufacturers, contractors and wholesalers.
- The marketing chain is a two-way process i.e. produce flows to the market and money from the market flows back.
- In horticultural farming where prices are rarely regulated, financial viability depends as much upon the business and marketing skills as on the farmers technical expertise.

Crucial points that govern a market

- That the whole market process has to be customer oriented.
- The marketing is a commercial process and is only suitable if it provides all the participants with profit.

Important characteristic of horticultural crops

- They are mainly eaten for their contribution to the flavor of food and for the supply of nutrients.
- They are not basic food commodities; people will not buy if the price is too high.
- The consumption levels vary depending on the selling price and the income of the buyer.
- Many of the crops are not traded in large volumes and there is limited market.
- Products are perishable which means that there is always reduction in the quality if not sold immediately.
- The products are normally traded in a very open market where the price is determined by the demand and supply.

Techniques which can be used to maximize farmers produce

a) Improving the quality and presentation of the produce
b) Identifying the highest price buyer
c) Negotiating from strengths
d) Scheduling production when there is limited competing supply

Techniques available to minimize risks

- Selling a proportion of products at farm contract.
- Growing a crop range which includes a mix of high and low risk products.
- Investing in technology which increases yield stability therefore income stability.

Conclusion

This learning outcome covered the post-harvest operations carried out after the produce has been harvested which included post-harvest handling, packaging, processing, transportation, pack house operations storage and marketing.

Further Reading

1. Kitinoja, L (1999) Costs and benefits of fresh handling practices perishables handling
2. Quarterly, special issue: Costs and benefits of post-harvest technologies, No 97: 7-13

8.3.8.3 Self-Assessment

1. Horticultural products include the following. which one is not?
    a) Tea
    b) Flowers
    c) Vegetables
2. The following are ways in which chemicals are used. Which one is not?
    a) Dip
    b) Sprays.
    c) Dust.
    d) Broadcasting method.
3. The post-harvest pests can be controlled by different techniques. Which among the following is a technique of controlling pests?
    a) Heat and cold.
    b) Controlled atmosphere.

4. Which one of the following is not a method of storage of agricultural crops?
    a) Controlled atmosphere.
    b) Hypobaric storage.
    c) Cold storage
    d) Hot storage.
5. What factors among the following can be considered when using chemical pest controls?
    a) Cost.
    b) Hygiene.
6. Fruit production is under which part of plant husbandry in horticulture? _____
7. The hydrocooler normally used are of two types. Which are they?
8. The methods of harvesting of fruit crops include?
9. The types of maturity indices used in judging the maturity of fruits and vegetables are.
10. What is the difference between physiological maturity and horticultural maturity?

Oral Assessment

1. Discuss on the handling operation after harvest.
2. Enumerate the types of maturity indices used for judging the maturity in fruits and vegetables.

Case Study Assessment

1. Visit a cold storage or CA storage facility in your locality and enlist the fruits and vegetables stored.
2. Visit fruit orchard or vegetable garden during harvesting and find out the methods of harvesting used by farmers.

Practical Assessment

1. Visit a horticultural collection center. Carry out practical activities involved in the following subheadings.
    a) Packaging
    b) Grading and sorting
    c) Storage

2. Visit a market nearby that has got a collection of agricultural crops in terms of fruits and vegetables and list down the factors that contributed to you buying the crops in terms of quality.

8.3.8.4 Tools, Equipment, Supplies and Materials

- Land
- Propagation materials
- Pangas
- Fork jembe
- Rakes
- ShovelWatering can
- Water Horse pipe Drip lines
- Water tank
- Nursery trays
- Pumps
- PPEs
- Green house kit
- Harvesting crates
- Harvesting knifes
- Harvesting pails and baskets
- Packaging materials
- Shade nets
- Soil containers/ poly tubes
- Soil sterilizers
- Soil sampling tools
- Media.

4.3.8.5 References

McGillivray, G. (1998). *Análisis económico e investigación de mercados para proyectos hortofrutícolas* (No. Doc. 23728) CO-BAC, Bogotá). Sena, Natural Resources Institute.

Gutiérrez Mayorga, F. P. (2012). *Introducción a la maduración de babaco (vasconcellea heilbornii cv.) con un generador de etileno* (Bachelor's thesis, Quevedo: UTEQ).

Ramírez, H. (2000, June). Apple growing in northeastern Mexico. In *VI International Symposium on Temperate Fruit Growing in the Tropics and Subtropics 565* (pp. 139-140).