Crop Production

Level-IV

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Module Title: -Developing production plans for Horticultural Crops

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Introduction to the Module

This module covers the knowledge, skills and attitude required to participate in processes to Select horticultural crop type and variety, determine yield potential for horticultural crop, greenhouse management, prepare production plan for individual horticultural crop and whole farm, implementing production plan, and monitor, evaluate and learning of crop production plan

LG #12	LO #1. Select horticultural crop type and variety

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Introduction to the module
- Assessing and selecting horticultural crop types and varieties for their market potential and gross margin returns
- Selecting most profitable cultural practices and rotations with pest management strategies, and available machinery resources, for sustainability of resources.
- Identifying and determining production risks and strategies for each crop
- Identifying environmental risks and developing appropriate strategies
- Selecting horticultural crop types and varieties based on their potential for import substitution, export potential, raw material for agro industry and small-scale processors

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Assess and select horticultural crop types and varieties for their market potential and gross margin returns
- Select most profitable cultural practices and rotations with pest management strategies, and available machinery resources, for sustainability of resources.
- Identify and determine production risks and strategies for each crop
- Identify environmental risks and develop appropriate strategies
- Select horticultural crop types and varieties based on their potential for import substitution, export potential, raw material for agro industry and small-scale processors

Learning Instructions:
1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information sheet 1	

1.1 Assessing and selecting horticultural crop types and varieties for their market potential and gross margin returns

Assessing and selecting horticultural crop types and varieties for their market potential involves analyzing various factors such as cultivation type, propagation methods, applications, and regional demand. The global horticulture market is categorized into food plants (fruits, nut crops, vegetables, and others) and ornamental plants (flowers, turf, and others)

Some key factors to consider when evaluating horticultural crop types and varieties for market potential include:

- Cultivation type: The market is dominated by food plants, which include fruits, nut crops, vegetables, and others
- Propagation methods**:** Propagation methods such as seed, vegetative, layering and cutting, grafting, breeding, and others are used in horticulture
- Applications: Horticultural crops can be applied in various settings, such as greenhouses, vertical farms, and indoor farms
- Regional demand: The demand for horticultural products varies across regions, with North America, Europe, Asia Pacific, Middle East, and Africa being key markets
- Post-harvest treatment: The post-harvest treatment market is essential for maintaining the quality and longevity of horticultural crops. Fruits, vegetables, and flowers are some of the crop types evaluated in this market
- Greenhouse horticulture: The greenhouse horticulture market is expected to grow due to factors such as population growth, food security, and technological advancements

To identify promising horticultural crop types and varieties for market potential, it is crucial to analyze regional demand, consider the advantages of different propagation methods, and evaluate the application of horticultural products in various settings.

Additionally, understanding the post-harvest treatment market and the growth of greenhouse horticulture can provide valuable insights into the potential of specific crop types and varieties.

Scope of horticulture

- Horticulture crops produce a higher yield per hectare than field crops.
- Horticulture crops are extremely valuable because of their high nutritional value. Fruits and vegetables, in particular, provide us with a lot of vitamins and minerals.
- Horticulture is very important because it improves the beauty of the environment.
- Small and marginal farmers can benefit from horticulture crops.
- Crop varieties with a wide variety of applications are available in the Horticulture section.
- Horticultural crops benefit the environment by minimizing waste, conserving soil and water, and enhancing the farmer's socioeconomic status.

Different types of horticulture are:

Horticulture is the cultivation of plants in gardens or greenhouses, focusing on various types of plants and food items for specific purposes. It can be divided into several categories, including

I. Olericulture: The production of vegetables, such as carrots, asparagus, lettuce, cauliflower, tomatoes, and peas
II. Pomology: Also known as fruticulture, this branch deals with the production of fruits and nuts, including edible fruits like tomatoes and seeds like peas
III. Viticulture: The production of grapes, primarily intended for winemaking
IV. Floriculture: The cultivation of flowers and ornamental plants, such as tulips and roses
V. Landscape Horticulture: This broad category includes plants for landscaping, such as lawn turf, shrubs, trees, and vines

Horticulture is influenced by factors like climate, terrain, and regional variations, and it requires intense individual attention and care for each plant grown

The success of horticulture depends on factors such as weather, rain, soil quality, and terrain Horticulture is a blend of science and art, and it is closely associated with botany, the study of plants and plant processes.

1.1.1. Assessing and selecting horticultural varieties

Horticultural varieties refer to the different types of plants cultivated for various purposes, such as food, ornament, and landscaping. These varieties are developed through selective breeding, crossbreeding, and other horticultural practices to exhibit specific traits and characteristics. Some **key aspects of horticultural varieties include:**

- Cultivars: Cultivars are cultivated varieties of plants, which mean they have been selectively bred and cultivated by humans for specific characteristics. Cultivars may not always be true to type, meaning the seedlings grown from a cultivar may not have the same unique characteristics as the parent plant
- Varieties: Varieties are part of the scientific name of a plant and refer to a unique characteristic of the plant, such as its growth habit, plant size, or resistance to certain diseases Varieties are typically true to type, meaning the seedlings grown from a variety will have the same unique characteristic as the parent plant
- Traits: When selecting horticultural varieties, gardeners and horticulturists consider various traits, such as growth habit (bush, upright, or vining), plant height, plant size, heat and cold tolerance, and ease of harvest. These traits help determine which varieties are suitable for specific garden conditions and goals.
- Naming conventions: Varieties are always written in lowercase and italicized, while cultivars may have different naming conventions. Both varieties and cultivars refer to some unique characteristic of a plant, but cultivars are not necessarily true to type, whereas varieties are selecting the right horticultural varieties for your garden depends on factors such as available garden space, climate, terrain, and personal preferences. It is essential to choose plants that are disease-resistant and yield nutritious, good-tasting produce

1.1.2. Assessing and selecting market potential and gross margin return of horticultural crop

According to the search results, maintaining a gross margin of 30% to 40% and a profit margin of 10% to 15% is recommended to be sustainable in the horticulture industry. Gross margin is calculated by subtracting the cost of goods sold (COGS) from the revenue, while profit margin is calculated by dividing the net income by the total sale. The profitability of horticultural crops can vary significantly depending on factors such as production costs, market demand, and yield

uncertainty due to pest control. Sensitivity analysis can help assess uncertainty when building enterprise budgets and provide insights to growers for evaluation of their entire operation

Some benefits of using GMROI include:

- Identifying profitable products: GMROI helps retailers identify their most profitable products, allowing them to focus on products that generate the most revenue and profit
- Inventory management: GMROI can reveal issues with inventory that may be holding back the company from higher profits, enabling better inventory management and decision-making
- Gauging profitability: GMROI helps retailers gauge whether they are making a profit on the inventory they have, providing valuable insights into the efficiency of their inventory investment. To calculate the GMROI, use the following formula

GMROI=Gross Margin/Average Inventory Cost

For example, if a retailer has a gross margin of $150,000 and the average inventory cost is $50,000, the GMROI would be: {GMROI} = {$150,000} {$50,000} =3

This means that for every dollar invested in inventory, the retailer earns three dollars in gross profit, showcasing the efficiency of inventory investment in relation to profit.

1.2 Selecting most profitable cultural practices and rotations with pest management strategies, and available machinery, for sustainability of resources

1.2.1. Profitable cultural practices for horticultural crop

Profitable cultural practices for horticultural crops involve various strategies and techniques that improve crop productivity, enhance quality, and reduce production costs. Some of these practices include:

- Crop Rotation: Rotating crops can help improve soil fertility, reduce pest and disease build-up, and increase yield
- Companion Planting: Planting complementary plants together can improve soil fertility, suppress weeds, and attract pollinators
- Cover Crops: Incorporating cover crops into the soil can improve soil and water quality, suppress weeds, and increase organic matter

- Soil Fertilization: Applying appropriate fertilizers can help balance nutrient levels in the soil, promoting healthy plant growth and yield
- Weed Management: Controlling weeds can help improve crop yield and quality, reduce pest and disease infestations, and minimize herbicide use
- Integrated Pest Management (IPM): Combining various strategies, such as biological controls, cultural practices, and pesticides, can help manage pests and diseases while minimizing environmental impacts
- Pollination and Bee Management: Attracting pollinators and managing their populations can improve crop yield and quality, especially for crops that rely on pollinators for fertilization
- Harvesting and Handling: Timely harvesting and proper handling of crops can help maintain their quality and extend their shelf life
- Plant Propagation: Propagating plants through methods such as grafting, cuttings, or seeds can help increase the number of plants available for sale or planting. By implementing these profitable cultural practices, horticultural crop producers can improve their crop's productivity, quality, and market value, ultimately increasing their profitability.

1.2.2. Pest management strategies for horticultural crop

What is the pest management strategies used in horticultural crop production?

Pesticides are often used to control pests in horticultural crops. However, they are often viewed as environmental hazards by the public. Integrated Pest Management (IPM) promotes the responsible and reasonable use of pesticides in combination with nonchemical controls

Relying only on pesticides for control has several disadvantages:

- Insects, diseases and weeds can become resistant to pesticides.
- Resurgence of the pest when the pesticide application kills a high proportion of its natural enemies. The pest population increases rapidly because natural enemies no longer provide control.
- Secondary pests are created when pesticides kill the natural enemies of a non-target pest. Without natural enemies, the pest population increases to where it becomes a problem.

- Possible environmental contamination (e.g. pesticides in well water).
- Input costs for growers.
- Potential health hazards.
- Negative public attitude towards pesticides

A. IPM SYSTEMS

There are four components to an IPM system:

- Pest identification
- Monitoring
- Control guidelines
- Methods of prevention and control.

IPM can reduce pesticide use and yet, maintains quality standards by treating pests as part of the total management system. Components of the system include the physical and biological environment of the crop and pest. Pest management practices are combined with production practices to achieve economical, long-term solutions

B. Pest Identification

Identifying the pest properly helps decide which method of control is best. Nutrient deficiencies or physical damage can cause symptoms similar to those caused by pests. Also, the presence of pests does not always cause economic damage. Factsheets on pests are available from the Ontario Ministry of Agriculture and Food to help in identification

Monitoring

Monitoring allows you to forecast and evaluate potential pest problems. It identifies the pests present, estimates numbers and examines conditions favourable to pests. Monitoring allows accurate timing of pesticide applications which may reduce pesticide use. Each field should be watched separately because conditions vary. Monitor at least once per week and preferably twice per week when the pest is usually most active. Scouts may be hired to monitor the crop.

Good record keeping is essential. Complete written records help decision-making by supplying information on previous problems and applications. It is useful to record:

- Crop health.
- Pest species present.
- Weather and other environmental conditions.
- Population level of pests and beneficial.
- Sprays and other controls applied.

C. Methods of Monitoring

There are several ways to monitor pests.

- Pheromone traps contain a chemical that attracts only the species of pest being monitored. This makes pest identification easier.
- Physical traps are visually attractive to many types of insects. This can make pest identification time consuming.
- Direct counts check the number of insects or the amount of disease on a set number of plants. Weed counts across the field will aid in herbicide selection.

Weather monitoring calculates when insects will first emerge in the spring or when a disease is most likely to occur (e.g. BOTCAST predicts when Botrytis leaf blight infection takes place in onions so fungicides can be applied at the best time).

D. Control guidelines

Control guidelines, or thresholds, indicate when pesticides need to be applied to prevent economic losses. Timing of control measures is critical. Guidelines for insects are based on an economic threshold where the cost of not applying a control will be higher than applying a control. Guidelines for diseases, weeds, nematodes and vertebrates may be based on weather, history of the field or region, stage of the crop and other field observations.

E. Control methods

There are three types of controls used in IPM systems: cultural, biological and chemical (pesticides). Cultural and biological controls are used wherever possible. When these are inadequate, pesticides are usually used. The most economical and reliable way to deal with pest problems is to avoid them when possible

I. **Cultural Control.** Many cultural practices reduce pest damage. They prevent problems and are effective and economical. Examples are:

- Site selection -choose sites that are less favorable to pests
- Cultivar selection -choose varieties that are resistant, when possible
- Crop rotation -rotate away from crops of the same family (e.g. turnip, Cole crops and canola) to prevent some pests and help control weeds
- Inter cropping -planting a mixture of crops may reduce insect damage (e.g. under seeding Brussels sprouts with clover). However, competition may reduce yields in some cases
- Cover crops -can provide shelter for beneficial
- Trap crops -plant crops to attract the pest away from the main crop. Pests can be killed with a localized spray. For example, in tomatoes, trap crops of potatoes and eggplant can be used for Colorado Potato Beetle (CPB).
- Tillage -provides weed control and may kill some insects and pathogens.
- **T**une and method of planting -may help to avoid a generation of the pest.
- Sanitation - remove pest habitat such as cull piles, dropped fruit or other plants. For example, potato cull piles provide a place for potato blight to overwinter.
- Pruning -removes a food source or a point for infection. For example, removal of pear suckers helps to keep psylla numbers down.
- Clean seed and transplants -avoid introducing pests. Use seed that has been certified disease-free.
- Plant health -healthy plants are less prone to infection.
- Irrigation -use good timing/scheduling to prevent disease.

II. Biological Control

Biological control uses a pest's natural enemies to control the population of the pest. Natural enemies include predators, parasites and diseases. The term, "beneficial", refers to predators and parasites of insect pests. IPM systems take maximum advantage of control by natural enemies.

There are two ways in which biological control is managed:

A. Encouraging natural enemies -provide shelters or food sources for natural enemies. For example, a sod or weedy cover in an apple orchard provides an overwintering site for predatory mites. These mites control European red mite and two-spotted spider mite.

- Select pesticides that have minimal effect on beneficial. For example, Bacillus thuringiensis (Bt) is specific to certain types of caterpillars.
- Time or schedule pesticide applications to have least effect on beneficial
- Apply pesticides only when needed.

Adding natural enemies to provide control -adding natural enemies is not usually economical in the field. However, in greenhouse operations, it is often possible. For example, whitefly can be controlled with Encarsiafatmosa (a parasitic wasp). At present, work to develop pest diseases is continuing. In the future, more of these products may come on the market.

B. Resistance

Is refers to the developed ability of a pest to survive applications of pesticides at rates that once, killed most of that species. This ability is passed from generation to generation making the pesticide useless. Coloado potato beetle resistance, for example, is a major problem. With fewer new pesticides coming onto the market, resistance could become a more widespread problem. Resistance is most likely when pesticides are applied at lower-than-recommended rates and when either the same pesticide or pesticides with the same mode of action are repeatedly used.

Resistance Management

- Use pesticides only when needed
- Avoid pesticide residues.
- Alternate pesticides with different modes of action
- Use recommended rates of pesticide.
- Use other controls where possible e.g. rotary hoe for weeds.
- Time pesticide sprays for the most vulnerable stage. For example, spray for the larvae of potato beetle rather than the adult.
- In any pest population there may be some individuals that have the genetic ability to survive a pesticide application
- A number of the offspring of the survivors inherit the resistance to pesticides. These individuals survive the next spraying
- If a similar pesticide is applied frequently, the resistant individuals will soon make up most of the pest population

I. Machinery

Machinery used in horticulture includes a variety of equipment designed to help with planting, cultivating, and harvesting crops. Some examples of horticultural machinery include:

- Tractors: Tractors are versatile machines used for a variety of tasks, such as plowing, tilling, and planting. They can be equipped with various attachments, such as cultivators, seeders, and sprayers
- Cultivators: Cultivators are used to break up soil and remove weeds, preparing the soil for planting. They can be either hand-operated or tractor-mounted
- Harvesters: Harvesters are machines used to harvest crops, such as fruits, vegetables, and grains. They can be specialized for specific crops, such as grape harvesters or potato harvesters
- Mulching Machines: Mulching machines are used to shred and spread organic material, such as leaves and grass clippings, to improve soil quality and reduce weed growth

- Mowers: Mowers are used to cut grass and other vegetation, such as hay. They can be either hand-operated or tractor-mounted
- Sprayers: Sprayers are used to apply pesticides, herbicides, and fertilizers to crops. They can be either hand-operated or tractor-mounted
- Seeders: Seeders are used to plant seeds in rows or broadcast them over a field. They can be either hand-operated or tractor-mounted
- Post Drivers: Post drivers are used to drive fence posts into the ground, making it easier to install fencing around a horticultural area. By using these machines, horticultural producers can improve their efficiency and productivity, ultimately increasing their profitability.

There are various types of ploughs but the best known are:

- ✓ Mould board plough, formed by the grating blade and mould board
- ✓ disc plough, disc concave formed by deep grooves to open shallow ploughing to remove the topsoil
- ✓ Subsoil plough to remove the soil depth

1.3 Identifying and determining production risks and strategies for each crop

1.3.1. Identifying production risks in horticultural crop production

What are the Production risks in horticultural crop?

Identifying and determining production risks and strategies for each crop are crucial for horticultural producers to minimize potential losses and maximize profits. Some common risks and strategies include:

1. Production Risks: These risks relate to the possibility of lower yields or quality due to factors such as adverse weather conditions, pests, diseases, and equipment failures

Strategies to manage production risks include:

- ✓ Following recommended production practices
- ✓ Diversifying enterprises by growing different crop varieties and new crops

- ✓ Expanding production through more intensive growing practices or planting more acreage
- ✓ Purchasing federal crop insurance coverage to stabilize income during times of loss
- ✓ Adopting risk-mitigating practices such as drip irrigation, tile drainage, trap crops, or resistant varieties
- ✓ Considering site selection and using fields less susceptible to frost or pests, and rotating crops
- ✓ Maintaining equipment and keeping facilities in good working condition

2. Marketing Risks: These risks relate to the possibility of losing the market for products or experiencing lower sales and prices due to increased competition or other market factors

Strategies to manage marketing risks include:

- ✓ Developing a marketing plan that outlines pricing strategies, distribution channels, and promotional activities
- ✓ Diversifying marketing strategies by targeting different markets or customer segments
- ✓ Monitoring market trends and adjusting marketing strategies accordingly

3. Financial Risks: These risks relate to the potential financial consequences of factors such as unpredictable income, high production costs, and market fluctuations

Strategies to manage financial risks include:

- ✓ Maintaining a gross margin of 30% to 40% and a profit margin of 10% to 15% to be sustainable in the industry
- ✓ Diversifying income sources by producing a variety of crops or offering additional services
- ✓ Monitoring financial performance and adjusting business strategies as needed

4. Legal Risks: These risks relate to potential legal issues such as regulatory compliance, contracts, and intellectual property protection

Strategies to manage legal risks include:

- ✓ Ensuring compliance with relevant laws and regulations
- ✓ Establishing clear contracts with suppliers, customers, and other stakeholders

- ✓ Protecting intellectual property by registering trademarks, patents, and other legal protections

5. Human Resource Risks: These risks relate to potential issues related to labor supply, employee performance, and safety

Strategies to manage human resource risks include:

- ✓ Recruiting and retaining skilled labor by offering competitive wages and benefits
- ✓ Implementing safety protocols and providing training to employees
- ✓ Regularly evaluating employee performance and providing feedback to improve productivity and job satisfaction

By identifying and addressing these risks, horticultural producers can develop appropriate strategies to minimize potential losses and maximize their profitability.

1.3.2. Determining the strategies in horticultural crop production risks

1.3.1. Tools for Mitigating and Planning for Production Risk

i. Diversify crops or enterprise
ii. Change production methods
iii. Use lease arrangements with crop or livestock shares.
iv. Invest in new technologies
v. Maintain farm infrastructure and equipment
vi. Use protected cultivation
vii. Stay informed
viii. Site selection.

1.4 Identifying environmental risks and developing appropriate strategies

1.4.1. Identifying Environmental risks for horticultural crop production.

Identifying environmental risks and developing appropriate strategies is crucial for businesses to minimize potential negative impacts on the environment and their operations. Here are some key environmental risks and strategies for managing them:

I. Air and Water Pollution: Risks: Emissions from industrial processes, transportation, and waste disposal can lead to air and water pollution, causing environmental damage and harm to human health
   - Strategies: Implementing emission control technologies, optimizing processes, and investing in wastewater treatment systems can help reduce pollution

II. Hazardous Waste: Risks: Improper management of hazardous waste can lead to environmental damage and pollution
   - Strategies: Developing a waste management plan, using hazardous waste disposal services, and promoting waste reduction and recycling can help manage hazardous waste responsibly

III. Biodiversity Loss: Risks: Human activities can lead to habitat destruction, species extinction, and loss of ecosystem services
   - Strategies: Implementing conservation practices, promoting sustainable land use, and supporting environmental regulations can help protect biodiversity

IV. Climate Change: Risks: Climate change can lead to extreme weather events, rising sea levels, and other environmental impacts that can affect businesses directly and indirectly
   - Strategies: Adopting sustainable practices, reducing greenhouse gas emissions, and investing in renewable energy can help mitigate climate change risks

V. Regulatory Compliance: Risks: Non-compliance with environmental regulations can lead to legal penalties, fines, and damage to a company's reputation
   - Strategies: Staying informed about relevant regulations, implementing compliance programs, and ensuring effective communication with regulatory agencies can help manage regulatory risks

VI. Social Conflicts: Risks: Business activities can sometimes lead to social conflicts, such as land disputes or community opposition to industrial projects

- Strategies: Engaging with stakeholders, addressing community concerns, and implementing socially responsible practices can help manage social conflicts. By identifying and addressing these environmental risks, businesses can develop appropriate strategies to minimize potential negative impacts on the environment and their operations, ensuring long-term sustainability and success.

1.4.2. Developing appropriate strategies

What are appropriate strategies for environmental risks in horticultural crop production?

Strategies for managing environmental risks in horticultural crop production include:

a. Crop diversification**:** Diversifying the range of crops grown can help mitigate production risks associated with adverse weather conditions, pests, and diseases. Growing different crop varieties and new crops can reduce the impact of specific risks on overall farm income
b. Risk-mitigating Practices: Adopting practices such as drip irrigation, tile drainage, and trap crops can help mitigate production risks. Drip irrigation and tile drainage can help manage water-related risks, while trap crops can be used to control pests. Additionally, using resistant crop varieties can help mitigate the risk of pest and disease damage
c. Site Selection and crop rotation: Selecting fields less susceptible to environmental risks, such as frost or pests, and rotating crops can help manage production risks and maintain soil health
d. Incorporating eco-friendly strategies:-Implementing climate-mitigating agricultural practices, such as cover cropping and agro forestry, can help reduce environmental risks and improve the resilience of horticultural cropping systems. By implementing these strategies, horticultural producers can effectively manage environmental risks and enhance the sustainability of their crop production operations

1.5 Selecting horticultural crop types and varieties based on their potential for import substitution, export potential, raw material for agro industry and small-scale processors

1.5.1 Horticultural crop types and varieties for import substitution

What are import substitution products?

When selecting horticultural crop types and varieties for import substitution, several factors should be considered. These factors include

- Climate suitability
- Production and storage attributes
- Market demand.

Additionally, the feasibility of long-distance trade in perishable products and the potential for climate vulnerability of countries that grow at scale should be taken into account. It is important to select crop types and varieties

- ✓ That can be grown in a variety of climates and locations
- ✓ That have diverse production
- ✓ Storage attributes.

Furthermore, the selection should be based on:-

- The proximity to major importers
- Growing season,
- The country's supply of suitable land
- Human capital
- Infrastructure for exploiting its resources and marketing potential.
- It is also essential to consider the potential for high volume, high value, or unique produce that is suitable for export.

Moreover, the adoption of integrated pest management practices and support for innovation and diversification can contribute to the selection of appropriate horticultural crop types and varieties for import substitution.

1.5.2. Horticultural crop types and varieties for export

When selecting horticultural crop types and varieties for export, several factors should be considered. These factors include climate suitability, production and storage attributes, and market demand. Additionally, the feasibility of long-distance trade in perishable products and the potential for climate vulnerability of countries that grow at scale should be taken into account.

Furthermore, the selection should be based on

- ✓ The proximity to major importers
- ✓ Growing season
- ✓ The country's supply of suitable land,
- ✓ Human capital,
- ✓ Infrastructure for exploiting its resources
- ✓ Marketing potential.

It is also essential to consider the potential for high volume, high value, or unique produce that is suitable for export. Moreover, the adoption of integrated pest management practices and support for innovation and diversification can contribute to the selection of appropriate horticultural crop types and varieties for export. Finally, it is important to consider the regulatory requirements of the importing countries, such as

- ✓ Phytosanitary regulations
- ✓ labeling requirements
- ✓ Food safety standards, to ensure compliance and avoid trade barriers.

The horticulture export sector is young, and it has shown quite an exponential growth in the last ten years.

Currently, there are 126 investments in Ethiopia in the export of

- ✓ Flower
- ✓ Fruits
- ✓ Vegetables
- ✓ Herbs.

Farm ownership is made up of

- Local investors (46)
- Direct foreign investors (76)
- Joint venture partnership (3)
- Development Bank of Ethiopia (1).

Currently the flower, fruit, vegetable, and herb farms occupy 10,897.21 hectars of land. The horticulture sector employs 199,640 citizens and in 2017/18 fiscal year generated US$ 307.04 million. In hard currency generation, the horticulture sector has stood at the fourth largest in export earnings

ii. **Floriculture**

Floriculture is the study and practice of producing plants that produce showy, colorful flowers and foliage for human enjoyment and the human environment. It is a commercially successful branch of horticulture and agriculture found throughout the world. Floriculture crops include cut flowers, cut cultivated greens, bedding plants, houseplants, and flowering potted plants. These plants are produced in ground beds, flower fields, or in containers in a greenhouse.

Protected cultivation is often used because these plants have a high value to humans.

The Floriculture Career Development Event (CDE) is a competition that requires students to identify plants, judge flower arrangements, and solve problems. Participants also demonstrate skills in flower arranging, propagation, and the preparation of floral and foliage products for sale. Ethiopia now has 72 active flower farms and are the second largest flower producer and exporter next to Kenya



https://upload.wikimedia.org/wikipedia/commons/thumb/3/37/Floriculture.jpg/1200px-Floriculture.jpg

The country is noted for high-quality flowers. In addition to the Rose farms, six farms are engaged in the production of cuttings, and seventeen farms produce other flower varieties including Carnations, Hypericum, Veronica, Alstromeria, Gypsophila and a range of different types of flowers.

Fruits



Figure. Different types of fruit

Although Ethiopia has a long tradition of producing fruits; like banana, pineapple, mango for home consumption and neighboring countries export, it is only recently that the investment has been made in large scale production and the production of less traditional fruits including strawberries, table grapes, and passion fruits. Currently, there are nineteen operators engaged in large scale and modern fruit production. Fruit production and export is seen as an area that has enormous potential for development.

iii. Vegetables

At present, there are 31 vegetable exporting farms throughout the country. These farms produce a wide variety of vegetables including green beans, snow peas, tomato, paprika, eggplant, baby corn, onions, and Physalis. The availability of fertile land, labor, and readily available water together with cold chain facilities at three airports and a rapidly improving road and rail transport network all make Ethiopia the right place to invest in vegetables.

Ethiopia's climate is very well and suitable for the production of herbs, and many investors are keen to exploit the potential.

Currently, there are four herb producing farms in Ethiopia

- Zuqualla Horti PLC Exports its First Cutting Flower to European market. ...
- Koga Vege Agricultural Development PLC Started Exporting Irrigated Hass Varity Avocado to the Europe market
- Beles Processing, Export needs active efforts.

1.5.3. Raw material of horticultural crop for agro industry and small-scale processors

In the agro-industry and for small-scale processors, horticultural crops serve as the raw materials for various products and applications. These raw materials can be derived from various parts of the plants, such as fruits, vegetables, flowers, and leaves. Some examples of horticultural crops used as raw materials for agro-industry and small-scale processors include:

- Fruits and Vegetables: These can be used for various purposes, such as producing juices, jams, jellies, canned goods, and fresh salads
- Flowers and Ornamental Plants**:** These can be used for decorative purposes, such as floral arrangements, gardens, and landscaping

- Plants and Plant Extracts: These can be used for medicinal purposes, pharmaceuticals, and cosmetics
- Grain and Oilseed Crops: These can be used for producing grains, oils, and protein-rich meals
- Root Crops: These can be used for producing starch, sugars, and other carbohydrates
- Herbs and Spices: These can be used for flavoring foods, beverages, and pharmaceuticals
- Mushrooms: These can be used for producing mushroom-based products, such as mushroom powders, supplements, and gourmet foods. By utilizing horticultural crops as raw materials, agro-industries and small-scale processors can create a wide range of products for various markets, including food and beverage processing, pharmaceuticals, cosmetics, and more

Self-Check 1	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Part I. Write true if the statement is correct and false if it is incorrect

1. Horticulture crops produce a higher yield per hectare than field crops.
2. Landscape horticulture is the practice of designing outdoor spaces, landmarks, and structures with the intention of achieving environmental, social-behavioral, or aesthetic objectives
3. The farmer needs to consider both environmental conditions and consumer preferences when selecting which varieties to grow
4. Koga Vege Agricultural Development PLC Started exporting irrigated hassa Varity avocado to the Europe Market

Part II: Short Answer Questions

5. List the four herb producing farms in Ethiopia?
6. List tools for mitigating and planning for production risk?
7. List two ways in which biological control is managed?
8. What is the pest management strategies used in horticultural crop production?
9. What are four components of an IPM system?
10. List some ways to monitor pests?
11. Mention the best known types of ploughs
12. What are the Production risks in horticultural crop?
13. What are appropriate strategies for environmental risks in horticultural crop production?
14. What are the four components of an IPM system?

LG #13	LO#2. Determine yield potential for horticultural crop

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Sourcing and assisting relevant benchmark for yield and setting target yields
- Analyzing and determining past production records and key determinant yield
- Using Available models for calculating water, nutrients and agronomic use efficiency in setting targeted
- Establishing quality specifications and target yields for the selected horticultural crop.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Source and assist relevant benchmark for yield and setting target yields
- Analyze and determine past production records and key determinant yield
- Use available models for calculating water, nutrients and agronomic use efficiency in setting targeted
- Establish quality specifications and target yields for the selected horticultural crop.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 2

2.1. Sourcing and assisting relevant benchmark for yield and setting target yields

Sourcing and assisting relevant benchmarks for yield and setting target yields in the agro-industry and horticulture can be achieved through various strategies and metrics. Some of these strategies and metrics include:

- Yield Ratio: This metric indicates the percentage of candidates' movements from one part of the hiring process to the next, measuring the efficiency of the recruitment process and identifying bottlenecks. Comparing yield ratios across different sourcing methods can help determine the most effective strategies for attracting top talent
- Industry Benchmarks: Comparing your yield ratio to industry benchmarks can provide insights into the effectiveness of your sourcing strategies and help identify areas for improvement
- Historical data: Analyzing historical data on yield ratios can help establish a baseline for comparison and identify trends over time
- Target Yield Strategies: In fixed income investing, target yield strategies aim to provide yield uplift and potential out-performance versus the benchmark. This approach can be applied to horticultural crop production by setting target yields based on historical data, industry benchmarks, and specific production goals.
- Crop Diversification: Diversifying the range of crops grown can help manage production risks associated with adverse weather conditions, pests, and diseases. By growing a variety of crops, producers can potentially increase overall yield and reduce the impact of specific risks on their operations.
- Risk Management Strategies: Implementing risk-mitigating practices, such as drip irrigation, tile drainage, and trap crops, can help manage production risks and maintain soil health. By sourcing and assisting relevant benchmarks for yield and setting target yields, horticultural producers can improve their crop production operations and enhance their overall profitability.

2.2.Analyzing and determining past production records and key determinant yield

2.2.1. Analyzing past production record

Analyzing and determining past production records and key determinant yield can be achieved through various strategies and metrics. Some of these strategies and metrics include:

- Machine Learning Analytics: Machine learning approaches can be used to investigate the determinants of yield variation in horticultural crops. For example, a study used a machine learning approach to investigate the determinants of almond yield variation in California's almond orchards
- Record Keeping: Keeping detailed records on crop production, including yield, can help identify trends and patterns over time. Forage production and stocking rate information from long-term record keeping can be used to estimate animal forage demand and stocking rate for livestock
- Historical Data Analysis: Analyzing historical data on yield variation can help establish a baseline for comparison and identify trends over time. Insurance providers analyze historical data to determine the risk associated with various factors
- Satellite-based Assessment: Satellite-based assessment can be used to assess yield variation and its determinants in horticultural crops
- Water Use Efficiency: Available models for calculating water use efficiency or other key determinants of yield can be used to analyze past production records and determine key determinants of yield. Utilizing these strategies and metrics, horticultural producers can effectively analyze and determine past production records and key determinant yield, ultimately improving their crop production operations and enhancing their overall profitability.

Overview of the sector’s growth

The Ethiopian horticultural sector is composed of fruits, vegetables, flowers, herbs and spices. Although the sector is only about a decade old, mechanized horticulture production has shown a great increase in farm number, revenue generation and volume of export. There are currently over 130 investments in the sector, made up of local investors (56), foreign direct investors (64)

and joint venture partnership (10). Flower farms occupy 1,426 hectares, while fruits and vegetables take up 11,371 hectares.

The sector provides employment for approximately 183,000 persons and has been growing exponentially, generating 275 million dollars in 2015-2016 compared to 28.5 million dollars in 2004-2005. This makes the sector the fifth largest foreign revenue generator for the country.

I. **Floriculture**

Ethiopia now has over 130 active flower-growing farms and is the fourth largest non-EU exporter of cut-flower to the European Union and the second largest flower exporter from Africa. Floriculture has contributed to 225 million dollars, or 80 percent of the total foreign revenue earning of the sector. The majority of the production is made of roses (about 80 percent of the production), and the country is noted for the high quality, long stems, large buds and vibrant colour of its roses.

In addition to the rose farms, five farms are engaged in the production of cuttings and eight farms produce a variety of other types of flower crops, including gypsophilia, hypericum, limonium, chrysanthemum, carnations, static, pot plants and a range of summer flowers.

II. **Fruits**

Ethiopia has a long history of producing fruits in a traditional way for home consumption and export to neighbouring countries. The main fruits produced and exported by the country are mangoes, banana, papaya, avocados, citrus and pineapple. However, recent larger scale investments in fruit growing have favoured the production of new crops such as strawberries, table grapes and passion fruits, and in addition pears, plums as emerging fruits. There are currently eight operators engaged in large scale and nontraditional fruit crop production, which is seen as an area that has enormous potential for development.

III. **Vegetables**

Vegetables grown in Ethiopia include, among others, green beans, snow peas, broccoli, asparagus, cherry tomatoes, cauliflower, eggplant and cucumber, onion and garlic. Much of the land available for growing fruits and vegetables in the country is suitable for organic certification. In 2014, there were 22 vegetable farms throughout the country – 16 owned by local entrepreneurs, five financed by foreign direct investments, and one joint venture.

IV. **Herbs and spices**

The major spices cultivated in Ethiopia are ginger, hot pepper, fenugreek, turmeric, coriander, cumin, cardamom, and black pepper. Close to 122,700 hectares are being used for spice farming, with spice production reaching 244,000 tonnes per year. Potential areas for the cultivation of spices are the regions of Amhara, Oromia, Southern Nations, Nationalities, and Peoples' Region and Gambella Region. The total potential for lowland spice farming is estimated to be 200,000 hectares. The companies already engaged in spices and herbs are highly productive and produce over 21 varieties of herbs and herbs for local consumption and export as fresh product to many international market destinations. Production standards are high and all investors in this sector comply with the Good Agricultural Practice and Food Safety Standards required for food crops entering the European market.

V. **Market proximity and destination**

In addition to its many natural gifts, Ethiopia benefits from its location, close to the markets of Europe and the Middle East, and possesses good freight links to all major and emerging markets including Western Europe, the Middle and Far East, Russia and the USA.

Currently, Ethiopian floriculture is mainly exported to the Netherlands (80.3 percent), but exports extend to France, Germany, Italy, Canada, Norway, Belgium, Sweden, UK, UAE, Saudi Arabia, Japan, USA and other EU countries.

Fruits and vegetables have traditionally been exported by road to neighboring countries, Somalia (56.8 percent), Djibouti and the Sudan, but increasing quantities are now also being shipped by air to the Netherlands, the UAE, the United Kingdom, Germany, Belgium, Russia and Yemen.

The new fast track electric-powered railway line connecting Addis Ababa to Djibouti, other railway lines under construction and improvements to the internal highway roads will also open up opportunities for road or rail transport of production to the coast, and then sea freight to a range of market destinations.

VI. **Development of new horticulture hubs**

The Ethiopian government has established new horticulture hubs at four geographical locations: Alagae, Arbaminch, Bahir Dar, and Hawassa, with the aim of accelerating the transformation of the horticulture industry

These hubs offer several competitive advantages, including:

- Favorable climate: Ethiopia has a diverse agro-climatic zone and long growing seasons, making it suitable for growing vegetables, flowers, spices, and herbs
- Available land: About 12,797 hectares of suitable land are available for horticulture, with only 11% of this surface currently used for horticulture
- Workforce: The sector has already created about 183,000 jobs, with 70% of these jobs being for women
- Investors in horticulture have zero tax privilege on exports, making it an attractive investment opportunity for foreign direct investors and the Ethiopian Diaspora
- The Federal and regional institutions responsible for horticulture sector development in Ethiopia include the Horticulture and Agriculture Investment Authority, Ethiopian Investment Commission, and Investment Commissions of the respective regions

The Ethiopian Horticulture Producers and Exporters Association (EHPEA) closely works with the government and other stakeholders to promote Good Agricultural Practices, Protection for the Environment, and other initiatives

The EHPEA code of practice, introduced in 2007, has been revised and upgraded on several occasions to ensure the highest standards in the sector).

VII. Incentives applicable to new horticulture hubs

Investors in the new horticulture hubs in Ethiopia can benefit from various incentives and competitive advantages. Some of the incentives applicable to these hubs include:

- Zero tax privilege on exports: Investors in horticulture can enjoy tax privileges on their exports, making it an attractive investment opportunity for foreign direct investors and the Ethiopian Diaspora
- Favorable climate and available land: Ethiopia's diverse agro-climatic zones and ample available land make it conducive for horticulture investment, with only a small percentage of the suitable land currently being utilized for horticulture
- Employment opportunities and workforce: The horticulture sector in Ethiopia has already created a significant number of jobs, with a majority of these being for women, presenting opportunities for investors to contribute to the country's employment growth. In addition to these incentives, the horticulture hubs offer access to extensive laboratory facilities, demonstration plantings, and the support of federal and regional institutions responsible for horticulture sector development

These initiatives aim to accelerate the transformation of the horticulture industry in Ethiopia and provide a range of benefits for investors and the local economy.

VIII. A responsible and sustainable industry

A responsible and sustainable industry is one that considers a wide range of environmental social and economic factors when making business decisions and monitors its impact to ensure sustainable initiatives gain public support and financially performing well. Sustainable industries aim to reduce their environmental impact, increase resource efficiency, and promote transparency and corporate responsibility. Several industries are leading the charge with sustainable innovation, including architecture and construction, consumer packaged goods, energy, process, and utility, and life sciences.

These industries can advance sustainable development goals by incorporating innovative technologies, developing and implementing improved processes, sourcing materials from sustainable sources, and increasing organizational awareness of sustainability aspects.

A responsible and sustainable industry must strike a balance between the economy, society, and the environment, meet demand without compromising future generations, and develop without causing harm. By adopting various energy-efficient technologies and diversifying energy resources, businesses can pose fewer effects on the environment and human health.

2.3.Using Available models for calculating water, nutrients and agronomic use efficiency in setting targeted

The available models for calculating water, nutrients, and agronomic use efficiency can provide valuable insights for setting targeted yields in horticultural crop production. These models offer a scientific approach to understanding and optimizing the use of resources, ultimately contributing to improved crop yields and sustainability. Some of the key insights and resources from the search results include:

- Nutrient Use Efficiency Models: The University of Nebraska - Lincoln provides insights into nutrient use efficiency models, which are used to calculate the effectiveness of nutrient utilization by crops. These models can be valuable for understanding the relationship between nutrient inputs and crop yields, thus informing the setting of targeted yields
- Water Use Efficiency Models: The search results also highlight the significance of water use efficiency models, which are instrumental in understanding the relationship between water inputs and crop yields. These models can aid in setting targeted yields by optimizing water usage and maximizing crop productivity
- Agronomic Use Efficiency Models: The search results emphasize the importance of agronomic use efficiency models, which encompass the overall effectiveness of resource utilization in crop production. By integrating these models, horticultural producers can gain a comprehensive understanding of the factors influencing crop yields and set targeted yields based on optimized resource use
- Training Resources: The search results also provide training resources that cover the development of production plans for crops, including the analysis of past production records

and the use of available models for calculating water use efficiency and other key determinants of yield. These resources can offer practical guidance for horticultural professionals seeking to enhance their understanding of yield determinants and efficiency calculations. By leveraging these available models and training resources, horticultural producers can gain valuable insights into the factors influencing crop yields and develop targeted yield strategies that are informed by optimized resource use and efficiency calculations**.**

2.3.1. The importance of NUE

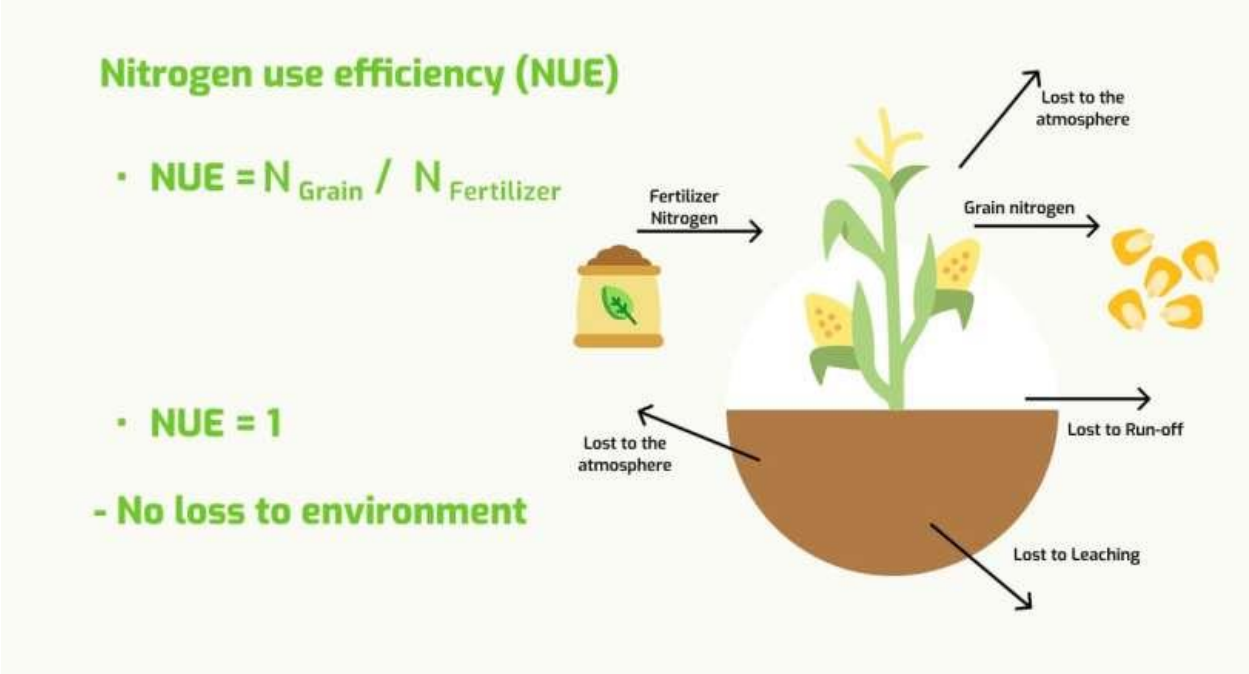
There are several reasons why nitrogen use efficiency is important in the soil. Here are some of them:

- It reduces economic losses from low yields and poor quality.
- It improves the sustainable use of natural resources.
- It reduces pollution from nitrogen fertilizer.
- Lower costs are associated with applying a lower amount of nitrogen fertilizer that is still sufficient to achieve crop-yield targets.
- Lower environmental impacts, particularly on water quality, due to reduced leaching and volatilization losses of nitrogen.
- Higher protein content in grain crops. This can increase the economic value of grain and improve the animal's ability to convert feed into meat or milk.

How to calculate nitrogen use efficiency?

NUE is calculated using the following formula:

The equation for NUE can be found by dividing grain yield by the total amount of N available to the crop. g/ha grain yield (crop dry matter) ÷ g/ha applied N.



For example, consider a crop yielding 3.5 t/ha of wheat with a total N content of 0.24%. The measured amount of N in the grain is, therefore:

3.5 × 0.24% = 8.4 kg/ha.

If the crop has been supplied with 100 kg/ha of N (including soil mineralization), then the crop's NUE is 8.4%.

How to increase the nitrogen use efficiency

Here are some ways farmers can improve it:

i. You can improve it by choosing the right type of fertilizer. Organic fertilizers are great. When these organic fertilizers are applied to the soil, they release nutrients slowly with the help of microbes present in the soil and thus enhance the NUE.

ii. Using appropriate cultivation methods

iii. Planting suitable varieties.

iv. Applying the right amount of fertilizer at the right time. Fertilizer should be applied before sowing or during sowing whenever possible in order not to waste crops as much as possible.

It can also be improved by crop rotation and cover crops. When used together, these practices can help reduce the negative environmental effects of conventional farming practices where farmers apply excess nitrogen to ensure all plants get enough nitrogen.

The traditional approach of applying adequate amounts of nitrogen is costly and inefficient. Cover crops and crop rotation can help reduce this cost by improving the NUE in your fields, which means that you will be able to produce more with less nitrogen fertilizer application.

When it comes to crop rotation, remember that not all rotations are created equal. Some rotations can decrease NUE compared to a straight corn-soybean rotation. For example, planting corn after soybeans will generally improve NUE compared to planting soybeans after corn.

Cover crops have been shown to increase NUE because they take up nitrogen from the soil; a process known as immobilization. Nitrogen immobilization is when microorganisms use organic sources of nitrogen in the soil and convert them into new living tissue (microorganisms).

What is green pest control?

The microorganisms then die and release this organic nitrogen back into the soil for plants to use. However, cover crops do require management, including proper termination methods and dates.

How can geo pard help to increase nitrogen use efficiency?

Geo pard is a precision farming solution that provides farmers with the necessary data and information to produce crops more efficiently. geo pard provides plant-specific insights into the yield potential of each field, and the status of nitrogen, potassium, and phosphorus in the soil.

They provide a full cycle of calculation (how much nitrogen is already in the soil, how much should be added, how much is left at the end of the season) and do planning for the next season.

Geopard helps to increase NUE by providing precise recommendations on how much fertilizer to apply and when to apply it. It helps farmers reduce the amount of fertilizer that is applied without affecting crop yield. This means that farmers will spend less money on fertilizer and reduce their environmental impact at the same time.

Geopard recommends precise amounts of fertilizer that should be applied based on soil characteristics, historical weather data (to estimate how much water will be lost to evapo-transpiration), and current weather data (which can be used to predict when a good window of opportunity will appear to apply the recommended amount).

- They make analyses based on infographics (Data from machinery (As-applied fertilization, as-planted, Yield, Protein)

The most important aspect of geopard is its ability to analyze information in a user-friendly way. This system provides the data in an easily understandable fashion, allowing for better decisions in the future. The information that is gathered by geopard includes the following: As-applied fertilization, as-planted, yield, and protein.

This information is gathered using machinery and using a simple process, providing the farmer with all of the most important data in one place. The data can then be used to help make important decisions about what needs to be done to improve nitrogen use efficiency on their farm.

- They provide analytics (Equations to calculate N uptake on each sq m)

One of the main benefits of the geopard crop management system is that it provides growers with an effective tool for understanding and analyzing crop growth. The geopard crop Management System uses advanced analytics to help growers with their NUE.

The system provides analytics for each square meter, which enables growers to understand the required amount of nitrogen needed for each area. By using this information, growers can avoid over-fertilization and save money by minimizing their fertilizer costs.

Analytics are provided in a simple form: equations that tell you how much nitrogen you need on each square meter.

- They create Agronomic planning for the next season based on accurate data and Geopard modeling

Geopard provides you with vital information about each part of the field and maps out areas where nitrogen is needed most. Based on this information, growers can plan the number of fertilizers to be applied in particular parts of the field, which saves time, money, and resources.

It is the ratio of crop nitrogen uptake to the amount of nitrogen applied. It is a major determinant of crop productivity and profitability, and an important indicator of sustainable agricultural practices.

The less amount of nitrogen that is used by a crop the more efficient it can be considered to be. Furthermore, the NUE is affected by many factors including soil properties, management practices, and environmental conditions

What are the benefits of increasing nitrogen use efficiency?

Increasing it brings several benefits. It enhances crop productivity, reduces environmental impact, saves costs, and promotes sustainable agriculture. Efficient nitrogen use ensures optimal plant growth, minimizes nitrogen runoff and greenhouse gas emissions, lowers input expenses, and supports long-term soil fertility. By prioritizing it, farmers can achieve better yields, protect the environment, save money, and contribute to sustainable farming practices.

How much fertilizer per square meter?

The amount of fertilizer per square meter varies depending on the crop, soil conditions, and nutrient requirements. It is best to conduct a soil test to determine the specific fertilizer recommendations for optimal plant growth. Soil testing provides accurate information to determine the correct amount of fertilizer to apply per square meter, ensuring efficient nutrient supply for the plants.

- What are two strategies for increasing nitrogen use efficiency?

There are two effective strategies for increasing NUE:

I. Split Application: Splitting the nitrogen fertilizer application into multiple doses throughout the growing season allows for better synchronization between plant demand and nutrient availability. This approach minimizes nitrogen losses and ensures that plants receive nitrogen when they need it most.
II. Enhanced nutrient management: Implementing precision nutrient management practices, such as using site-specific application techniques and adjusting fertilizer rates based on soil and plant needs, can significantly improve it. By tailoring nutrient inputs to specific areas or zones within a field, farmers can optimize fertilizer usage and minimize nutrient wastage.

These strategies contribute to maximizing the effectiveness of nitrogen fertilizers, reducing environmental impacts, and improving crop performance while maintaining sustainable agricultural practices.

- Which crop is the most efficient user of nitrogen?

Among various crops, legumes are considered the most efficient users of nitrogen. Leguminous crops, such as soybeans, peas, and lentils, have the unique ability to form a symbiotic relationship with nitrogen-fixing bacteria in their root nodules.

This enables them to acquire nitrogen directly from the atmosphere, reducing their dependence on external nitrogen sources like fertilizers. As a result, legumes have higher nitrogen use efficiency and can contribute nitrogen to the soil, benefitting subsequent crops in a rotation system.

2.3.2. Calculating agronomic efficiency in horticultural crop

Agronomic efficiency (AE) is the efficiency of applied nutrients in increasing grain or biomass yield. It is calculated as the increase in yield per unit of nutrient applied. For N application to cereals, typical AE values range from 10 to 30 kg grain kg^{-1} N fertilizer applied

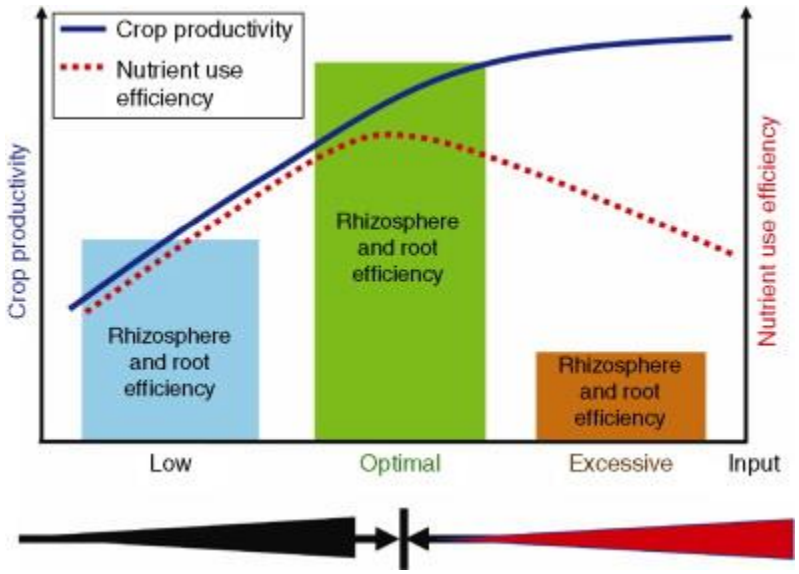


Figure. Crop productivity vs nutrient us efficiency
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.sciencedirect.com%2Ftopic

The AE is the mathematical product of two other NUE concepts: recovery efficiency (RE) and physiological efficiency (PE). The RE is the proportion of the nutrient applied as fertilizer that is taken up by the plant and is influenced by fertilizer management and crop nutrient needs. For N fertilizer, typical values for RE are in the range of 0.30–0.50 kg kg^{-1}

The PE describes the ability of plants to transform acquired nutrients into economic yield and is impacted by partitioning, environment, and management. For N fertilizer applications to cereals, typical PE values range from 30 to 60 kg yield kg^{-1} N taken up by the plant.

Agronomic NUE has been defined as the ratio of crop biomass per unit amount of applied or recovered fertilizer N or the total amount of N fixed by legumes.

Agronomic NUE = Crop biomass / Total plant-available N inputs

It is the proportion of applied fertilizer N that is recovered in the target crop. The ideal efficiency, which is rarely achieved, would be 100%, meaning that the entire N applied is recovered in the crop.

The term agronomic does not refer to the farming practice but to the actual amount of N that is used by a crop. This may be less than what was actually applied or supplied and can be due to various factors such as losses through leaching or de-nitrification or immobilization of fertilizer N by microorganisms in the soil.

2.4. Establishing quality specifications and target yields for the selected horticultural crop.

The process of establishing quality specifications and target yields for horticultural crops involves considering various factors such as nutrient application guidelines, cultural practices, yield sensing technologies, and crop quality indicators. Here are some key insights from the provided sources:

- Nutrient application guidelines: Nutrient application guidelines, such as those provided by the Wisconsin soil testing program, offer valuable information on target soil pH, moisture content, and nutrient demand levels for specific horticultural crops. These guidelines are essential for determining the appropriate amount of nutrients to apply to maximize yield and profitability
- Cultural practices: Wise selection of cultural practices, as outlined in resources such as the Commercial Vegetable Production Guide, is crucial for improving production efficiency, lowering costs, and increasing profitability. Timely implementation of effective cultural practices enables growers to minimize risks and enhance the incidences of success
- Yield sensing technologies: Yield sensing technologies provide detailed insights into crop production and quality parameters, which are essential for measuring key quality attributes and determining crop value. These technologies enable growers to understand yield patterns,

differentiate between total production yield and marketable yield, and make informed decisions to optimize quality and quantity

- Crop quality indicators**:** Crop quality indicators, including canopy and geometric characteristics, serve as measures of crop health and yield potentiality. Understanding and monitoring these indicators are essential for assessing and optimizing crop quality and overall yield potential. By integrating insights from nutrient application guidelines, cultural practices, yield sensing technologies, and crop quality indicators, horticultural producers can establish comprehensive quality specifications and target yields, ultimately enhancing the productivity and profitability of their crop production operations..

The quality of fresh fruits and vegetables may be explained in terms of the following:

i. Fresh market quality
ii. Edible quality
iii. Storage quality
iv. Transport quality
v. Shipping quality
vi. Table quality
vii. Internal quality
viii. Nutritional quality
ix. Appearance quality
x. Processing quality

For producers of horticultural crops “good quality” produce (fruits, vegetables or flowers) should give

- High yield with good appearance
- Disease resistance
- Insect resistance
- Good transport quality and bring higher profit.

To receivers and market distributors, appearance quality is most important and also the firmness and long storage quality.

Consumers consider good quality fruits, vegetables or flowers to be those that have good fresh market quality i.e., good appearance, good colour, firm or tender (good and optimum texture), good flavour and nutritive value. Although, consumers buy on the basis of appearance and feel,

their satisfaction and repeat purchase are dependent upon good edible quality in case of fruits and vegetables

A. Quality components

The different components of quality are listed in the following table. These components are used to evaluate quality of the commodities in specifications for grade and standard, selection in breeding programme, and evaluation of responses to various environmental factors and post harvest treatments. Quality components of fresh fruits and vegetables

Main factor	Quality components
Appearance(visual)	Size, dimension, weight, volume, shape and form, smoothness, compactness, uniformity colour, uniformity and intensity Gloss, nature of surface wax Defects: external, internal (morphological, physical and mechanical, physiological, pathological and entomological)
Texture	Firmness, hardness or softness, Crispness, succulence, juiciness, Mealiness, grittiness, fibrousness, Toughness
Flavour (Taste and smell)	Sweetness, sourness(acidity), astringency, bitterness, aroma, off odour, off flavour
Nutritive value	Contents of carbohydrates, proteins, Lipids, vitamins, minerals, fiber, water Antioxidants etc.
Safety	Naturally occurring toxicants, Contaminants (chemical residues, heavy metals) Mycotoxins Microbial contamination

B. Factors affecting horticultural crops production

- **Internal factors**

Internal factors are related to genetic make-up of plants and thus less influenced by environmental factors.

These are called genetic factors which attributes crop yield and other desirable characters for crop production.

- ✓ High yielding ability
- ✓ Early maturity
- ✓ Resistance to lodging
- ✓ Tolerance to insect pests and diseases
- ✓ Drought, flood and salinity tolerance
- ✓ Chemical composition of grains (oil content, protein content) and Quality of grains (fineness, coarseness)
- ✓ Quality of straw (sweetness, juiciness)

- **External factors**

I. Climatic
II. Edaphic
III. Biotic
IV. Physiographic and
V. Socio economic factors.

I. Climatic factors

The climatic factors are the atmospheric weather variables which influences the crop production. In fact, success and failure of crops is intimately related to the weather during the crop periods. Nearly 50 % of yield is attributed to the influence of climatic factors. However, by adjusting cropping pattern and by following suitable agronomic practices one may mitigate the adverse effect of weather in order to get high yield.

The factors are-

(a) Precipitation- It includes all water which falls from atmosphere such as rainfall, snow, hail, fog and dew. Total precipitation in amount and distribution greatly affects the choice of a

cultivated species in a place. Rainfall is one of the most important factors influences the vegetation of a place.

- Distribution of rainfall is more important than total rainfall to have longer growing period especially in dry lands.
- In heavy and evenly distributed rainfall areas, crops like rice in plains and tea, coffee and rubber in Western Ghats are grown.
- Low and uneven distribution of rainfall is common in dry land farming where drought resistance crops like pearl millet, sorghum and minor millets are grown.
- In desert areas grasses and shrubs are common, because of hot desert climate exists.

Though the rainfall has major influence on yield of crops, yields are not always directly proportional to the amount of Precipitation as excess above optimum reduces the yields**.**

(b) Temperature- Temperature is a measure of intensity of heat energy. Most of the agricultural plants require temperature between 15 and 40^0C for growth. The minimum, maximum (above which crop growth ceases) and optimum temperature of individual's plant is called as cardinal temperature.

The temperature of a place is largely determined by its distance from the equator (latitude) and altitude

- Germination, growth and development of crops are highly influenced by temperature. It affects leaf production, expansion and flowering.
- Physical and chemical processes within the plants are governed by air temperature.
- Diffusion rates of gases and liquids changes with temperature.
- Solubility of different substances in plant is dependent on temperature.

(c) Atmospheric Humidity (Relative Humidity-RH) Water present in the atmosphere in the form of invisible water vapour, known as humidity. RH is the amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature.

If relative humidity is 100% it means the entire space is filled with water and there is no soil evaporation and plant transpiration.

- Relative humidity influences the water requirement of crops.
- Relative humidity of 40-60% is suitable for most of the crop plants.
- When relative humidity is high there is chance for the outbreak of pest and disease.

(d) Solar radiation (without which life will not exist) It is the source of energy for all the physical processes taking place in the atmosphere. It drives the process of photosynthesis, evaporation and heating the soil and air.

(e) Wind velocity. The basic function of wind is to carry moisture (precipitation) and heat. The moving wind also supplies fresh CO_2 for the photosynthesis.

- Wind movement for 4 – 6 km/hour is suitable for more crops.
- When wind speed is very high, it causes mechanical damage of the crops like it removes leaves and twigs and damages crops like banana, sugarcane.
- Pollen and seeds are dispersed by wind, what we call wind dispersal and is necessary for certain crops.
- Helps in cleaning produce to farmers.
- Causes soil erosion, increases evaporation and spread of pest and diseases

(f) Atmospheric gases on plant growth

- CO_2 is important for Photosynthesis and is taken by the plants by diffusion process from leaves through stomata.
- CO_2 is returned to atmosphere during decomposition of organic materials, all farm wastes and by respiration.
- O_2 is important for respiration of both plants and animals while it is released by plants during Photosynthesis
- Nitrogen is one of the important major plant nutrients; Atmospheric N is fixed in the soil by lightning, rainfall and N fixing microbes in leguminous/pulses crops and available to plants.

II.Edaphic factors (soil)

The soil factors that affect crop growth are-

(a) Soil moisture- Water is an essential constituent of growing plant which it extracts from soil

(b) Soil air- Aeration of soil is absolutely essential for the absorption of water by roots

(c) Soil temperature-It affects the physical and chemical processes going on in the soil

(d) Soil mineral matter- The mineral content of soil is derived from the weathering of rocks

(e) Soil organic matter- It is composed of humic and non-humic substances and supplies all the major and micro nutrients to crops

- OM is source of plant nutrients which are liberated in available forms during mineralization.
- It improves soil structure, its drainage and aeration, water holding capacity buffer and exchange capacities, influences the solubility of minerals.
- It is a source of food for most microorganisms.
- Nearly 95% of Nitrogen and 33% of Phosphorus of soil are obtained from OM.
- It has the capacity to control soil temperature.

(f) Soil organisms- The raw organic matter in the soil is decomposed by different micro-organisms which in turn releases the plant nutrients. Atmospheric nitrogen is also fixed by microbes in the soil and is available to crop plants through symbiotic (Rhizobium) or non-symbiotic (Azospirillum) association.

(g) Soil reaction (pH) – Soil reaction is the pH (hydrogen ion concentration) of the soil.

- Soil pH affects crop growth and neutral soils with pH 7.0 are best for growth of most of the crops.
- Soils with low pH are injurious to plants due high toxicity of Fe and Al.
- Low pH also interferes with availability of other plant nutrients

3. Biotic factors

Beneficial and harmful effects caused by other biological organism (plants and animals) on the crop plants.

(a) Plants

- Competitive (allelopathy) and complementary nature among field crops when grown together.
- Competition between plants occurs when there is demand for nutrients, moisture and sunlight particularly when they are in short supply or when plants are closely spaced. Competitive interaction may be also due to release of chemical substances or toxins called allelopathy.
- When different crops of cereals and legumes are grown together, mutual benefit results in higher yield (synergistic effect).
- Competition between weed and crop plants as parasites eg: Striga parasite weed on sugarcane crop.

(b) Animals

- Soil fauna like protozoa, nematode, snails, and insects help in organic matter decomposition, while using organic matter for their living.
- Insects and nematodes cause damage to crop yield and considered as harmful organisms.
- Honey bees and wasps help in cross pollination and increases yield and considered as beneficial organisms
- Burrowing earthworm facilitates aeration and drainage of the soil as ingestion of organic and mineral matter by earthworm results in constant mixing of these materials in the soils.
- Large animals cause damage to crop plants by grazing (cattle, goats etc).

4. Physiographic factors

(a) Topography is the nature of surface earth (leveled or sloppy) is known as topography. Topographic factors affect the crop growth indirectly.

(b) Variation in aspects and elevation influence the climatic factors. Altitude increase in altitude cause a decrease in temperature and increase in precipitation and wind velocity (hills and plains).

(c) Steepness of slope**:** it results in run off of rain water and loss of nutrient rich top soil.

(d) Exposure to light and wind: a mountain slope exposed to low intensity of light and strong dry winds may results in poor crop yields (coastal areas and interior pockets).

5. Socio-economic factors

Society inclination to farming, land tenancy, size of land holdings, fragmentation of field, Availability of labour, capital

The economic condition of the farmers greatly decides the input/ resource mobilizing ability.

I. Government policies
II. Appropriate choice of crops by human beings to satisfy the food and fodder requirement of farm household
III. Breeding varieties by human invention for increased yield or pest & disease resistance.

Self-Check 2	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Part I: Write True or False

1. The water requirements of a crop per acre depend on various factors, including climate, soil type, and growth stage of the crop.
2. The nitrogen requirements of crop per acre vary depending on several factors, including soil fertility, environmental conditions, and the specific growth stage of the wheat crop.
3. Soil fauna like protozoa, nematode, snails, and insects help in organic matter decomposition, while using organic matter for their living
4. Germination, growth and development of crops are highly influenced by temperature.
5. Soils with low pH are injurious to plants due high toxicity of Fe and Al.

Part II: Short Answer Questions

1. What are the benefits of increasing nitrogen use efficiency?
2. How much fertilizer per square meter?
3. What are two strategies for increasing nitrogen use efficiency?

Which crop is the most efficient user of nitrogen?

Part III: Fill in the black space

1. ---------- is the pH (hydrogen ion concentration) of the soil?
2. ---------- is a combination of characteristics, attributes and properties that give the commodity value to humans for food (fruits and vegetables) and enjoyment (ornamentals)?
3. ---------- is the efficiency of applied nutrients in increasing grain or biomass yield?
4. ---------- yield is that obtained from a relatively poor crop, and is frequently not economical to produce, unless particularly high prices are realized

LG #14 LO #3 Greenhouse management

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying specific criteria and materials for greenhouse establishment
- Performing site selection and green house establishment based on the identified criteria
- Preparing green house management plan
- Determining proper planting methods based on the crop type
- Selecting and confirming basic equipment and tools against the work plan and prepared to manufacturer's specifications
- Selecting fertilizer and amendments based on greenhouse standard for growth stages
- Identifying and preparing growing media in accordance with production requirements
- Applying agronomic management practices according to the requirements and greenhouse management procedures
- Identifying and applying pest management practices in line with crop type and level of infestation
- Identifying existing and potential OHS hazards in the workplace and assessing and controlling risks in line with organization requirements
- Reporting and documenting greenhouse activities

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify specific criteria and materials for greenhouse establishment
- Perform site selection and green house establishment based on the identified criteria
- Prepare green house management plan
- Determine proper planting methods based on the crop type
- Select and confirm basic equipment and tools against the work plan and prepared to manufacturer's specifications

- Select fertilizer and amendments based on greenhouse standard for growth stages
- Identify and prepare growing media in accordance with production requirements
- Apply agronomic management practices according to the requirements and greenhouse management procedures
- Identify and apply pest management practices in line with crop type and level of infestation
- Identify existing and potential OHS hazards in the workplace and assessing and controlling risks in line with organization requirements
- Report and document greenhouse activities

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the "LAP test"

Information Sheet3

3.1. Identifying specific criteria and materials for greenhouse establishment

3.1.1. Specific criteria to establish green house

When building a greenhouse, there are several specific criteria to consider. After considering the following factors and making a few additional preparations, you'll be all set to grow food for you and your family in your backyard greenhouse for years to come

I. Orientation(East-west)

An east-facing orientation can work as well, especially if there is some glazing with a southern exposure. In most situations western orientation or exposure should be avoided because of the potential to overheat.

These recommendations, by the way, should be understood to be guidelines, not hard and fast rules; it's important to examine your situation carefully.

In regions where it's cloudy for most of the winter, such as the Northwest, orientation is less important because the cloud cover diffuses sunlight over the entire sky. Also, at higher latitudes, the summer sun moves much farther north.

II. Foundation:

Freestanding or Attached

A freestanding greenhouse can be a great opportunity to create a completely new space with few restrictions. My Phoenix greenhouse at CRMPI is certainly a terrific example of using design flexibility to truly pick and choose details from the ground up, offering perhaps greater potential for high-end performance.

However, the costs inherent in building a heavily insulated north wall can be significant**,** and it doesn't make much sense to build a small freestanding greenhouse for this reason; they tend to be overbuilt and inefficient unless of adequate size.

I recommend minimum dimensions of 12 × 30 feet**.** Also, without an attached structure, it is more likely to need backup heat, depending on the climate zone step you want to achieve.

Attached greenhouses offer an oasis right off of your home**,** an extra living space through the winter, shared heating, and reduced construction costs because of a preexisting north wall. They can be any size, and they don't necessitate the extra paths and infrastructure that a separate structure would.

At the same time an attached greenhouse will almost certainly obstruct the view to the outside and without a screen door can introduce insects to your home. They carry some risk of unwanted humidity without a sliding glass door and proper ventilation. Also, your design will be bounded by the preexisting conditions of the house that you want to retrofit.

III. Length-Width Proportions

A greenhouse that is shorter than it is wide doesn't have as long a window for solar gain during the day. Greenhouse is 24 × 35 feet and tends not to work as well as the 76 × 26 foot dimensions of phoenix. This difference is because the sun has a lot more time in the day to heat up a space with a long east-west axis**.** It's an especially important consideration if you're building a freestanding greenhouse. A good rule of thumb is a 3:1 size ratio.

VI. Foundation

There are many different materials and methods for building foundations and you can use any that apply to building other structures to a greenhouse. At CRMPI the most recent foundations I've used have been concrete piers (see image below) tied together with the framing of the structure. Two earlier greenhouses here used sunken pressure-treated wooden posts for foundation footers.

It's easy to overbuild greenhouse foundations because they are only holding up glazing and occasional snow loads, but depending on engineering regulations in your area and your approach to permitting, your options may be limited. Liability concerns can also be a factor in a school or business setting.

V. Roof Slope

Though Phoenix's roof has a slope of 4/12 (falling 4 inches for every foot of length), at Ecosystems Design we typically plan for a 6/12 slope to shed heavy snow loads, depending on the climate of the region. Because the greenhouse is warmer than the outside air, a layer of snowmelt often forms between polycarbonate glazing and snow, helping the roof to shed any snow of significant weight. Snow tends to stick more to double-inflated poly.

Related to the roof slope is the freeboard, the space between the lowest point of the roof and the ground**.** In areas with heavy snow, at least 3 or 4 feet is good to have so that snow won't pile back up onto the greenhouse roof or obstruct any vent

VI. Framing and Glazing Materials

The two most common framing materials are wood and metal. Wood is excellent for smaller greenhouses and has the advantage of being a cheaper, familiar material that is easier to work, with or without specialized tools. Salvaged, rough-sawn, or beetle-kill lumber is readily available.

Wood requires greater upkeep; although depending on the type of lumber, it can easily last fifty years in a dry climate with the proper paint and maintenance.

Nearly all commercial greenhouses today are made with galvanized steel, often designed to be connected in a long series.

Kit greenhouses are most often made of steel, and the included fasteners and instructions can make assembly quite easy.

Galvanized steel has a much longer life span than wood and doesn't require staining, sealing, or much maintenance**.** As shown by the roof slope of Phoenix, steel framing often offers less flexibility in construction, especially when salvaged from other projects.

Glazing options are constantly evolving. Six-mm double- inflated poly will be cheaper, more flexible, and less insulating, while more expensive, rigid polycarbonate panels tend to last longer and hold up better against snow.

Double-inflated poly was an excellent cheaper option in the early years at CRMPI, and it continues to function well on the roof of several of our greenhouses.

Glass can be appropriate for eastern or southern walls, but it should be used only for vertical glazing because of its considerable weight.

Mounting problems can occur because of expansion and contraction, and glass presents a much bigger problem than polycarbonate or plastic if it breaks. It is typically more expensive and less insulating than polycarbonate and will also tend to intensify direct sunlight, which can even burn plants in some cases

VII. Insulation

Insulation is essential on the north wall and the west wall; make sure to insulate all the walls you do not have glazing on. Foam insulation or structural insulated panels (SIPs) work well but need to be sealed and kept dry they aren't rated for the humidity in a greenhouse.

I used these panels when constructing Phoenix, but commercially we've started to use metal siding directly against the Styrofoam on the inside of the SIP to eliminate any wood product. There's a lot of room to implement your own preferred method here.

Straw bales are a popular natural building method but probably not a good idea for use in a greenhouse because of the potential for mold problems in a high-humidity environment

VIII. Beds and Paths

People often want to install large paths to accommodate carts and wheelbarrows, but think carefully about the way you're going to be using your greenhouse.

After the initial construction and bed preparation, there isn't much need to bring large amounts of material in and out.

IX. Microclimates

Each greenhouse creates a new macroclimate inside it, but within that can be a variety of microclimates. These will be produced by your design and the materials used and may change over time with the addition of thermal mass by water tanks, more plant biomass, or new infrastructure.

While the greenhouse climate will be mostly homogenous, it's important to identify existing microclimates to help in establishing thriving plant communities.

For instance, cold air sinks, so if your greenhouse has two levels or slopes, the lowest path will be a cold sink, and the outer edges of the space will be colder in the winter where they lose heat to the outside. By installing circulating fans, you can help mitigate this problem.

The southwest corner will usually be the sunniest and hottest quadrant of the greenhouse because it receives the most sun exposure. The northeast will be cooler and is a good place for a

propagation table or washing station. Be aware of the way plant growth will create shady zones over time, and plan for your tallest perennials in the northwest, often the tallest point of the greenhouse.

Why do plants grow better in a greenhouse?

Warmth and humidity promote plant growth. Plants need moisture, warmth and light to grow.

A greenhouse stabilizes the growing environment by buffering the ambient temperature and protecting the plants from extreme cold.

What is the importance of the greenhouse?

Safeguarded environment for plants, a greenhouse is a haven of safety. It lessens the availability of insects and other creatures that may harm or devour your plants. Extreme weather events like heavy rain and droughts are less likely to occur in this greenhouse climate.

What are the advantages of green house?

The main benefits of a greenhouse are**:-**

- Good distribution of light inside the greenhouse
- Energy efficiency
- Control of microclimate.
- Protection against diseases, pests and other vermin.
- Excellent ventilation.
- Optimum sealing against rain and air.
- Increased production.
- Production off-season.

What is the main purpose of a greenhouse?

A greenhouse lets you create your own microclimate, controlling the temperature and humidity you expose your plants to. Whether you want to grow vegetables all year long, cultivate exotic plants, or start seedlings off very early in the season, your greenhouse provides the adaptable growing environment you need

Why are greenhouses important to the economy?

- Increased production

Greenhouse farming can increase crop production because you can create the optimal climate conditions needed for plant growth and grow more plants per square foot than growing crops in an open field

What are the disadvantages of a greenhouse**?**

- High initial and maintenance costs
- Increased energy consumption.
- Reliance on fossil fuels and non-renewable energy sources.
- Potential for pests and disease outbreaks.
- Limited crop diversity.
- Limited scalability in certain regions.
- Risk of environmental degradation and pollution.

3.1.2. Materials required to establish green house

Common materials used for the frame are wood, PVC pipes, aluminum, and galvanized steel.

The covering materials can be greenhouse nylon, polycarbonate sheet, or polyethylene film

For the foundation, you can use concrete or treated wood

Ventilation materials include hinges, latches, and ventilation windows

Other materials needed are brackets, corner connectors, glazing, and greenhouse wire

The specific materials needed will depend on the size and type of greenhouse you want to build. It is important to consider your climate before choosing the materials for your greenhouse



https://i2.wp.com/gardenprofessors.com/wp-content/uploads/20220525_151356.jpg?fit=1200%2C707&ssl=1

Materials used in structures

The structure **is** the frame of the greenhouse, consisting of columns, beams, straps, etc. that support the roof, wind, rain, snow, devices that are installed and overload trellising plants, etc. They should be kept to a minimum shading and freedom of internal movement. Greenhouse structures must meet the following conditions:

- They should be light and strong.
- Economical and easy care materials.
- Susceptible of being extended.
- Fill the surface optimally.
- Adaptable and modifiable to cover materials.

The greenhouse structure is the constructive element that more time is devoted to be studied in terms of their robustness and economy concerned, to decide whether certain type of greenhouse choose.



The most widely **materials** used for building greenhouses structures depending on its use are:

- In Pillars, supports and reinforcements: : wood ,galvanized steel, iron and aluminium.
- In straps and beams: galvanized steel, iron and aluminum.
- Arches: galvanized steel or aluminium.
- In foundation supports or foundation bases: concrete.
- In securing the cover: galvanized wire or profiles galvanized steel or aluminum, depending on the type of greenhouses.
- Canals: galvanized steel or aluminum.
- Crop wire: galvanized steel or aluminum and galvanized wire.

It is difficult to find a structure type that uses only one kind of material since it is common to use different materials.

Materials used on the cover:

The most important properties that define a cover are the transmission of solar radiation, transparency to infrared or thermal radiation and heat transfer of material they are made of.

Covers are usually made of the following materials:

- ✓ Plastic Films: polyethylene copolímeto ethylene vinyl acetate and polyvinyl chloride plastics and multilayer
- ✓ Rigid plastics**:** of methyl polymethacrylate, polycarbonate and polyester.
- ✓ Glass: glass patterned glass.

There are a few basic materials that you will need to build a greenhouse**:**

A frame. The frame is the skeleton of the greenhouse and can be made from a variety of materials such as wood, metal, or PVC pipes.

- Doors and Windows
- Greenhouse Nylon
- Polycarbonate Sheet.
- Glazing.
- A foundation.
- Ventilation.
- Heating and cooling systems.

3.2. Performing site selection and green house establishment based on the identified criteria

3.2.1. Site selection criteria for green house establishment

Careful planning prior to construction is an essential first step in the development of a successful, profitable greenhouse production system. Before anything else, the site of the operation must be chosen. When selecting a proper site for the greenhouse a number of “location factors” must be taken into consideration before a final decision on the greenhouse site is made.

I. Microclimate

Climatic conditions have dictated worldwide geographical shift in horticulture. Such forces are also at work within local regions. The primary limiting factor to crop production in greenhouses is low light intensity during the winter. Areas having frequent fog, inclement weather, or shadows cast by trees or tall mountains are poor for crops in general.

II. Water Availability and Quality

Water is one of the most frequently overlooked resources in the establishment of a greenhouse business. A sufficient quantity of high quality water is extremely 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. Although water is usually obtained from deep wells, generally municipal systems can also supply water of adequate quality for greenhouse production.

III. Topography

The topography of the site affects where a growing structure is built. (Topography refers to the shape of the land, e.g., hilly, steep, rocky, flat.) The surface of the ground of the greenhouse should be level. Placing a growing structure on a flat surface is efficient because it facilitates easy adjustments to various mechanical controls in the greenhouse, which is economical. The site should be well drained.

IV. Windbreaks

Outside the greenhouse, a windbreak can reduce infiltration of cold air and convection of heat away from the greenhouse. Wind speed greatly affects infiltration rates; 15 mile-per-hour winds can double heat loss in a greenhouse. Well-designed windbreaks can reduce wind speeds by 50 percent, reducing heat losses by 5 to 10 percent compared to an open area. They can also reduce snow accumulation on roofs.

V. Room for Expansion

A parcel of land larger than the grower's immediate needs should be acquired. The ultimate size of the range should be predicted. Area should then be added to this predicted figure to accommodate service buildings, storage, access drives, and a parking lot. Additionally, extra space should be allotted to cover unforeseen needs. To meet the environmental codes of some municipalities, it is necessary to use holding ponds for water effluent from the range in order to reduce nutrient release into streams. Doubling the area covered by greenhouses would constitute a bare minimum land requirement.

VI. Availability of Labor

Present and future labor needs should be assessed and should be in accord with the labor supply in the area. Procurement of a labor supply has been a perennial problem in the horticulture industry. While the solution has appeared to rest on locating close to an urban area, this brings on a problem of higher wages. The greenhouse owner must also determine if labor is available to perform both routine and harvest-time duties.

VII. Infrastructures

Proximity to transport networks (e.g. roads, railway), access to communication systems (e.g. telephone, internet) and availability of energy (e.g. gas, electricity) must all be considered. Greenhouses also need convenient access to materials for growing plants (growing media, fertilizers, pesticides, etc.). Transportation requirements to the greenhouse site relate directly to the intended operation's size and marketing arrangements.

VIII. Market Accessibility

Locating near the market is very important for retail growers who rely on customers getting to the greenhouse. The market potential should be explored before building. The competition should be scouted out and surveys conducted (if possible) as to the greenhouse market demands of the local area.

IX. Legal Considerations

Site selection involves various legal considerations. Permits, licenses, and zoning regulations govern where a greenhouse may be built and often even dictate what type of building materials may be used. Selecting an appropriate site also involves how the greenhouse operation affects its neighbors. If the proposed site is near a school, hospital, or residential community, the greenhouse must cooperate with the zoning rules of these entities. If water from the site drains into parks, farms, or ecological areas, the land may be subject to various state and federal regulations. Some states require the owner to obtain certification to purchase restricted-use pesticides. In addition, the greenhouse owner must also be aware of relevant mandates from the Occupational Safety and Health Administration that ensure employee safety.

X. Greenhouse Orientation

Quite possibly the largest design consideration when planning a winter or year-round greenhouse is determining the orientation and angle of glazing for the structure. In general, growers optimizing for winter growing should orient their free-standing greenhouse in an east-west orientation, meaning that the longer, glazed side of the greenhouse should face south, with the shorter ends facing east and west. This orientation allows low angle light from the winter sun to enter from the side where it will not be blocked by ribs of the frame. In the orientation of multi-bay greenhouses structural components come into play.

XV. Angle of Incidence

The pitch of a roof means the degree of slant or the angle of divergence from the horizontal. The glass of the roof not only allows the light and heat rays to pass through it, but it alos acts to some extent as a mirror, thus reflecting a part of the rays. The amount lost by reflection is proportional to the angle of incidence. Thus, if the sun's rays fall upon the roof at right angles, little or none is lost by reflection; but when they fall at a less angle, the amount reflected increases as the angle of incidence increases. The amount of sun's energy lost by reflection when the rays strike the roof at various angles

- ✓ Microclimate
- ✓ Water Availability and Quality
- ✓ Topography
- ✓ Windbreaks
- ✓ Room for Expansion
- ✓ Availability of Labor
- ✓ Infrastructures
- ✓ Market Accessibility

XI. Greenhouse Structures and Design

Greenhouses are used to provide optimal environments for plant growth and development. The greenhouse design must deal with the local outdoor circumstances, like minimum, maximum and average temperature, humidity, solar radiation, clearness of the sky (clouds), precipitation (rain, hail and snow) and average wind speed and wind direction.

Some of the components of a greenhouse design are location, orientation, site selection, drainage, structure, foundation, flooring, glazing, and ventilation facilities together with the technical equipment needed to control the climate inside the greenhouse. The location and orientation of a greenhouse determine the amount of light that enters it.

Determining the best location to erect the greenhouse is an important decision. A suitable greenhouse location will include a spot where the sun hits the greenhouse all day long and no shadows are cast on the greenhouse. Greenhouses can be classified as free-standing or gutter-connected. A free-standing greenhouse can have a quonset (hoop), gothic, or gable roof shape.

A gutter-connected greenhouse is a series of bays with gable or quonset arches connected together at the gutter level. Structural members, used for the greenhouse "skeleton", must be strong enough to prevent structural failure during adverse weather conditions but be kept to a minimum size and number to reduce the amount of shading and to provide for maximum light transmission. The framing of the structure is made of aluminum, galvanized steel, PVC pipe, or such woods as redwood, cedar, or cypress. A greenhouse has a large expanse of glazing on its sides and roof so that the plants are exposed to natural light for much of the day. Glass has been the traditional glazing material, but plastic films, such as polyethylene or polyvinyl, and fibreglass or polycarbonate are increasingly used.

A. Types of Greenhouses

Greenhouse styles can vary from small stand-alone structures to large gutter-connected greenhouses. Free-standing greenhouses are completely independent structures that come in a variety of different designs. The gutter connected greenhouses are joined at the eave by a common gutter. Greenhouse designs can be simply classified as attached (i.e., lean-to), free standing (i.e., even-span, uneven span, Quonset, arch), and ridge-furrow or gutter connected (i.e.,

sawtooth, venlo). There are many designs and structures to select from, thus it is important to become familiar with the advantages and disadvantages of each. Here is a brief rundown of some of the styles available to growers.

i. Free-Standing Greenhouses

A free-standing greenhouse can have a Quonset (hoop), A-frame, gothic, or gable roof shape. This type of structure is what one usually envisions when the word greenhouse is mentioned. The free-standing design is usually the best choice for the small grower planning on less than 10,000 square feet of growing space.



https://sturdi-built.com/wp-content/uploads/2021/06/Deluxe-G2G-Slider-3.jpg

Advantages and Disadvantages of Free-standing greenhouses

One advantage of a separate house is that it is easier to program and maintain the temperature to meet specific crop requirements. In addition, free-standing greenhouses are easier to ventilate without exposing the plants to erratic temperature fluctuations or harsh blasts of cold air. The light in a free-standing greenhouse is uniformly distributed over the entire growing area. In gutter-connected greenhouses, the roof gutters cut down on the light admitted and shade the crops, affecting their growth.

ii. Quonset greenhouses

Quonset greenhouses, also known as hoop houses or polyethylene tunnels, are constructed from pipe, either PVC or metal, bent into hoops and draped with polyethylene film (See Figure 1.2). Quonset greenhouses are ventilated through roll-up sidewalls and large open doors at both ends. Some hoop houses are fitted with end walls that frequently can be opened for ventilation. Because hoop houses generally lack foundations and permanent environmental control systems, regulations and permits in some states are typically less rigorous for these types of structures than for greenhouses.



https://growerssolution.com/cdn/shop/files/Untitleddesign-81_67d1e130-b1e0-4e73-8504-15cd6fb0cb5f_1200x.png?v=1696958121

iii. A-Frame greenhouses

The A-frame, also referred to as an even-span structure, represents a traditional greenhouse design, with a peaked roof of two equal-length slopes (See Figure 1.3). The A-frame is constructed of trusses in the shape of an elongated A (thus the name) either welded or bolted together and affixed to gutter posts spaced on center. Additional members, referred to as purlins or girts, are placed perpendicular to the trusses along the slope.



https://www.gothicarchgreenhouses.com/images/instru2.jpg

iv. Gothic arch greenhouses

Gothic arch greenhouses have an arched roof line and walls that form a continuous shape. The slope of the arch allows highly uniform light transmission and decrease interior condensation. Glazing options for the arch house include double poly, polycarbonate, and glass.



https://www.advancegreenhouses.com/wp-content/uploads/2020/02/88-gothic-arch-style-greenhouse.jpg

v. Gabled roof greenhouses

Gable-style greenhouses have sloping, flat roofs connected to vertical sidewalls. The roof angle determines how well snow slides off as well as the total height of the structure. This type of greenhouse design can use actual glass or rigid plastic panels for the transparent material.



https://www.gothicarchgreenhouses.com/images/gab_01.jpg

vi. Gutter-connected greenhouses

Gutter-connected greenhouses consist of a number of even span greenhouses attached by a common gutter only at the lower edges or eaves of the roof (See Figure 1.6). These greenhouses are sometimes called ridge and furrow. Gutter connect greenhouses are composed of a number of "bays" or compartments running side by side along the length of the greenhouse. Typically these compartments are approximately 120 feet (37 m) long by 21 to 25 feet (6.5 to 7.5 m) wide. The production area is completely open between the bays inside the greenhouse; there is no division of the structure by inner walls. With a gutter connect greenhouse, the lowest part of the roof are the gutters, the points where the adjacent arches begin and end. The roofs of these greenhouses can either be curved or gabled.



https://fullbloomlightdep.com/wp-content/uploads/2018/06/gutter-connect-standard-greenhouse.jpg

Advantages and Disadvantages of Gutter-Connected Greenhouses

Gutter-connected greenhouse structures occupy less land and have no sidewalls; therefore, fewer materials are needed for construction. Because there are no walls where the gutters are, more interior space is available than in several free-standing structures. Less energy is required to heat and cool the greenhouse because the exposed wall surface area is reduced. It is cheaper, and thus more feasible, to automate the single consolidated space inside a gutter-connected greenhouse than the multiple equivalent spaces in several free-standing greenhouses.

A. Greenhouse Structures and Design

I. Open-Roof Greenhouse Systems

Open-roof greenhouses are becoming more popular with commercial growers. The open-roof greenhouse offers maximum natural light and ventilation to the greenhouse crop. Similar in construction to that of the Venlo, the open-roof is constructed of two or more roof peaks per greenhouse bay. Each roof section is hinged at the gutter and is connected to a rack-and-pinion or push-pull drive system. Computer-controlled motors push the roof sections open, in effect making the entire roof into a vent. Open-roof greenhouse designs can often control the greenhouse temperature sufficiently without exhaust fans. Natural ventilation works primarily on the principle that wind blowing across a roof vent will create a low-pressure zone that will suck the air out of the greenhouse while letting air in the side vents.



https://prinsgreenhouses.com/wp-content/uploads/2016/05/Max-Air-02.jpg

Advantages of Open-Roof Greenhouses

Growers cite many benefits to open-roof greenhouses, but the biggest is the improvement to crop quality and production efficiency due to the improved range of environments they provide. A traditional greenhouse offers good climate control during inclement weather, but during warm,

sunny weather it can be a struggle to maintain the best temperature and humidity much of the year without expensive, sophisticated environmental controls.

II. Open-Panel Greenhouse Systems

Open-panel greenhouses use the entire greenhouse roof like a ridge-vent (See Figure 1.9). These "open-panel" structures are typically hinged at the gutters, allowing the glass, rigid-panel, or double-poly glazings to be raised to a vertical position. When closed, the structure functions similar to a covered greenhouse with typical heating and cooling requirements and typical snow and wind loads



https://roostandroot.com/wp-content/uploads/2021/02/Roost-Root-Greenhouse-Interior-S-Horiz-1-scaled.jpg

III. Retractable-Film Greenhouse Systems

Retractable-film greenhouse systems act by "folding" the glazing as the glazing is retracted (See Figure 1.10). The plastic film glazing is suspended from hooks that slide along heavy-gauge, stainless steel wires. To operate bays independently, individual motors are needed for each bay (increased installation cost). When open, retractable-film systems provide over 95 percent

ventilation. Only the rolling-roof systems can compete with retractable-film systems for total amount of natural ventilation. Although originally designed with solid sidewalls, the majority of retractable-film designs are now built with seasonally removed or roll-up sidewalls

IV. **Flat-Roof Greenhouse Systems**

The flat-roof greenhouse system is very similar to retractable-film systems, but they do not have trusses, which significantly reduces structural, installation and glazing materials costs. Without trusses, flat-roof systems may not be compatible with all types of greenhouse automation equipment, or installation adjustments may be needed to use automation equipment. For example, boom irrigation systems cannot hang, so they must be mounted to sidewall posts.



https://www.gothicarchgreenhouses.com/images/retrac25.jpg

V. Low-Profile Greenhouse Systems

Low-profile greenhouse systems are either very wide-span systems with low-pitch roofs or they may have saw tooth-style roofs. The low-pitch roofs often use specialized film glazings that contain hundreds of small channels that direct rainfall or melted precipitation to the gutters. They typically require the use of expensive energy-trusses to design them for reasonable wind and snow loads



https://obcnw.com/images/products/detail/520.20.low_profile_semiq_greenhouse.jpeg

VI. **Rolling-Roof Greenhouse Systems**

The rolling-roof greenhouse system typically has bows mounted on lattice trusses spanning each bay Tube-type motors drive aluminum pipes that roll the covering up or down on each side of the bow. The covering is typically a nylon mesh film enclosed within two layers of plastic and provides from 15 to 25 percent shade when closed.



https://prospex.in/img/hs2-2.jpg

B. Greenhouse Structural Components

The greenhouse is a structure made by assembling different parts or components. Each part has specific role in greenhouse structure. The main components of a greenhouse are its structural components like trusses, purlins, and side posts. Most frames are made from steel, aluminum, plastic, or wood. There are several materials to consider when deciding the kind of foundation to use for the greenhouse. Wood timber, concrete or concrete block, and brick are all suitable choices. The covering material of the greenhouse, also known as glazing, is usually the most expensive component of the structure. It is also one of the most important because the glazing is what allows the entry of light and heat into the greenhouse.

- **Greenhouse framing members**

Trusses are the fundamental vertical support structure of a greenhouse, which supports the weight of the roof. They provide strength to the basic structure and a hence placed at a distance of 2, 3, 4 feet or as required. The truss is made up of rafter, strut, and chords. Struts are support members under compression while chords are supports members under tension. Trusses are connected by the roof ridge and the purlins which run the length of the greenhouse.

- **Greenhouse Framing Materials**

There are number of structural parts of a greenhouse roof which include bar caps, gutters, purlins, trusses, ridge cap, sash bar, and sideposts. Bar caps are attached to the outside of the greenhouse sash bars to hold the glazing material in place. The bar caps also hold the glazing compound used to seal around the glass (or other glazing material) to prevent leaks. The bar caps shield the glazing compound from the ultraviolet rays.

- **Greenhouse Foundation**

When setting up a greenhouse, one of the most important aspects of the construction process is the foundation. There are a few different types of foundations that can be used for greenhouses. The type of foundation used is determined by the style of greenhouse and building codes. Essentially, the foundation is the complete system on which the greenhouse structure sits. One of the key components of a foundation is the footing. The footing refers to the point at which the structure meets the soil.

- **Greenhouse Walls**

The end and side walls are typically covered with one of the rigid plastics. The structured acrylics and polycarbonates will provide heating costs can be gained. Better insulation and security against theft or vandalism, but at greater initial costs, than fiberglass. Since the structured plastics come in 8- or 10-foot panel lengths, less cutting and splicing will be needed in comparison to polyethylene which comes in a minimum of 20-foot wide rolls.

- **Greenhouse Flooring**

Growers may choose from a range of floor surfaces for container grown crops from gravel to concrete. The actual floor design will be dependent upon the type of production being planned and the available capital.

- **Soil Floors**

Soil floors are rarely found in large greenhouse operations, except for small-scale vegetable operations. Muddy conditions due to irrigation, roots growing into the soil, and. the challenge of controlling weeds make this practice hard to manage unless the soil is naturally very well drained.

- **Gravel Floors**

One of the simplest floor systems is a gravel floor. In this case plants are grown on a pad of 3/8 inch crushed rock or pea gravel. This is a low-cost floor production system and the gravel allows for excellent drainage. However, weeds may grow in the gravel and sanitation can be difficult on gravel floors. It may also be difficult to have small containers sit upright and level on gravel floors.

- **Concrete Floors**

Concrete floors are very common with commercial greenhouses. In part because of environmental legislation that requires growers to capture drainage and runoff, and also to accommodate mechanization equipment and general cleanliness. Where concrete is used, it should be slightly sloped to allow water to drain off. Concrete floors prevent weeds and are generally easy to clean. They are durable and long-lasting and provide the advantage of maximizing space usage efficiency as well as flexibility. There are two basic types of concrete that may be used for greenhouse floors.

- **Floor Drainage** Although there is generally very little excess water on a concrete floor, sloping the floor to a drain is important. A slope of 1/8-inch per linear foot is usually the standard.

Other Types Greenhouse Structures

I. Growing Rooms

Growing rooms, also commonly referred to as plant growth rooms, have been used for many years in Europe. However, their use in the United States has grown with their increased use for germinating seed for plugs and high value specialty crops. Seed trays are kept on ebb and flow benches, which are sub-irrigated several times a day. The temperature (24°C or 75°F, continuously) and the humidity inside the growth room are maintained by a climate control system.

II. Head house

All greenhouse locations should have a head house or service building. Large operations may have two or more head houses. When you plan a greenhouse layout, use this rule of thumb. Make the head house equivalent in size to at least 10 percent of the total greenhouse growing area. For example, a certain greenhouse contains 40,000 square feet of growing area. Its head house, then, should contain at least 4,000 square feet. This may seem like too much space for a service building, but many important functions are carried out in the head house. The following services and operations might be included in a head house.

III. Office

Every operation needs a private area for phone conversations, keeping records, receiving customers, and giving instructions to employees. In larger businesses it can also house the secretary, bookkeeper, and sales staff.

IV. Utilities

The head house is a good place to locate the main electric panel and water supply tanks. Its central location with access to the greenhouses keeps wiring and piping distances short

V. Restrooms

Depending on the size of the operation, one or more restrooms may be needed. Connection to a sewer system or septic system generally requires a permit.

VI. Lunchroom

An area separate from the work area should be provided for lunches and breaks. This should be partitioned to keep out dust and odors. In large facilities, space for lockers, refrigerator, microwave, and sink is desirable.

VII. Pesticide Storage

If properly designed, the pesticide storage can be placed in the headhouse. The room must have continuous ventilation with makeup air brought in from outside. Identification signs and positive locking are also required. The area for mixing should be nearby.

VIII. Storage

Much of the smaller items (replacement parts, hardware, labels, etc.) can be stored where there is easy access and good inventory control. If the head house has a high ceiling (14 ft. minimum), a raised storage area above some of the other rooms can be used to hold containers and other light material Bags of growing mix, peat, etc. are usually stored outdoors or in a vacant greenhouse.

IX. Work Area

The remaining area in the building should be open so that it can be used for a work area. Flexibility is important as the needs change from season to season. In early spring, the space is needed for potting and transplanting. Later, when the plants are grown, more space is needed to assemble orders for shipping. Except in large operations, equipment such as the mixer and pot/flat filler should be portable so that they can be moved out of the way when not in use.

XII. Cold Frames

Cold frames are low-to-the-ground structures consisting of a wood or metal frame with a transparent covering. As their name suggests, they have no heating source except the sun. Cold frames are good when you want to grow cool weather crops in early spring, fall, and even into the winter months. They work well for early planting of summer annuals and seeds, faster rooting of cuttings, starting perennials from seeds in summers, and protecting delicate plants in winters.

XIII. Cold Frame Construction

Decay-resistant wood such as redwood, cypress, or cedar should be used, and preferably pressure-treated with wood preservatives, such as chromated copper arsenate (CCA). This compound retards decay for many years and does not give off fumes toxic to plants. Creosote must not be used on wood structures in which plants will be grown, since the fumes released, particularly on hot days, are toxic to plants.

XIV. Hot Frames

Structurally similar to cold frames, hot frames are heated with electric heating cables and are primarily used as an inexpensive way to root cuttings. Hotbeds can be used throughout the year, except in areas with severe winters where their use may be restricted to spring, summer, and fall. They are also ideal for overwintering non hardy seedlings or newly rooted cuttings.

XV. Shade houses

Shade houses (See Figure 1.16) provide outdoor shade and protect container-grown plants from excessive sunlight by suspending shade fabric over the plants. Reducing sunlight also serves to create a cooler, more comfortable climate. Provided the outdoor conditions are conducive to growing, shade houses offer not only a low-cost alternative for expanding your growing area, but also provide an excellent environment for hardening off the plants prior to sale.

XVI. Fabric

Fixed roof shade houses have traditionally incorporated black woven or knitted shade fabrics to produce the required shading. It is generally accepted that knitted fabrics are slightly more expensive though they do resist the tendency to tear even if damaged.

Structural Designs

In general, there are three recognized designs for shade houses including the cable-frame, rigid-frame, and retractable roof systems.

3.3. Preparing green house management plan

When preparing a greenhouse management plan, several factors should be considered. These include site selection, access, greenhouse orientation, structural strength, glazing materials, energy conservation, environmental control systems, and more

Here are some key aspects to consider:

- Site selection and access: Choose a location with adequate land (a minimum of 2 acres), good drainage, and proximity to necessary facilities and transportation networks. Ensure the site has convenient access to materials for growing plants, such as growing media, fertilizers, and pesticides
- Greenhouse orientation: Orient the greenhouse in an east-west direction to optimize winter growing and maximize light utilization
- Structural strength: Use light and strong materials, such as steel, aluminum, or wooden lumber, for the greenhouse structure to withstand weather conditions, including wind and snow
- Glazing materials: Choose suitable greenhouse glazing materials, including plastic film, rigid plastic panels, or glass, based on factors such as light transmission, insulation, and durability
- Energy conservation: Consider energy conservation measures, such as double-layer glazing or curtain systems, to reduce energy consumption and lower operating costs
- Environmental control systems: Implement environmental control systems, including heating, ventilation, lighting, and CO2 management, to maintain optimal conditions for plant growth
- Management residence: Growers and managers should live relatively close to the greenhouse in case of emergencies
- Utilities: Ensure access to necessary utilities, such as telephone service, three-phase electricity, and fuel for machinery
- Level and stable ground: The greenhouse site should have level and stable ground, free from shifting or poor drainage

- Pest and disease management: Develop a plan for pest and disease management, including prevention strategies and treatments
- Emergency action plan: Prepare an emergency action plan for your greenhouse operation, outlining steps to take in case of accidents or natural disasters
- Expansion and future planning: Plan for the possibility of future expansion and consider the potential growth of your greenhouse business. By addressing these factors and incorporating them into your greenhouse management plan, you can create a comprehensive and effective strategy for the successful operation of your greenhouse

3.4.**Determining proper planting methods based on the crop type**

When determining the proper planting methods based on the crop type, it is important to consider the most suitable propagation and planting techniques for the specific plants. Here are some methods that can be considered:

- **Plant Propagation Techniques:**
  - ✓ Seed Propagation**:** Suitable for many types of crops and is a common method for growing plants from seeds
  - ✓ Cutting: Involves taking a part of the plant, such as a stem or leaf, and allowing it to develop into a new plant
  - ✓ Layering: This method involves inducing a stem to produce roots while it is still attached to the parent plant, and then detaching it to form a new plant
  - ✓ Division: Suitable for plants that form clumps, such as ornamental grasses and some perennials, where the plant is divided into sections, each of which can grow into a new plant
  - ✓ Grafting and Budding: These are more advanced techniques used for specific purposes, such as combining the qualities of two different plants or propagating certain fruit trees
  - ✓ Tissue Culture Technique: A laboratory-based method used for mass propagation of plants under sterile conditions, often employed for rare or valuable plants

- Crop Rotation:
  - ✓ Another important consideration for proper planting methods is crop rotation, which is the practice of growing a series of different types of crops in the same area across a sequence of growing seasons
  - ✓ Crop rotation helps optimize nutrients in the soil, combat pest and weed pressure, and improve soil health

By understanding the specific needs of the crops and the advantages of each propagation method, growers can make informed decisions about the most suitable planting techniques for their crops. Additionally, implementing crop rotation practices can contribute to the overall health and productivity of the planting area.

3.5. Selecting and confirming basic equipment and tools against the work plan and prepared to manufacturer's specifications

When selecting and confirming basic equipment and tools against the work plan and manufacturer's specifications, it is important to consider the specific requirements of the manufacturing process and the product being produced. This includes having the right equipment and tools and meeting product requirements and specifications

Here are some steps that can be taken:

- Establish selection criteria: Establish selection criteria based on key manufacturing volumes, value of the product, part geometry, required tolerances, and required material. The material choice will be very effective in narrowing down the options since many processes work exclusively with certain materials
- Identify inputs and outputs: Identify the inputs, such as labor, materials, facilities, and equipment, and the outputs, which are the finished products that will be delivered to customers
- Map out workflows: Map out the activities that will achieve a certain result, including machine utilization and routine, which will impact the plan

- Consider the manufacturing bill of materials: The manufacturing bill of materials is different from the engineering bill of materials, and it involves the complexity of turning one unique structure into another
- Consider automation: Consider automating process planning systems to remove the human element in the steps between preparing, but there still must be human oversight to ensure compatibility with the
- Consider the main factors: Consider the main factors when selecting equipment and tools, including physical size, cutting forces, machine accuracy, power, and surface finish
- Consider the manufacturing processes**:** Consider the manufacturing processes used to form a component or joint, whether a component is custom-made or purchased "off-the-shelf supplier," the quantity of materials or components being purchased, and quality problems associated. By following these steps, manufacturers can select and confirm basic equipment and tools against the work plan and manufacturer's specifications, ensuring that the manufacturing process is efficient and meets the required standards.

3.6. Selecting fertilizer and amendments based on greenhouse standard for growth stages

Selecting fertilizer and amendments for greenhouse growth stages involves considering the nutrient requirements of the plants and the different developmental stages they go through. The objective of a sound fertilizer management program is to supply the required nutrients for normal growth and reproduction. Here are some guidelines for selecting fertilizers and amendments based on growth stages:

1. Nutrient requirements: Greenhouse crops require 17 elements for normal growth and reproduction. The most important nutrients for controlling plant height are nitrogen (N) and phosphorus (P). Plant nutrient requirements change as the plant grows and enters new developmental stages, such as vegetative vs. reproductive
2. Fertilizer concentration: Lower fertilizer concentrations with less leaching (10-15 percent) can be just as effective as higher concentration. It is essential to provide enough fertilizer during periods of rapid growth to avoid deficiency symptoms, but avoid over-fertilizing during slow growth periods, as it may lead to excess soluble salts

3. Fertilizer sources: Materials used to supply nutrients for greenhouse vegetable production should be chosen based on their solubility in water and their ability to supply multiple nutrients. Some common fertilizers include ammonium sulfate, ammonium nitrate, calcium nitrate, urea, and Osmocote 14-14-14
4. Amendment selection: Foliar analysis and the DRIS (Diagnosis and Recommendations Integrated System) can be used to guide fertilizer amendments based on the growth stage and specific nutrient needs of the plants
5. Controlling plant height: Non-chemical cultural methods can be used to control plant height without causing stunting, deficiency symptoms, or undesirable delays in crop development. The "phosphorus starvation" technique, using fertilizers with lower phosphorus content (e.g., 20-10-20), can result in shorter, stockier plants. Selecting fertilizers and amendments for greenhouse growth stages should be based on the plant's nutrient requirements, growth stages, and specific needs. It is crucial to balance fertilizer concentrations, choose appropriate sources, and use amendment selection methods to ensure optimal plant growth and development

3.7. Identifying and preparing growing media in accordance with production requirements.

To identify and prepare growing media in accordance with production requirements in a greenhouse, it is essential to consider the physical and chemical properties necessary for plant growth. Here are some key points based on the search results:

- Growing Media Components: Growing media components are either organic or inorganic. Organic components include peat moss, bark, and coconut coir, while inorganic components include perlite, vermiculite, and rice hulls
- Preparation Objectives: The preparation of growing media should aim to produce a medium that is porous, well-drained, moisture-retentive, low in soluble salts, and free from harmful soil pests and pathogens
- Nutrient Supply: The media should supply the necessary nutrients for plant growth, provide a source of moisture, and offer mechanical support for the plant and its roots

- Custom vs. Commercial Media: While custom growing media can be tailored to specific needs, the cost of mixing a custom growing medium should be carefully considered. Commercially prepared media may be a more cost-effective option
- pH and EC: Two important measurements for growing media are pH and Electrical Conductivity (EC). pH indicates the acidity or alkalinity of the medium, while EC measures the medium's ability to conduct an electrical current, which is related to the concentration of soluble salts
- Media Formulations: The composition of a growing medium should be largely determined by the crop being produced. Different types of media, such as peat moss, vermiculite, perlite, shredded coconut husks, or composted materials, can be used and combined in desired proportions based on specific requirements. Considering these factors, growers can select and prepare growing media that meet the specific production requirements of their greenhouse crops, ensuring optimal conditions for plant growth and development.

Properties of Growing Media

Successful greenhouse production of container-grown plants is largely dependent on the physical and chemical properties of the growing media. A number of critical physical and chemical properties need to be evaluated before making a final media decision.

A. Growing Media Physical Properties

i. Bulk Density

Bulk density is the mass per unit volume of a substrate and is expressed as grams per cubic centimeters (g/cm3), kilograms per cubic meter (kg/m3), pounds per cubic foot (lbs/ft3), and pounds per cubic yard (lbs/yd) or by any other weight to volume units. In other words, it is the dry weight of the substrate that occupies a certain volume when the medium is moist.

In practical situations, bulk density is important since wet, dense potting mixes are heavier that wet light mixes.

(ii) Water-Holding Capacity

Water-holding capacity is the proportion or percentage of a substrate's pore space that remains filled with water after gravity drainage. A good growing medium has a high water-holding capacity but also contains enough macro pores to allow excess water to drain away and prevent water logging.

Water-holding capacity varies by the types and sizes of the substrate ingredients. If the growing medium in the container is made up of materials which create very small pores or air spaces, the growing medium retains large quantities of water.

(iii) Air-Filled Porosity

When we fill a container with media, the total volume of space in that container is filled with two things: the solid media components and the spaces or voids between all the solids. Ideally the total volume of empty pores should be in the range of 50 to 70 percent. This is referred to as total porosity. The total porosity of a media is further composed of two parts: air and water. Both components are critical for good plant growth, but not enough of either can limit growth.

(iv) Media Stability

The stability of a planting substrate needs to be considered. It is undesirable to use a substrate that decomposes quickly, since this will result in a dramatic reduction in substrate porosity. The need for stable substrates is especially important for larger containers, which require more than a growing season for the plant to reach a marketable size.

B. Growing media chemical properties

I. Cation Exchange Capacity

Cation exchange capacity (CEC) is the total capacity of a soil to hold exchangeable cations (CEC). Substrates such as clay, silt, organic matter, and vermiculite have fixed negative electrical charges that attract and hold positively charged nutrient ions, known as cations.

CEC can vary widely depending on the type of component. Cations associated with plant nutrition are calcium (Ca2+), magnesium (Mg2+), potassium (K+), and ammonium (NH4+), listed in order of decreasing retention in the substrate.

In addition to cations, plants also require negatively charged anions such as nitrate (NO3-), chloride (Cl-), sulphate (S04-), and phosphate (HPO4)

II. pH

Media pH is a measurement of the acidity or alkalinity of a substrate. Substrate pH is a critical issue because it plays a major role in determining the availability of many nutrients. In an acid substrate, calcium and magnesium, nitrate-nitrogen, phosphorus, boron, and molybdenum are deficient, whereas aluminum and manganese are abundant, sometimes at levels toxic to some plants. Phosphorus, iron, copper, zinc, and boron are frequently deficient in very alkaline substrate. Most greenhouse crops grow best in a slightly acid pH range of 6.2 to 6.8 in soil-based substrate and 5.4 to 6.6 in soilless substrate.

III. Electrical Conductivity

Electrical conductivity (EC) is used to measure total dissolved salts (free ions) in the substrate and is commonly expressed in units of decisiemens per meter (dS/m). High salt concentrations cause problems by changing the osmotic potential of the substrate, causing water to leave plant roots and flow into the medium. Therefore, affected plants will grow poorly since they are in essence suffering from drought or water stress.

IV. Carbon-to-Nitrogen Ratio

Most greenhouse media are formulated primarily from organic materials, such as saw dust, coir, compost, bark, and peat moss. The C:N ration of the organic materials is a good indicator of whether nitrogen will be limiting or excessive; the higher the C:N, the higher the risk of nitrogen being unavailable to plants. If the amount of carbon exceeds the amount of nitrogen from the organic materials, microorganisms use the nitrogen intended for the plant in the container.

3.8. Applying agronomic management practices according to the requirements and greenhouse management procedures

Proper greenhouse management is extremely important for the efficiency and health of a farm. It may seem simple put a seed in a tray with soil, add water, and voila, there are young plants to transplant into the field. In theory, yes, that's all there is to it. But optimal air temperature and water delivery are crucial for the development of seedlings. Also, hidden in the air all around us,

in the water coming out of a hose, and in the ground inside a greenhouse, there are many mysterious little life forms ready to wreak havoc on young plants. The three most important greenhouse management practices are optimal temperature control, consistent air circulation and proper moisture delivery.

I. Optimal Temperature Control

Air and soil temperature are widely known to be important for seed germination, but the specifications for each type of seed are so different it can be hard to manage. For instance, solanums (tomatoes, eggplant, etc) need an optimum soil temperature of around 90 degrees while spinach needs an optimum soil temperature of 70 degrees. For tomatoes, if the temperature is too low, the seeds will remain dormant; for spinach, soil temperature that is too high can cause thermo-dormancy, preventing germination.

So how does one manage the soil temperatures per specific crops?

Generally maintaining the temperature of a greenhouse in the 70-80 degree range is best for all crops. Proper ventilation and air circulation help maintain that temperature in warm months. Remembering to open the greenhouse before it's too hot and closing it before it's cool (to keep the heat in) are important practices.

In the winter months, some people use electric or propane heaters to maintain warm temperatures. In hot climates, shade cloth can be draped over a greenhouse to keep the temperature down if needed. Managing specific soil temps for different crops can be done using location specific heating mats to raise the soil temperature or using small shade structures to keep flats cooler on your greenhouse tables.

In order for all of this to work, don't forget to purchase quality soil and ambient air thermometers. If funds are available, purchasing a system that is automatic, where the ventilation is hooked directly into your thermometer, can make life much easier. Remember to continue checking in on your greenhouse. Greenhouses are extremely fussy and the slightest changes in sunlight and wind, or technological difficulties can leave your greenhouse bone dry and seedlings wilted or dead.

II. Air Circulation

To help maintain temperature and prevent pests of the insect or fungal kingdoms, proper air circulation is crucial. A greenhouse ventilation system should be made up of low, side-wall and end-wall vents to allow cool air in, and ridge vents to allow the hot air to exhaust out. Fans in the end walls and in the ridge are important to circulate the air around the greenhouse as well as create a slight breeze through the plants, preventing spores and insects from hanging out on small starts.

Air circulation is also important in mitigating excess humidity in the greenhouse that molds and "damping off" organisms love. "Damping off" organisms are fungal pathogens that will be discussed in the next section

III. Proper Moisture Delivery

Perhaps the most important part of germinating a seed is water. For many reasons, monitoring the moisture levels of your soil media is extremely important and the optimal moisture needed for germination may not be intuitive. Seeds need consistent moisture to germinate, but they don't need very deep watering. Seeds should be watered on a regular basis just enough to maintain a shallow and high moisture content in the upper part of the soil media where the seed lies. Allowing the very top of the soil to dry down occasionally is important in preventing soil borne pathogens.

Once the seed has germinated and emerged, it is important to begin incorporating a consistent wet-dry swing in your media to both promote drought tolerance for their time in the field and prevent "damping off" organisms from growing. As discussed, "damping off" organisms are fungal pathogens that inhabit the soil surface of your seedling flats and trays, often forming a green hard crust. These organisms can make the stems of seedlings rot and the plants ultimately die.

The depth of the watering is also an incredibly important aspect of moisture management practices in the greenhouse. Once the seedlings begin to grow, the deeper their roots are incorporating longer and deeper watering less frequently gives the plants the needed wet-dry swing (especially on the soil surface) but also promotes good root growth and drought tolerance.

In addition to these three important management practices thinking about soil media as well as, the size and shape of the greenhouse are important in creating an ideal greenhouse environment. Soil media is important in its physical and biological characteristics.

Thinking about drainage and biological activity will help prevent contamination. The size and shape of a greenhouse depends on the farm and its ultimate purpose on the farm. Utilizing these ideal practices will give you beautiful seedlings that will have a greater success rate in the field.

3.9. Identifying and applying pest management practices in line with crop type and level of infestation

3.9.1. Integrated Pest Management in Greenhouses

Integrated Pest Management (IPM) is a holistic approach to managing diseases, insects, and mites in greenhouses, using the best tools, tactics, and strategies to control pests with the least disruption to the environment. IPM involves a combination of cultural, biological, and chemical control methods to minimize pesticide use and maintain high-quality, pest-free plants

Here are some key principles and practices of IPM in greenhouses:

I. Accurately Identifying Pests: Correct pest identification is essential for effective pest management. Employees must be trained to identify insects, pathogens, and other pests
II. Developing Economic Thresholds: Economic thresholds are the point at which the cost of controlling a pest is equal to or less than the potential damage it could cause. These thresholds help determine when control measures are necessary
III. Cultural Pest Control in Greenhouses: This involves managing the greenhouse environment, such as maintaining proper temperature, humidity, and light levels, as well as implementing good sanitation practices
IV. Sanitation: Regular cleaning and disinfection of greenhouse surfaces, as well as proper disposal of plant debris, can help prevent the spread of pests
V. Greenhouse Insect Screening: Installing insect screening over greenhouse openings, such as ridge vents, sidewalls, and air intake vents, can help reduce the migration of winged aphids and other pests

VI. Ventilation: Proper ventilation is crucial for maintaining a healthy growing environment and reducing the risk of pest outbreaks

VII. Positive Air Pressure: Maintaining positive air pressure in the greenhouse can help prevent the entry of pests and reduce the spread of diseases

VIII. Airlock Entrance: Using an airlock entrance can help prevent the entry of pests and diseases while allowing people and materials to enter the greenhouse

IX. Quarantine: Implementing a quarantine protocol for new plants and materials can help prevent the introduction of new pests into the greenhouse

X. Biological Pest Control: This involves using natural enemies, such as parasites, predators, and biorational pesticides, to control pests

XI. Chemical Pest Control: When necessary, using chemicals allowed for organic crop production can help control pests

XII. Record Keeping: Maintaining accurate records of pest populations, control measures, and environmental conditions can help growers make informed decisions about pest management

By implementing these principles and practices, greenhouse growers can develop an effective IPM plan that minimizes pesticide use, reduces the risk of pest outbreaks, and maintains high-quality, pest-free plants..

Successful IPM programs use a five-tiered implementation approach:

(1) Monitoring crops for pests

(2) Accurately identifying pests

(3) Developing economic thresholds

(4) Implementing integrated pest control tactics

(5) Record keeping. The focus of IPM is to use a combination of integrated pest management control tactics, whether it be cultural, mechanical/physical, biological, biorational, or chemical.

3.9.2. Greenhouse insect and mite pest management

The warm, humid conditions and abundant food in a greenhouse provide an excellent, stable environment for pest development. Often, the natural enemies that serve to keep pests under control outside are not present in the greenhouse. For these reasons, pest situations often develop in this indoor environment more rapidly and with greater severity than outdoors. Successful control of insect and mite pests on greenhouse crops depends on several tactics. These include regular scouting or monitoring for problems, identifying pests and their life stages, keeping good records of pest management practices, using exclusion techniques, practicing good sanitation, testing soil or plants for nutrients, using biological controls when possible, and using selective pesticides, properly timed and applied.

Some greenhouse insects can transmit diseases to the crops which are often more serious than the feeding injury that the insect causes. These insect "vectors" include some aphids, leafhoppers, thrips and whiteflies. In these instances, the diseases must be managed through early insect control

3.9.3. Greenhouse disease management

Plant diseases pose a major threat to horticultural crops grown in greenhouses. High relative humidity (RH) and the presence of a film of water on susceptible plant organs for long periods of time provide favorable conditions for the germination of conidia and infection by many pathogens: bacteria, fungi and viruses.

Fungal diseases are plant infections caused by fungi. Fungi can be single or multicellular, but either way infects plants by stealing nutrients and breaking down tissue. Bacteria are microscopic, single-celled prokaryotic organisms, without a defined nucleus, that reproduce asexually by binary fission (one cell splitting into two). Viruses are sub-microscopic, infectious particles that multiply only inside living host cells. When disease management is neglected, pathogen populations build up and continue to increase as long as there is susceptible plant tissue available for infection and disease development.

Successful crop production requires that crop diseases be managed so that the effects of diseases on the plants are minimized. The management of crop diseases is directed at preventing the establishment of diseases and minimizing the development and spread of any diseases that become established in the crop. Integrated disease management that is based on cultural, biological, biorational, and chemical controls is suggested strategy for keeping plants healthy in greenhouse cropping systems.

3.9.4. Greenhouse pesticides

Greenhouse environments provide a variety of benefits for plant production; however, many greenhouses favor pest development as well. The warm, humid conditions and abundant food are ideal for pest build up. Natural enemies that serve to keep some pests under control in the field are absent in the greenhouse. For these reasons, pest problems often develop more rapidly and are more severe in enclosed systems, which require the use of pesticides. Pesticides include any substances used either to directly control pest populations or to prevent or reduce damage to the crops in the greenhouse.

There are many pesticides available for use in greenhouses, all of which control specific pest and disease problems in growing crops. Although many pesticides are designed to kill pests, some may only inhibit their growth, or simply attract or repel them. There are several approaches to the classification of pesticide types. Pesticides are often referred to according to the type of pest they control. For example, insecticides are pesticides that target insects, fungicides target fungal diseases, and herbicides target weeds. Pesticides can also be organized by their chemical class. There are many classes of synthetic pesticides. The main classes consist of organochlorines, organophosphates, carbamates, and pyrethroids. We define conventional or chemical pesticides as those having a broad spectrum of activity and being more detrimental to natural enemies. Another way of classifying pesticides is how or when they work—contact, systemic, preemergent, postemergent, selective, and non-selective (or broad-spectrum). Pesticides can be grouped according to their mode of action or the way a pesticide controls the target pest.

This is also referred to the primary site of action. For example, one insecticide may affect an insect’s nerves while another may affect moulting. Pesticides can also be classified as

biorationals— pesticides that are more selective because they are most effective against pests with certain feeding habits, at certain life stages, or within certain taxonomic groups. These are also known as “least toxic” pesticides. Because the biorationals are generally less toxic and more selective, they are generally less harmful to natural enemies and the environment. A similar term used is “biopesticides.”

3.9.5. Pesticide application and equipment in greenhouses

When developing an integrated pest management strategy, it is important to know the target pests, their economic threshold levels, and multiple control strategies that can minimize pesticide inputs in the greenhouse. The objective in applying pesticides in greenhouses is to deliver an effective, uniform dose to a target area in a safe and timely manner. Selecting the correct pesticide for the job is very important to the success of a pest management program, but equally important is the equipment and application technique used to apply the pesticide. The equipment chosen for the application of pesticides must be properly selected to allow the chemical to reach the target at the proper rate and with sufficient coverage.

The pesticide label will specify the application rate, spray volume, crop, and application methods or restrictions as to where the product can be used. The application equipment used in the greenhouse may be as simple as a backpack sprayer, air-assisted low-volume sprayer, or ultra-low volume sprayers such as foggers.

3.10. Identifying existing and potential OHS hazards in the workplace and assessing and controlling risks in line with organization requirements

3.10.1. Identifying OHS hazards

Hazard identification in the context of occupational health and safety involves recognizing and recording potential hazards that may be present in the workplace. It is a critical step in the risk assessment process and is essential for creating a safe work environment. Some common methods and sources for identifying hazards in the workplace include:

Workplace Inspections: Conducting regular worksite inspections to visually assess equipment, work practices, and potential hazards

- Interviews with Workers and Managers: Allowing workers to express concerns and gather feedback on potential hazards that may not be immediately obvious
- Creating a Hazard Map: Drawing a map of the worksite(s) and marking existing and potential hazards to increase awareness and solicit feedback from workers
- Reviewing Information Sources: This includes examining Safety Data Sheets (SDSs), manufacturer's operating instructions, manuals, and previous incident reports
- Training and Education: Providing hazard identification training to workers and management to increase awareness and understanding of potential workplace hazards. Utilizing these methods and sources, employers can effectively identify and address potential hazards in the workplace, ultimately contributing to the development of a comprehensive occupational health and safety program.

3.10.2. Assessing risk and reporting risks

Risk assessment is a process for developing knowledge and understanding about hazards and risks so that sound decisions can be taken about control. A risk assessment will provide knowledge to make informed decisions about controlling hazards and risks. The risk assessment needs to be tailored to the situation and to the organization in which it is conducted; it can be as simple as structured discussion during consultation or it can be more elaborate and formal.

Risk assessment assists in determining:

- What levels of harm can occur
- How harm can occur
- The likelihood that harm will occur.

A risk assessment should be done when:

- There is only limited knowledge about a hazard or risk, or about how the risk may result in injury or illness
- There is uncertainty about whether all of the things that can go wrong have been found
- The situation involves a number of different hazards that are part of the same work process or piece of plant and there is a lack of understanding about how the hazards may impact upon each other to produce new or greater risks.

3.10.3. Controlling hazards and risks

Workplaces can be dangerous; there are many hazards that have the potential to kill, injure or cause ill health or disease. Protecting the health and safety of people in the workplace is a community expectation that makes good business sense. Workplace incidents can have a dramatic impact on people's lives (people in the workplace, families and friends), and they can have significant financial impacts on organizations through loss of skilled staff and lost production of goods or services.

However, in many circumstances it will be the best way to determine the measures that should be implemented to control risks. It will help to:

- Identify which workers are at risk of exposure
- Determine what sources and processes are causing that risk
- Identify if and what kind of control measures should be implemented
- Check the effectiveness of existing control measures.

3.10.4. Reporting and documenting greenhouse activities

Reporting and documenting greenhouse activities is crucial for maintaining accurate records, tracking progress, and ensuring compliance with regulations. Some key aspects of reporting and documenting greenhouse activities include:

- Daily Logs: Keeping daily logs of greenhouse activities, such as temperature, humidity, light levels, and watering schedules, can help identify trends and issues
- Pest Management Records: Documenting pest management activities, such as the use of pesticides, biological controls, and cultural practices, can help track the effectiveness of control measures and ensure compliance with regulations
- Crop Management Records: Recording crop management activities, such as planting dates, harvest dates, and yield data, can help optimize crop production and identify areas for improvement
- Maintenance Records: Documenting greenhouse maintenance activities, such as cleaning, repairs, and equipment maintenance, can help ensure that the greenhouse remains in good working condition and complies with safety regulations

- Training and Education Records: Keeping records of employee training and education can help demonstrate compliance with regulatory requirements and ensure that employees are equipped with the necessary knowledge and skills to perform their duties safely and effectively
- Environmental Monitoring: Regularly monitoring and documenting environmental factors, such as temperature, humidity, and light levels, can help maintain a healthy growing environment and ensure compliance with regulations
- Incident Reports: Documenting any incidents or accidents that occur in the greenhouse, such as equipment malfunctions or injuries can help identify potential hazards and improve safety procedures. Maintaining accurate records and documents, greenhouse operators can effectively manage their operations, ensure compliance with regulations, and continuously improve their practices.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Test I: True/False

1. Greenhouse environments provide a variety of benefits for plant production; however, many greenhouses favor pest development as well
2. Successful greenhouse production of container-grown plants is largely dependent on the physical and chemical properties of the growing media
3. Propagation medium is a substance in which plant parts are placed for propagation.
4. Pasteurization of propagation media at higher temperatures with aerated steam is generally preferable to fumigation with chemicals.
5. Facilities-disinfection refers to the reduction of pathogens and algae, while sanitation refers to the level of cleanliness.

Test I: Short Answer Questions

1. Explain the purpose of the growing media
2. The various media component constitutes of

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   ---------- ----------
3. Determine those growing media for plant requirements?
4. List the two major groups and components of soil-less media?
5. The choice for substrate components will depend on the

   ----
6. Nutrient requirements might be determined by_____
7. Explain the general characteristics of growing media?

Operation sheet 3	Preparing growing media mix

Preparing growing media mix

Objective:-

- To perform the right growing media mixtures for potting.

Theory:

Most nurseries use mixtures of topsoil with organic and inorganic additions. Good plant development depends to a large part on the growing medium used. If a plant develops a good root system in a well-balanced substrate, this does not mean that the plant is pampered and will not adapt to the harsh life outside a nursery. In fact, the opposite applies. To survive in the harsh environment of a field, often without additional watering and fertilizing, a plant needs a well-developed and strong root system. The development of a healthy root system depends not only on the genetic properties of the plant but to a large extent on the physical and chemical properties of the substrate used.

Materials and tools:

- Forest soil
- Sand
- Local soil
- Manure
- Compost
- Shovels
- Digging tools
- Rakes
- Wheelbarrow
- Plastic pots
- Watering can
- Pot cutting roll

Procedures:

- Wear your personal protective clothing's.
- And try to accomplish the following typical growing media mixtures proportion 3:2:1 (which means three part local soil; two part forest soil; and one part sand).
- Spray water on the prepared substrate mixture to make it suitable for pot soil making. But don't make it too wet.
- Try to fill this growing media mixture in to the plastic pot available in the nursery.

Finally, try to practice the following:

- As a rule of thumb when soil is to be part of the growing medium, use the following mixtures (topsoil: fine gravel or sand: well-decomposed organic matter such as manure or compost):

  - For heavy (clayey) soils 1:2:2
  - For medium (loamy) soils 1: 1:1
  - For light (sandy) soils 1: 0:1

LAP test 3	Sheet

Name……..ID……Date……..

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **60** minutes. The project is expected from each student or in a group to do it.

Task 1: prepare growing media

Task 2: perform growing media in green house

LG #15

LO#4.Prepare production plan for individual horticultural crop and whole farm

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Assessing fields for their nutrient, pest status, water reserves, tillage requirements, and other factors before selecting crop type and variety.
- Using appropriate chemical records to assist planning for reduce chemical residue
- Selecting horticultural crop variety and planning field preparation, planting; fertilizing and other treatments
- Determining Optimum timing of planting, applications of input is and preparing operational calendar
- Identifying and planning the requirements Labour, machinery and equipment
- Preparing Production plan

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Assess fields for their nutrient, pest status, water reserves, tillage requirements, and other factors before selecting crop type and variety.
- Use appropriate chemical records to assist planning for reduce chemical residue
- Select horticultural crop variety and plan field preparation, planting; fertilizing and other treatments
- Determine optimum timing of planting, applications of input is and preparing operational calendar
- Identify and plan the requirements Labour, machinery and equipment
- Prepare Production plan

Learning Instructions:

6. Read the specific objectives of this Learning Guide.
7. Follow the instructions described below.
8. Read the information written in the information Sheets
9. Accomplish the Self-checks
10. Perform Operation Sheets
11. Do the “LAP test”

Information Sheet 4

4.1. Assessing fields for their nutrient, pest status, water reserves, tillage requirements, and other factors before selecting crop type and variety.

4.1.1. Assessing field for their nutrient

Assessing a field for its nutrient levels involves several steps, including soil sampling, chemical analysis, and interpreting the results. Here are some key aspects to consider:

- Soil sampling: Soil sampling is the first step in assessing nutrient levels. It is essential to take multiple samples from different areas within the field to get a representative estimate of the nutrient levels
- Chemical analysis: Soil samples are analyzed for various nutrients, such as pH, nitrogen, phosphorus, potassium, zinc, soluble salts, cation exchange capacity, and organic matter content
- Nutrient deficiencies: Plant tissue analysis is a tool that can be used to assess nutrient deficiencies within fields. Sampling multiple areas within a given field allows for the identification of nutrient deficiencies and areas of concern
- Interpreting results: The objective of sampling is to obtain the average nutrient level and the average pH for a given field. The data obtained from soil samples can be used to determine the nutrient status of the field and guide decisions about fertilizer application
- Nutrient management: Nutrient uptake patterns change as plants grow and enter different developmental stages. Fertilizer should be applied during periods of highest demand and reduced or stopped at times when the plant does not require as much nutrient. By following these steps, growers can assess the nutrient levels in their fields and make informed decisions about fertilizer application, ensuring optimal plant growth and development.

There are many ways that farmers can reduce nutrient losses from their operations, including, but not limited to

- Adopting Nutrient Management Techniques**:** Farmers can improve nutrient management practices by applying nutrients (fertilizer and manure) in the right amount, at the right time of year, with the right method and with the right placement.
- Using Conservation Drainage Practices: Subsurface tile drainage is an important practice to manage water movement on and through many soils, typically in the Midwest.

Drainage water can carry soluble forms of nitrogen and phosphorus, so strategies are needed to reduce nutrient loads while maintaining adequate drainage for crop production. Conservation drainage describes practices including modifying drainage system design and operation, woodchip bioreactors, saturated buffers, and modifications to the drainage ditch system.

- Ensuring year-round ground cover: Farmers can plant cover crops or perennial species[8] to prevent periods of bare ground on farm fields when the soil (and the soil and nutrients it contains) are most susceptible to erosion and loss into waterways.
- Planting field buffers: Farmers can plant trees, shrubs and grasses along the edges of fields; this is especially important for a field that borders water bodies. Planted buffers can help prevent nutrient loss from fields by absorbing or filtering out nutrients before they reach a water body.
- Implementing conservation tillage: Farmers can reduce how often and how intensely the fields are tilled. Doing so can help to improve soil health, and reduce erosion, runoff and soil compaction, and therefore the chance of nutrients reaching waterways through runoff.[10]
- Managing livestock access to streams: Farmers and ranchers can install fence along streams, rivers and lakes to block access from animals to help restore stream banks and prevent excess nutrients from entering the water.
- Engaging in watershed efforts: The collaboration of a wide range of people, stakeholders and organizations across an entire watershed is vital to reducing nutrient pollution to our water and air. Farmers can play an important leadership role in these efforts when they get involved and engage with their State governments, farm organizations, conservation groups, educational institutions, non-profit organizations, and community groups.

- Applying fertilizers in the proper amount, at the right time of year and with the right method can significantly reduce how much fertilizer reaches water bodies.
- Keeping animals and their waste out of streams keeps nitrogen and phosphorus out of the water and protects stream banks

4.1.2. Assessing pest status in the field

Assessing the pest status in a field involves monitoring for the presence and activity of pests. This can be done through:-

- Visual inspection
- Trapping, or scouting, depending on the type of pest.

Monitoring can also include checking environmental conditions such as temperature and humidity, which are important clues in predicting pest outbreaks. Expert judgment and the synthesis of pest records and other sources of information are required to determine the pest status in an area. This determination is based on the current distribution of a pest, using both current and historical records. The NPPO (National Plant Protection Organization) should base its determination of pest status on the most reliable and timely information available and maintain pest records and supporting evidence. Additionally, it is important to consult expert sources for help in identifying pests and to use insecticide products for key greenhouse pests after careful scouting and testing.

Pest status is determined using information from individual pest records, pest records from surveys, data on pest absence, findings of general surveillance, and scientific publications and databases.

4.1.3. Purposes of Pest Status Determination

The purposes of pest status determination are as follows:

a. Identifying risks: Determining the pest status in an area helps countries identify risks associated with specific pests and apply phytosanitary measures to protect biodiversity and the environment
b. Informing decision-making**:** Pest status determination provides valuable information for decision-makers, such as whether to apply phytosanitary measures, adjust crop management practices, or implement quarantine measures
c. Facilitating trade: Pest status determination is a vital component of various activities undertaken to the International Plant Protection Convention (IPPC) and covered by the principles described in ISPM 1 (Phytosanitary principles for the protection of plants and the application of phytosanitary measures in international trade)
d. Monitoring and controlling pests: Pest status determination helps monitor and control pests by identifying their presence, extent, and potential impact on crop production
e. Regulating pesticide use: Pest status determination can guide the use of pesticides, ensuring that they are applied correctly and in a manner that minimizes harm to human health and the environment
f. Promoting best practices: Pest status determination can help promote best practices in pest management, such as integrated pest management (IPM) strategies, which combine cultural, biological, and chemical control methods to minimize pesticide use and maximize pest control. By assessing pest status, growers can make informed decisions about crop management practices, pesticide use, and other strategies to protect their crops and maintain sustainable agricultural practices.

Importing countries need pest status information to:

- Conduct a pest risk analysis (PRA) on a pest in another country
- Establish phytosanitary regulations to prevent the entry, establishment or spread of a pest
- Conduct a PRA on a non-quarantine pest in their own territory with a view to regulating it. Exporting countries need pest status information to:
- Comply with import regulations by not exporting consignments infested with the regulated pests of the importing country
- Meet requests for information from other countries for the purpose of PRA on pests in their territory.

All countries may use pest status information for:

- PRA purposes - planning national, regional or international pest management programmes
- establishing national pest lists
- establishing and maintaining pest free areas

Information on the status of a pest in areas, countries and regions may be used to establish the global distribution of a pest.

The ISPM 6 (Guidelines for surveillance) describes the elements of information from general surveillance and specific surveys that may be included in a pest record.

The basic information needed in a pest record includes the following:

- Current scientific name of the organism including, as appropriate, sub specific terms (strain, biotype etc.)
- Life stage or state
- Taxonomic group
- Identification method.
- Year, and month if known, recorded; normally the day will only be required for specific circumstances (e.g. the first detection of a particular pest, pest monitoring)

- Locality, e.g. location codes, addresses, geographical coordinates; important conditions such as if under protected cultivation (e.g. greenhouses) should be indicated - scientific name of host, as appropriate
- Host damage, or circumstances of collection (e.g. trap or soil sample), as appropriate
- Prevalence, indication of the level of pest presence or pest numbers
- Bibliographical references, if any.

A list of references is noted in the appendix to this standard for consultation in the preparation of a pest record.

Reliability

Pest record information is available from many sources and has varying levels of reliability. Some key components are identified in the following table. Although the table ranks the categories in descending order of relative reliability, it must be recognized that these are not rigid and are only designed to provide guidance in evaluating the record. In particular, it should be noted that pests differ in the level of expertise needed for their identification. NPPOs have responsibility to provide accurate information on pest records upon request.

Guidance for evaluating the reliability of a pest record

1. Collector/ Identifiers	2. Technical identification	3. Location and date	4. Recording/ Publication
Taxonomic specialist	Discriminating biochemical or molecular diagnosis (if available)	Delimiting or detection surveys	NPPO record/RPPO publication (where refereed)
Professional specialist,	Specimen or culture maintained in official collection, taxonomic description by specialist	Other field or production surveys	.Scientific or technical journal refereed
Scientist	Specimen in general collection	Casual or incidental field observation,	Official historical record

		possibly with no defined location/date	
Technician	Description and photo	Observation with/in products or byproducts; interception	Scientific or technical journal non-refereed
Expert amateur	Visual description only	Precise location and date not known	Specialist amateur publication
Non-specialist	Method of identification not known		Unpublished scientific or technical document
Collector/identifier not known			Non-technical publication; periodical/ newspaper
			Personal communication; unpublished

Pest Status in an Area

Describing pest status in an area

Determination of pest status requires expert judgement on the current distribution of a pest in an area. This judgement is based on a synthesis of pest records and information from other sources. Both current and historical records are used in assessing the present-day situation. Pest status can be described under the following categories

g. Presence

A pest is present if records indicate that it is indigenous or introduced. If a pest is present and sufficient reliable records are available, then it may be possible to characterize its distribution using phrases, or combinations of phrases, such as the following examples:

- Present: in all parts of the area
- Present: only in some area
- Present: except in specified pest free areas
- Present: in all parts of the area where host crop (s) are grown
- Present: only in some areas where host crop (s) are grown
- Present: only in protected cultivation
- Present: seasonally
- Present: but managed
- Present: subject to official control
- Present: under eradication
- Present: at low prevalence.

Other similar descriptive phrases may be used, as appropriate. If few reliable records are available, it will be difficult to characterize the distribution. As appropriate, it is useful to characterize the prevalence of the pest (e.g. common, occasional, rare), and the level of damage and/or losses caused by the pest on relevant hosts.

h. Absence

If there are no records of the presence of the pest in the general surveillance data of an area, it may be reasonable to conclude that a pest is or has always been absent. This may be supported by specific records of absence. It is also possible to conclude that a pest is absent even if there are pest records suggesting the contrary. These different situations are described below. Absence may also be confirmed by specific surveys (see ISPM 6) and, in that case, the phrase “confirmed by survey” should then be added. Similarly, when a pest free area is established according to the appropriate ISPM (see ISPM 4 (Requirements for the establishment of pest free areas)) the phrase “Pest free area declared” should be added.

Absent: no pest records General surveillance indicates that the pest is absent now and has never been recorded

Absent: pest eradicated Pest records indicate that the pest was present in the past. A documented pest eradication programme was conducted and was successful (see ISPM 9 (Guidelines for pest eradication programmes)). Surveillance confirms continued absence

Absent: pest records invalid Pest records indicate the presence of a pest, but the conclusion is reached that the records are invalid or no longer valid, as in the following officially declared cases: - changes in taxonomy - misidentification - erroneous record - changes in national borders where reinterpretation of the record may be needed.

Absent: pest records unreliable Pest records indicate the presence of a pest, but the determination leads to the conclusion that the records are unreliable, as in the following officially declared cases: - ambiguous nomenclature - outdated identification or diagnostic methods - records cannot be considered reliable (see table). Absent: intercepted only the pest has only been reported on consignments at a point of entry or initial destination or while under detention before release, treatment or destruction. Surveillance confirms that the pest has not established.

Determination of pest status in an area

Determination of the status of a pest is provided by an NPPO. It results in deciding upon the most appropriate description of the pest status in an area based on supporting information.

This may include:

- Individual pest records
- Pest records from surveys
- Records or other indication of pest absence
- Results of general surveillance
- Information from scientific publications and databases
- Phytosanitary measures used to prevent introduction or spread

- Other information relevant to assessing pest absence or presence. The reliability and consistency of the information should be considered. In particular, careful judgement is needed when there is conflicting information

4.1.4. Assessing water reserves in the field

Assessing water reserves in the field involves evaluating the availability and quality of water for various uses. This assessment typically includes the examination of surface water flows and storage, ground water levels and storage, and water use.

Water quality monitoring is also an essential part of this assessment, involving the analysis of parameters such as stream flow, dissolved oxygen, temperature, pH, turbidity, phosphorus, nitrates, total solids, conductivity, total alkalinity, and fecal bacteria.

Additionally, water resources assessment aims to develop a comprehensive understanding of all water flows and storages, including renewable water resources and exploitable water resources. Furthermore, the potential of agricultural reservoirs as a source of environmental flow is also considered in the assessment of water reserves. Overall, assessing water reserves in the field is crucial for informed water resource management and sustainable agricultural practices

4.1.5. Assessing tillage requirements

Assessing tillage requirements involves evaluating the soil structure, texture, and organic matter content to determine the appropriate tillage system for a given field.

Tillage systems can include:-

- Conventional tillage
- Reduced tillage
- No-till systems, each with different levels of soil disturbance and residue management.

The choice of tillage system should be based on the specific needs of the crop, soil type, and environmental conditions. Reduced tillage and no-till systems can help reduce soil erosion, conserve soil moisture, and improve soil health by increasing organic matter content. However, the effectiveness of these systems depends on the specific conditions of the field, and improper implementation can lead to a loss of productivity or profitability.

Soil parameters such as temperature, secondary aggregate size, bulk density, and volume of the zone can be used to evaluate tillage needs and operations. Overall, assessing tillage requirements is essential for selecting the appropriate tillage system, optimizing crop yields, and promoting sustainable agricultural practices.

Another classification of tillage systems

There are two types of tillage namely a. Conventional tillage or clean tillage and b. Conservation tillage

I. Conventional tillage or clean tillage**:** Ploughing the entire field several times to prepare a seed bed is called conventional tillage
II. Conservation tillage: Ploughing the field with lesser number of passes over the entire land or ploughing only in the required space of the land and then sowing is called conservation tillage. . Different types of conservation tillage are as fallows

a. Minimum Tillage -Minimum soil manipulation necessary to meet tillage requirements





b. Mulch Tillage **–** Tillage operations in which nearly 30 % of crop residue or other mulching materials are left on or near the soil surface is called mulch tillage

c. Rotary Tillage for crop production is called minimum tillage.

d. Strip Tillage - In strip tillage system only isolated bands of soil are tilled. **-** Tillage operations employing rotary action of the tool to cut break and mix the soil is called rotary tillage.



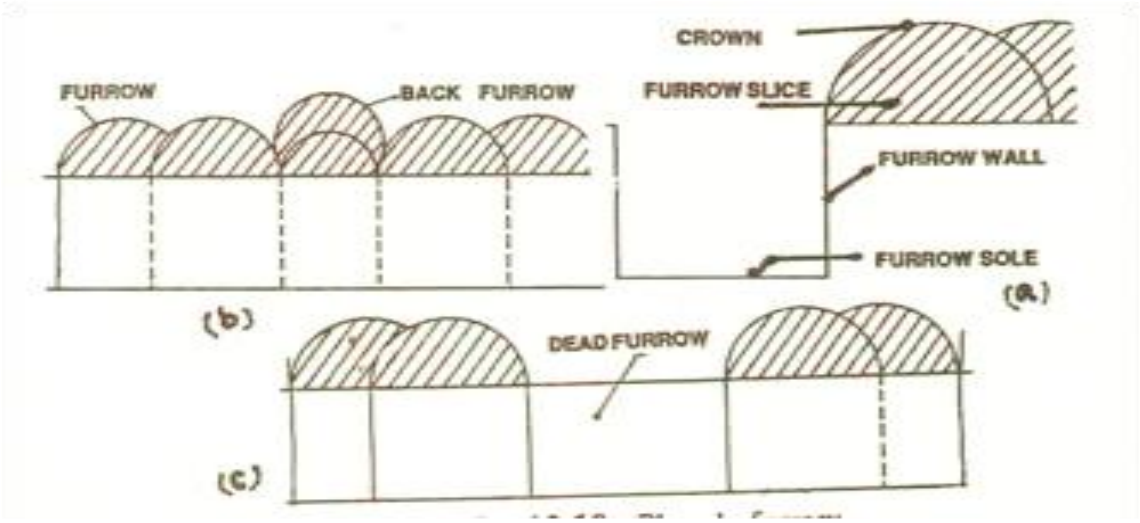



e. Combined Tillage – Tillage operations utilizing simultaneously two or more different types of tillage tools or implements to simplify, control or reduce the number of operations over a field is called combined tillage.

A. **PLOUGHING OF LAND**

Ploughing of land separates the top layer of soil into furrow slices. The furrows are turned sideways and inverted to a varying degree, depending upon the type of plough being used. It is a primary tillage operation, which is performed to shatter soil uniformly with partial or complete soil inversion.

Furrow terminologies



There are a few important terms frequently used in connection with ploughing of a land.

- Furrow**:** It is a trench formed by an implement in the soil during the field operation
- Furrow slice: The mass of soil cut, lifted and thrown to one side is called furrow slice

- Furrow wall: It is an undisturbed soil surface by the side of a furrow.
- Crown**:** The top portion of the turned furrow slice is called crown.
- Back furrow: A raised ridge left at the centre of the strip of land when ploughing is started from centre to side is called back furrow. When the ploughing is started in the middle of a field**,** furrow is collected across the field and while returning trip another furrow slice is lapped over the first furrow. This is the raised ridge which is named as back furrow
- Dead furrow**:** An open trench left in between two adjacent strips of land after finishing ploughing is called dead furrow (Fig.1c).
- Head land**:** While ploughing a land with a tractor a strip of unploughed land is left at each end of the field for the tractor to turn, which is called head land. At the end of each trip, the plough is lifted until the tractor and the plough have turned and are in position to start the return trip. The head land is about 6 meters wide for two or three bottom tractor plough and one meter more for each additional bottom.

B. Methods of ploughing a land

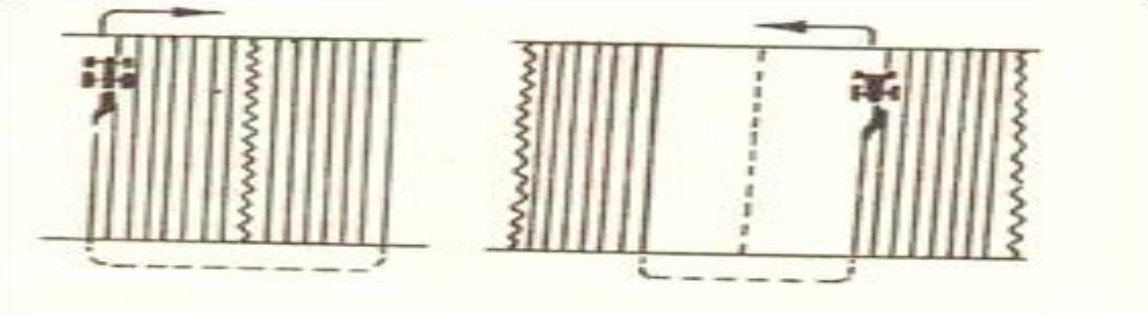
There are two main methods of ploughing a field which are known as “inlands” and “round about” ploughingA normal right hand plough must always have an open furrow on the right in which to lay the next furrow slice. It is therefore, necessary to travel across the field in one place and come back in another. There are two ways of doing this by “gathering” and “casting’

Gathering

whenever a plough works round a strip of ploughed land, it is said to be gathering. The tractor and plough turns to right each time the head land is reached. When the land is ploughed, a raised ridge (double width ridge) is formed in the center of the field. This however would be uneconomical way of working as time is wasted at the start in making awkward turns, while later, total idle running would be increased along the head land

Casting

whenever a plough works round a strip of un ploughed land, it is said to be casting. The tractor and plough turns to the left each time the head land is reached. When the land is ploughed in this way a wide furrow (double width furrow) will be left in the center and is termed as ‘finish’ or open furrow or dead furrow

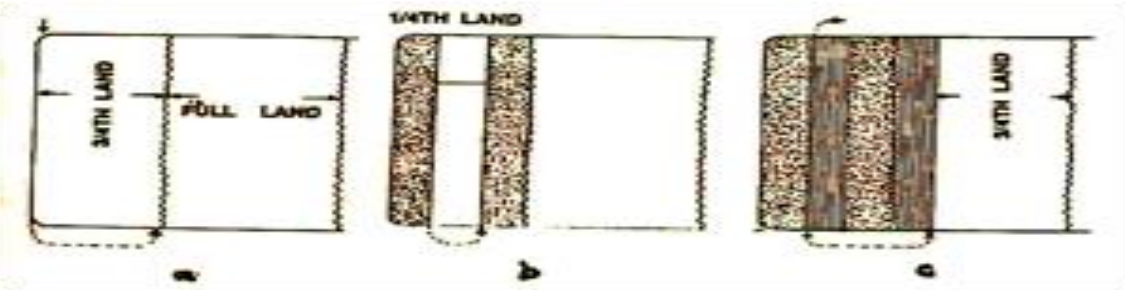


a. Gathering b. Casting

It is recommended that long field should be ploughed by gathering in one season and casting in another season. It avoids building up of a ridge in the centre and an open furrow at each side or vice versa. However, ploughing of a field either by casting or by gathering alone is normally uneconomical. For economical ploughing the following methods are used

a) Continuous ploughing method

In normal conditions, the continuous ploughing method is considered very convenient and economical. This is a method usually used in which the tractor and plough never run idle for more than three quarter land width along the headland and never turn in a space narrower than a quarter land width. In this method, first the headland is marked and the first ridge is set up at three quarter of a land width from the side (Fig. a). The other ridges are set at full width over the field. The operator starts ploughing between the first ridge and the side land. The operator continues to turn left and cast in the three quarter land until ploughing is completed in a quarter land width on each side (Fig. b). At this stage, the plough is lifted to half depth for the last trip down the side land of the field. This leaves a shallow furrow where the finish comes



After this stage, the driver turns right and gathers round the one fourth lands already ploughed. Gathering is continued till the UN ploughed strip in first three-quarter land is ploughed and completed. This gathering reduces the first full land by a quarter (Fig. c). The remaining three quarter land can be treated in exactly the same manner as the original three quarter land completed earlier. This process is repeated for all other lands in the field.

b) Round and round ploughing

In this method, the plough moves round and round in a field. This system is adopted under conditions where ridges and furrows interfere with cultivation work. The field can be started in two ways.

a) Starting at the centre

A small plot of land is marked in the middle of the field and it is ploughed first. After that, the plough works round this small plot and the entire plot is completed. This is not a very economical method.

b) Starting at the outer end

Tractor starts ploughing at one end of the field and then moves on all the sides of the field and comes gradually from the sides to the centre of the field. Wide diagonals are left unploughed to avoid turning with the plough. There are no back furrows in this method. Conventional ploughing is usually done by this method.

c) One way ploughing

This system requires the use of a special type of plough known as reversible plough or one way plough. Such a plough turns furrows to the left or right. After the head land has been marked, the operator plough along a straight side land mark. At the end of the first trip, he turns his tractor in a loop and returns down the same furrow. No dead and back furrows are left in the field. In gently sloping fields, this method is suitable.

Field performance of machines

The rate at which a machine can cover a field while performing its intended function is one of the considerations in determining the cost of operation of the machine

- Theoretical field capacity

It is the rate of field coverage that would be obtained if the machine were performing its function 100 % of the time at the rated forward speed and always covering 100 % of its rated width, Theoretical Field capacity FCT =

$$\frac{\text{width (cm) x speed (metre / sec) x 36}}{10000} \text{ Ha/hr}$$

Another equation

Theoretical field capacity FCT = $\frac{SW}{10} ha/h$

Where

FCT = effective field capacity, hectare per hr.

S = speed of travel in km per hour.

W = theoretical width of cut of the machine in metre, and

1.Theoretical time per hectare

It is the time that would be required at the theoretical field capacity

2.Effective operating time

It is the time during which the machine is actually performing its intended function. The effective operating time per hectare is greater than the theoretical time per hectare if less than full rated width is utilized

3.**Effective field capacity**

it is the actual coverage of the machine based on the total field time. Effective field capacity is usually expressed as hectares per hour

4.**Field efficiency**

It is the ratio of effective field capacity to theoretical field capacity expressed as percent.

Field efficiency = $\frac{\text{Effectifive field capacity}}{\text{Theoretical field capacity}} \times 100$

Effective field capacity is calculated as follows

FCA = $\frac{S \times W}{10} \times \frac{E}{100}$ ha/h

Where

FCA = effective field capacity, hectare per hr.

S = speed of travel in km per hour.

W = theoretical width of cut of the machine in meter

E = field efficiency in per cent.

Soil inversion = $\frac{\text{No.of weeds seen on the surface after ploughing in the same area}}{\text{No.of weedsseen on the surface before ploughing in an area}} \times 100$

Soil pulverization

It is the quality of work performed by a plough expressed in terms of particle size distribution. It is determined by sieve analysis.

A. Problems on field capacity and field efficiency of tillage implements

i. **Theoretical field capacity**

It is the rate of field coverage of the implement, based on 100 per cent of time at the rated speed and covering 100 per cent of its rated width.

Theoretical field capacity in hectares / hr = $\frac{\text{width (cm)} \times \text{speed (metre / sec)} \times 36}{10000}$

ii. Effective field capacity

It is the actual area covered by the implement based on its total time consumed and its width.

Field efficiency

It is the ratio of effective field capacity and theoretical field capacity expressed in percent.

Field efficiency = $\frac{\text{Effectifive field capacity}}{\text{Theoretical field capacity}} \times 100$

Effective field capacity is calculated as follows

C = $\frac{S \times W}{10} \times \frac{E}{100}$

Where

C = effective field capacity, hectare per hr.

S = speed of travel in km per hour.

W = theoretical width of cut of the machine in meter, and

E = field efficiency in per cent.

I. Problem.1**.** A 5 x 20 cm double action disc harrow is operated by a tractor having a speed of 5 km/h. Calculate the actual field capacity, assuming the field efficiency of 80 percent.

Solution:

Size of the harrow (width) = 5 x 20 = 100 cm

Area of coverage = $\frac{S \times W}{10} \times \frac{E}{100}$ = (1 x 5 x 80) / 1000 = 0.4 ha/h

II. Problem 2. A 3 x 30 cm plough is moving at a speed of 4 km/h. calculate how much time it take to plough 500 x 500 m field when the field efficiency is 70 %.

- Solution

Width of the plough = 3 x 30 = 90 cm = 0.9 m

Effective field capacity= (0.9 x 4 x 70)/ 1000 = 0.25 ha/h

= 2500 m2/h

Time required = 500 x 500/ 2500 = 100 h

III. Problem.3**.** a 4 bottom 40 cm mould board plough is operating at 5.5 km/h speed with 75 % field efficiency. Calculate

What is the rate of doing work in hectares per hour?

- Solution: Width of the plough = 4 x 40 = 160 cm = 1.6m

Area covered = 1.6 x 5.5 X 75/1000= 0.66 ha/h

IV. Problem**.4.** an indigenous plough has a 20 cm wide furrow at the top and 10 cm depth. Calculate the volume of soil handled per day 8 hours if the speed of working is 2.5 km/h.

- Solution: Furrow cross section = 10 x20/2= 100 cm2

Distance traveled in 8 hours = 8 x 2.5 x 1000 = 20,000 m

Volume of soil handled = 20000 x 100/10000 = 200 m3

http://www.eagri.org/eagri50/FMP211/lec05.html

4.2. Using appropriate chemical records to assist planning for reduce chemical residue Using chemical record

4.2.1. Chemical recordkeeping:

Chemical recordkeeping is a critical aspect of regulatory compliance and safety management in various industries. Here are some key points based on the search results:

- Pesticide Record Keeping: The U.S. Department of Agriculture (USDA) administers the Federal Pesticide Recordkeeping Program, which requires certified private pesticide applicators to keep records of their use of federally restricted use pesticides (RUPs). The required elements that must be recorded within 14 days of each RUP application include the brand or product name, EPA registration number, total amount applied, date, location of application, crop, size of area treated, name of the certified applicator, and certification number
- TSCA Section 8(a)(1) .Reporting and Recordkeeping: Under the Toxic Substances Control Act (TSCA) section 8(a)(1), the EPA may require reporting and recordkeeping of information related to chemical substances or mixtures, including their common or trade name, chemical identity, molecular structure, categories of use, amounts manufactured or processed, environmental and health effects, and employee exposure data
- Employee Exposure and Medical Record Standard: The Employee Exposure and Medical Record standard (§1910.1020) requires employers to keep records of the chemicals used in the workplace, including what chemical was used, where and when it was used. This information must be kept for at least thirty years to comply with environmental requirements and ensure proper hazardous waste disposal

4.2.2. Chemical Residues and Contaminants

The USDA's Food Safety and Inspection Service (FSIS) oversees the monitoring of chemical residues in imported meat, poultry, and egg products through the import reinsertion sampling plan, which is a chemical residue monitoring program. In summary, chemical recordkeeping is a regulatory requirement aimed at ensuring the safe and responsible use of chemicals, protecting human health and the environment, and facilitating traceability and accountability in various industries.

4.2.3. Planning for reduce chemical residue

Planning for reduced chemical residue in food involves several strategies to minimize the presence of pesticides and other chemicals in food products. Here are some key steps based on the search results:

- Washing and cleaning: Washing fruits and vegetables under running water is the most effective method for removing pesticide residues and minimizing dietary intake. Washing, soaking, or dunking produce in water can help remove pesticide residues
- Choosing organic or locally grown produce**:** Opting for organic foods or produce from local farmers' markets can help reduce pesticide exposure, as these options often involve less pesticide use or allow for direct communication with farmers about their pesticide practices
- Peeling and trimming: Peeling and trimming fruits and vegetables can reduce dirt, bacteria, and pesticide residues
- Using Integrated Pest Management (IPM): IPM strategies combine cultural, biological, and chemical control methods to minimize pesticide use and maximize pest control
- Proper storage and handling: Proper storage and handling of food can help reduce the migration of pesticide residues from packaging materials to food
- Regulatory compliance: Ensuring that pesticide applicators follow label directions and adhere to regulatory requirements can help minimize the risk of unacceptable chemical residues in food. By following these strategies, consumers can plan for reduced chemical residue in food, promoting healthier and more sustainable food choices.

4.2.3.1.Factors affecting Chemical residues in crops and produce

Chemical residues in crops and produce can be affected by several factors, including:

- Formulation and properties of the chemical product: The type of chemical used, its concentration, and its properties can affect the persistence and accumulation of chemical residues in crops and produce
- Adjuvants added to the chemical product at application: Adjuvants are added to chemical products to improve their effectiveness. However, they can also affect the persistence and accumulation of chemical residues in crops and produce

- Equipment used: The type of equipment used for chemical application can affect the distribution and effectiveness of the chemical product, which can impact the persistence and accumulation of chemical residues in crops and produce
- Climatic conditions during and after application: Weather conditions, such as temperature, humidity, and rainfall, can affect the persistence and accumulation of chemical residues in crops and produce
- Crop characteristics and growth stage: The type of crop, its growth stage, and its physiology can affect the persistence and accumulation of chemical residues in crops and produce
- Rate and frequency of chemical application: The rate and frequency of chemical application can affect the persistence and accumulation of chemical residues in crops and produce
- Soil characteristics: Soil type, pH, and organic matter content can affect the persistence and accumulation of chemical residues in crops and produce
- Managing chemical residues is essential to ensure that chemicals are used correctly to minimize any chance of chemicals that may be detected as residues. Growers are responsible for ensuring that chemicals are used in accordance with good agricultural practice to minimize the risk of chemical residues being detected at unacceptable levels, above the maximum residue limit (MRL



Figure. Chemical residues

4.2.3.2. Analytical residue testing and withholding periods

Residue testing data is used to determine WHP (with holding period) statements placed on chemical product labels. A WHP is the minimum period of time that must elapse between the last application of chemical product, and the 'use' or consumption of the agricultural produce to which the chemical was applied. The WHP on a label is designed to ensure that food and fibre derived from chemically treated and crops complies with domestic market MRL's.

In Ethiopia, tolerances for chemical residue levels permissible in domestically consumed food products are set by the Ethiopian Food and Drug Authority (EFDA). The EFDA regulates the use of food additives, which must comply with both international and national food safety standards. Any food additive to be imported into Ethiopia shall be permitted by Codex Alimentarius or the country's standard concerning its use as an input for food processing with its due level

The Ethiopian standards for food and feed products comply with the Codex General Standard for Contaminants and Toxins in Food and Feed (Codex Stan 193)

This standard sets maximum residue limits (MRLs) for various pesticides and other contaminants in food and feed products. The EFDA is responsible for enforcing these standards and ensuring that food products sold in Ethiopia meet the required safety and quality standards Crops or produce with residue levels below the MRL are considered to meet GAP and are acceptable for sale and consumption.

There is a greater likelihood that produce treated off-label will contain unacceptable residues, which is why off-label chemical users are particularly at risk, as any residual effect from using the chemical off-label may be unknown. Given that there may be no MRL established, any detection could seriously impact on trade markets, both domestic and international.

There are significant penalties that may be imposed on growers that are found to be selling produce that is contaminated with unacceptable chemical residues.

4.2.3.3.Managing Off-label use of chemicals

While Agriculture Victoria encourages the use of chemicals in accordance with label directions, it is recognized that there are some situations where a chemical can be used off-label.

Managing residues when using a chemical off-label is a complex task, and growers should seek professional advice whenever possible. While each situation may be different,

There are steps that growers can take to manage residue risks.

Step 1: Examine all control options

Examine physical, cultural, biological control options and chemicals registered for use in the situation. Chemical use may be avoidable or minimized if an alternative pest control method can be used. Off-label chemical use should be only used as a last resort.

Step 2: Know the crop and situation

Knowing the crop and situation may not be as simple as it sounds. The type and growth stage of the crop can have a major effect on the uptake and degradation of a chemical.

For example, a fast, actively growing crop is more likely to degrade or disperse chemical residues within the plant.

It should not be assumed that it is safe to use a chemical according to label directions when it is used off-label in a situation that appears to be similar to the registered use, as there can be unforeseen outcomes from such a use.



Case Study 1 – Strawberry growers

Several strawberry growers used an off-label chemical to control Rutherglen bug.

The chemical was registered to control cluster caterpillar and cutworm in strawberries in Queensland and the Northern Territory and there is a MRL established for strawberries.

The growers followed the label directions for strawberries when Rutherglen bugs were problematic. In some cases, multiple applications were conducted. As a result, residues were detected in the strawberries at levels up to three times the MRL.

Climatic differences between the states and increased frequency of application were likely to have contributed to the unacceptable residue.

Step 3: Choose the chemical

Choosing an effective and safe chemical can be difficult. Growers are encouraged to seek professional advice when selecting a chemical to use. A professional can advise on issues such as the effectiveness and risks of using a particular chemical, appropriate application rates and methods. Where possible, choose a chemical that has the crop or situation listed on the label.

Care should also be taken when tank mixing with other chemicals, adjuvants or fertilisers.

Step 4: Know the intended markets

There is a risk that the market may not have an established MRL, particularly with respect to off-label use and export markets. In this situation, any detection of the chemical residue may be considered unacceptable.

Many countries have established their own MRLs for a range of produce to suit their requirements, many of which differ to those in Australia. Some countries choose to adopt the international MRLs set by the Codex Alimentarius Commission. There are also instances where there is no MRL established.

Growers supplying export markets must be aware of the differing MRL requirements for the countries they supply and factor them into their chemical use. The absence of a MRL may be a good reason to select a different chemical.

Step 5: Apply a suitable withholding period (WHP) and/or post-harvest treatment

After applying a chemical, growers should allow a suitable WHP before selling or using the treated crop or produce. In some circumstances, a post-harvest wash may assist to reduce surface residues however; this won't alter the need to adhere to any WHP's that apply.

Step 6: Testing for residues

Many chemical users are aware that unacceptable chemical residues can present problems. Unfortunately, this is often overlooked because the problem cannot be physically seen. Often, a problem isn't found until it is detected through a governmental testing program or by the produce buyer.

To manage unacceptable residues risks (particularly when using chemicals off-label), growers should send a sample of the treated crop to a National Association of Testing Authorities (NATA) accredited laboratory for chemical testing. The laboratory should be asked to test for all chemicals that are used where the crop or produce was grown, including neighbouring crops.

Growers should consider annual testing as a risk assessment tool to verify that unacceptable residues are not the product of any off-label chemical use.

If unacceptable residues are detected, the chemical user must re-examine their options and chemical use practices.



Figure. Re-examine chemical use practices.

4.3. Selecting horticultural crop variety and planning field preparation, planting; fertilizing and other treatments

When selecting horticultural crop varieties and planning field preparation, planting, fertilizing, and other treatments, several key factors should be considered.

- Variety Selection: It is crucial to select the right crop varieties based on factors such as disease resistance, growth habit, plant size, and local adaptation. For example, choosing disease-resistant varieties can help prevent the spread of diseases and reduce the need for chemical treatments
- Field Preparation: Field topography, soil type, and water availability and quality are essential considerations during field preparation. Minimizing potential production problems, such as ensuring proper soil drainage and depth, is crucial for successful vegetable production
- Water Availability: Assessing water availability and quality is vital for crop planning. Proper water supply and quality are key factors in vegetable production, and early planting to avoid heavy monsoons is recommended in some regions
- Crop Establishment: Using locally adapted varieties is important to ensure good crop establishment and high yield with acceptable grain quality. Variety selection should consider factors such as cooking characteristics, color, shape, taste, aroma, and headrice recovery
- Market Development: Considering market demand and preferences for specific crop varieties is important for successful horticultural production. Understanding consumer preferences can help in selecting the right crop varieties to grow. By considering these factors, growers can make informed decisions about crop variety selection and field preparation, ultimately contributing to successful horticultural crop production



https://www.highmowingseeds.com/wp-content/uploads/2020/02/trials_transplanting_brassicas-51415-026.jpg

4.3.1.Variety selection criteria for horticultural crop

When selecting horticultural crop varieties, there are several criteria to consider. These include:

i. Disease resistance: Choosing disease-resistant varieties can help prevent the spread of diseases and reduce the need for chemical treatments
ii. Growth habits: Consider factors such as growth habit (e.g., bush, upright, or vining), plant height, and plant size when selecting varieties
iii. Environmental adaptation: Successful varieties must perform well under a range of environmental conditions, including seasonal adaptation (e.g., early, main season, late)
iv. Horticultural quality: Select varieties that meet grower or processor quality requirements, such as taste, texture, size, shape, color, uniformity, and the amount of defects
v. Yield: The variety should have the potential to produce crops at the same or better yield

vi. Days to harvest/maturity: Choose varieties that meet grower or processor requirements based on days to harvest or maturity

vii. Grain quality: A variety should have good quality grain, especially in terms of cooking characteristics, color, shape, taste, aroma, headrice recovery, and grain characteristics

viii. Adaptability: Locally adapted varieties are preferred to ensure good crop establishment and high yield with acceptable grain quality

ix. Management considerations: Consider the specific management practices required for each variety, such as pest and disease management, irrigation, and fertilization

4.3.2.**Planning field preparation for horticultural crop**

Planning field preparation for horticultural crops involves several key steps to ensure successful growth and yield. Here are some insights based on the search results:

- Soil Testing**:** Soil testing is an essential step in field preparation, as it helps determine the soil's nutrient levels, pH, and other critical factors that may impact crop growth
- Cover Crops: Using cover crops can help improve soil health, fertility, and pH levels. Mowing and incorporating cover crops into the field is an important step before preparing beds
- Tillage: Tillage practices, such as conventional tillage, reduced tillage, or no-till systems, can vary depending on the specific needs of the crop and soil type. These practices help in breaking down residue, aerating the soil, and controlling weeds
- Soil Amendments: Adding soil amendments, such as compost, organic matter, or other soil-improving materials, can help enhance soil fertility and structure, thereby promoting healthy plant growth
- Crop Rotation: Planning crop rotations can help prevent soil erosion, suppress weeds, and improve nutrient management. Rotating crops can also help reduce the risk of disease build-up and improve overall soil health
- Water Management: Water management is crucial for successful horticultural crop production. Developing a watering schedule and ensuring proper irrigation systems are in place can help maintain optimal soil moisture levels for healthy plant growth
- Field Sanitation: Field sanitation involves practices such as removing weeds, debris, and any potential pest habitats from the field. This helps in preventing the spread of diseases and

pests. By following these steps, growers can effectively plan and prepare their fields for horticultural crop production, ensuring optimal growth and yield.

Critical factors to consider during this planning exercise are summarized as follows:

- ✓ Availability and quality of irrigation water
- ✓ Field selection
- ✓ Mechanical actions to be implemented
- ✓ Chemical needs for pre-plant soil improvement
- ✓ Tools and equipment needed for date cultivation
- ✓ Labour needs
- ✓ Irrigation design and installation;
- ✓ Leaching schedule;
- ✓ Hole preparation;
- ✓ Financial requirements and
- ✓ Time schedule.

I. **Field selection**

The area selected for the establishment of the crop plantation can influence the cost of land preparation to the extent that it may not be viable to proceed with the development at all. The authors' aim is to highlight the critical areas to be considered when selecting the land for the establishment of horticultural crop

II. **Availability of water**

Although not always realized, the date palm requires a rather large quantity of water for sustainable growth. Critical factors regarding water for irrigation purposes are:

(ii) The sustainability of the water source
(iii) The quantity of water available for irrigation
(iv) The distance to the field,
(v) The quality of the water.

III. **Soil depth**

In time date palms grow very tall and become top heavy especially during the fruit bearing stage. They therefore need sufficient room for proper root development to support the palms. Besides the importance of root development, soil depth also influences drainage and leaching possibilities. Any obstructive layers must be evaluated to determine whether they will influence root development and whether they can be corrected

IV. **Soil quality**

Date palms can grow and produce in different types of soil in both hot arid and semi-arid regions. Adaptation could go from a very sandy to a heavy clay soil. The soil quality is related to its drainage capacity mainly when soils are salty or the irrigation water is characterized with a high salt content. Sandy soils are common in most date plantations of the old world. Rare cases of clay soils (i.e. Basra-Iraq) with drainage systems are found allowing the culture of date palms. The optimum soil conditions are found where water can penetrate to at least 2 m deep.

When evaluating the soil quality, attention must be given to:

a. the soil texture which will influence the water retention capacity
b. The nutrient content to determine the corrective measures necessary for soil improvement.

V. **Soil salinity or acidity**

Plant growth is influenced by either saline or acid soil conditions which, in the end, will result in a loss of potential yield.

Saline and alkaline soils are common in date plantations and are characterized by a high concentration of soluble salts, and exchangeable sodium, respectively. Soluble salts present in these soils belong to cations: sodium, calcium and magnesium and to chloride and sulphate anions.

Saline soils have an electric conductivity (EC) of their saturated extract higher than, 4 mmhos/ cm at 25°C, with sodium absorption rate less than 15 and a pH generally less than 8.5. Saline

soils can be recognized by the presence of a white layer on the surface of the soil resulting from the high salt concentration which may harm the growth and development of date palm.

Alcaline soils are characterized by an EC of their saturated extract less than 4 mmhos/cm at 25°C with a sodium absorption rate higher than 15, and a pH higher than 8.5. Alcaline soils do contain harmful quantities of alkalis with the hydroxyl group - OH, especially NaOH. These types of soil are usually diffi cult to correct coupled with a low production resulting from low content of calcium and nitrogen. However, it is recommended to eliminate the excess of sodium by the addition of acidifying agents (gypsum, sulphate of iron or sulphur)

Saline and alkaline soils are usually the result of:

(i) An increase of the underground level caused by excessive drought situations (high evaporation

(ii) The use of high salt content water, and

(iii) Very poor drainage system.

Where date palm grows in climates of little rain, but great heat and much evaporation, irrigation or flood water evaporates quickly, and its salts are left on the surface of the soil.

The negative influence of saline conditions is:-

- High concentration of soluble salts
- High soil pH
- poor drainage and aeration
- The negative effect of sodium on the plant metabolism.

Table1 shows the relationship between crop responses and soil salinity expressed in terms of the conductivity of the saturation extract (Richards et al (1954)).

Relationship between crop response and soil salinity

Crop Response	Scale of Conductivity (Millimhos/cm at 25°C)
Salinity effects mostly negligible	0 - 2
Yields of very sensitive crops may be restricted	2 - 4
Yield of many crops restricted	
Only tolerant crops yield satisfactorily	8 - 16
Only a few very tolerant crops yield satisfactorily	17 +

Source: Richards et al., 1954.

The electrical conductivity values of the saturation extract in millimhos per cm at 25°C associated with a 50 % decrease in yield.

The numbers following $EC_e \times 10^3$ are the electrical conductivity values of the saturation extracts in millimhos per cm at 25°C associated with a 50 % decrease in yield.

According to Arar (1975), the date palm is more salt tolerant than any other fruit crop. It will survive in soils containing 3 % soluble salts; when this content goes above 6 %, the date palm will not grow. This author also studied the crop tolerance and leaching requirements of some important crops, including date palms (Table 39). It is clear from these results, that it is possible to irrigate date palms with water of a salinity of up to 3.5 mmhos/cm with no, reduction in yield provided that a leaching requirement of 7 % is provided for. A ten (10) % reduction in yield is obtained when irrigation water is of 5.3 mmhos/cm salt content and with a leaching requirement of 11 %.

a. ECe-Electrical Conductivity of soil saturation extract in milliohms per centimeter (mmohs/cm)
b. ECw-Electrical Conductivity of irrigation water in mmhos/cm
c. LR-Leaching Requirement

d. ECdw-maximum concentration of salts that can occur in drainage water under crops due to ET

N.B. For conversion to TDS as PPM multiply mmhos/cm by 640.

Soil acidity contributes towards negative plant growth and is mainly due to:

(ii) the toxic levels of certain elements (aluminium, manganese)
(iii)the deficiency of certain elements (calcium, magnesium, molybdenum)
(iv) the low availability of phosphorous
(v) A drop in the efficiency of fertilizer and water usage because of poor root development.

A. Physical land preparation

Once a suitable area for establishing the plantation is selected and the planning operation is finalized, the actual preparation can be activated. These activities are divided to structure and pace the implementation process in order to be ready for planting at the most suitable time, according to the specifi c regional climatic conditions.

B. Mechanical field preparation

The mechanical or initial soil preparation concerns mainly the preparation of a field for further detailed preparation such as irrigation system installation, whole preparation, etc. Actions, if applicable to the area, include:

- Debushing/bush clearing
- Removal of stones and rocks
- Ripping;
- Leveling of the soil.

C. Irrigation system installation

The type of irrigation system to be used will be determined by the availability of water, topographical and soil conditions. When the initial soil preparation is completed, the installation of the required irrigation system will be implemented according to the prescribed design

D. Soil improvement

The scheduling of the soil improvement programmed will depend on the date grower, as certain applications could be combined with the initial actions of soil preparation. Due to the long waiting period, planting to first production, it is a trend to establish date plantations on new soils, with the exception of areas where date palm is used for intercropping.

If new soils are considered, the soil improvement programme will mostly deal with:

b. the application of organic matter; and/or
c. The elimination of soil salinity.

E. Organic material

In general, most soils are poor in organic matter content and the improvement of this situation plays an important role in soil fertility. Some of the advantages of a higher humus content in the soil are summarized as follows:

- Enhances crumb formation which improves the respiration of the roots
- Increases the water infiltration rate
- Increases the water holding capacity
- Lowers soil compaction and crust formation
- Limits the harmful effects of alkalinity and improves the leaching of salts.

F. Salinity

In an attempt to reclaim salt affected soil, consideration should be given to:

(i) The type of salinity/alkalinity
(ii) The drainage possibilities of the soil profile
(iii) The origin or the source of salts
(iv) The quality of irrigation water
(v) The leaching of salts from the soil.

If the source of salts is identified as drainage water from higher lying areas, a cut-off canal may be sufficient to eliminate this source of "salt" supply.

Poor drainage normally goes hand in hand with soil salinity problems and therefore the improvement of the drainage potential should be addressed before any leaching programme is implemented. A soil cover (mulching) and the application of organic material will improve the water infiltration resulting in improved drainage (excluding soils with obstructive layers).

In saline soils (soluble salts present as chlorides, sulphates and/or carbonates of calcium, sodium or magnesium), only leaching will be necessary to drain the excess salts. In the case of alkaline and/or saline-alkaline soils, sodium can be replaced through the application of gypsum or acidifying agents like sulphur. Once the sodium has been replaced, a programme should be followed to leach it out.

When the irrigation water is of poor quality, proper drainage and over irrigation, without the development of a water table, is very important.

G. Hole preparation

The actual digging of the hole is one of the last actions before planting takes place, but it must be emphasized that this is not the final preparation for the planting operation itself. This is the point where the required inputs such as gypsum and organic materials are worked into the soil and a start is made with the leaching programme. The reason why the leaching is only applied at this stage is because of the relatively small area that is occupied by the date palm. If the total area had to be leached, it would become very costly with little or no benefit t in the long run.

It is recommended that a hole of 1 m^3 be prepared and that the soil from the hole be mixed with the organic material and gypsum. The soil mix is then put back into the hole, where after the site is clearly marked for positioning of the small date palm plants.

At this stage, once the hole has been prepared and closed, it is irrigated and a leaching programme implemented. The water supply will then enhance the leaching of excessive salts and contribute to the fermentation process of the organic material. Subsequent irrigation, several times (2 to 3) before planting, will also allow the mixed soil to settle in the hole.

In most soils, the early and rapid growth of the date plant is better when the holes are prepared one to two months before planting. Well-rotted manure can also be used in holes prepared and irrigated shortly before planting, but extreme care must be taken to put the manure (and fertilizers) deep enough to allow a layer of soil at least 15 to 20 cm thick to be placed between the manure and the roots of the date plant.

4.3.3.Planting horticultural crop

This is probably the most critical phase in the establishment of a new date plantation. Mistakes at this point may lead to a poor survival rate of offshoots or tissue culture-derived plants, regardless of the efforts put in during the preparation phases. The aim is to assist the date grower to execute the planting operation in a way that will ensure a high transplanting survival rate in the newly established plantation. The planting operation is divided into different activities which will be discussed separately.

- **Plant spacing**

It is difficult to prescribe definite plant spacing but there are specific factors influencing the spacing such as:

- to allow for sufficient sunlight when palms are tall
- to allow for sufficient working space within the plantation
- Provide sufficient space for root development.

Previously, the general assumption for a commercial date plantation was to use a plant spacing of 10 m × 10 m (100 palms/ha). It has, however, changed over time and a plant spacing of 9 m × 9 m (121 palms/ha; Israel) or 10 m × 8 m (125 palms/ha;Namibia), is used in modern plantations.

The planting density also depends on ecological factors (mainly humidity) and on varieties. In general, commercial plantations use 10 m × 10 m, 9 m × 9 m or 10 m × 8 m, for all varieties except for Khadrawy (dwarf variety with a small canopy) which could be planted at a higher density. The tendency to plant more closely is found when the prevailing wind is dry and extremely hot and strong. The 10 × 10 is desired in areas where humidity during the date ripening period. This wider spacing is to allow sun and wind to counteract the humidity's

influence. According to Nixon (1933), wide spacing is also recommended whenever there is considerable danger of rain damage to dates during the ripening season.

4.3.4.Fertilizer application for horticultural crop

Fertilizer application for horticultural crops is essential for optimal growth and yield. There are several methods of fertilizer application, including:

- Foliar application: Foliar fertilization involves applying nutrients to plant leaves and stems, which can be absorbed at those sites. This method is useful for supplying plants with magnesium, sulfur, and micronutrients while supplementing N-P-K needs for short or critical growth periods



https://www.earth-smart-solutions.com/cdn/shop/articles/shutterstock_1070972669_1000x.jpg?v=1553532899

- Fertigation: Fertigation is the application of soluble fertilizers through irrigation systems, a process that allows for greater flexibility in application timing and optimal placement. This method increases the rate of nutrient uptake and predictability of plant response



https://www.aces.edu/wp-content/uploads/2021/05/shutterstock_1684269736-scaled.jpg

- Broadcasting: Broadcasting involves applying fertilizers evenly over the entire area of the field. This method can be done at the time of sowing (basal application) or after planting



https://www.haifa-group.com/sites/default/files/practice/Soil-Spreader.jpg

- Band application: Band application involves applying fertilizers in bands near where developing roots will easily reach them, either to the side and below the seed rows, slightly below the seeds, or in between row



https://www.greenwaybiotech.com/cdn/shop/articles/Psoriasis_Blog-6_800x.png?v=1660235046

- Starter solutions: Starter solutions refer to the application of a solution of N, P2O5, and K2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting, particularly for vegetables
- Drip irrigation: Drip irrigation systems can be used to apply fertilizers directly to the plant roots, ensuring efficient delivery of nutrients to the plant

The choice of fertilizer application method depends on factors such as the crop, available equipment, fertilizer-pesticide combination, labor, irrigation, and tillage practices, as well as the type of fertilizer

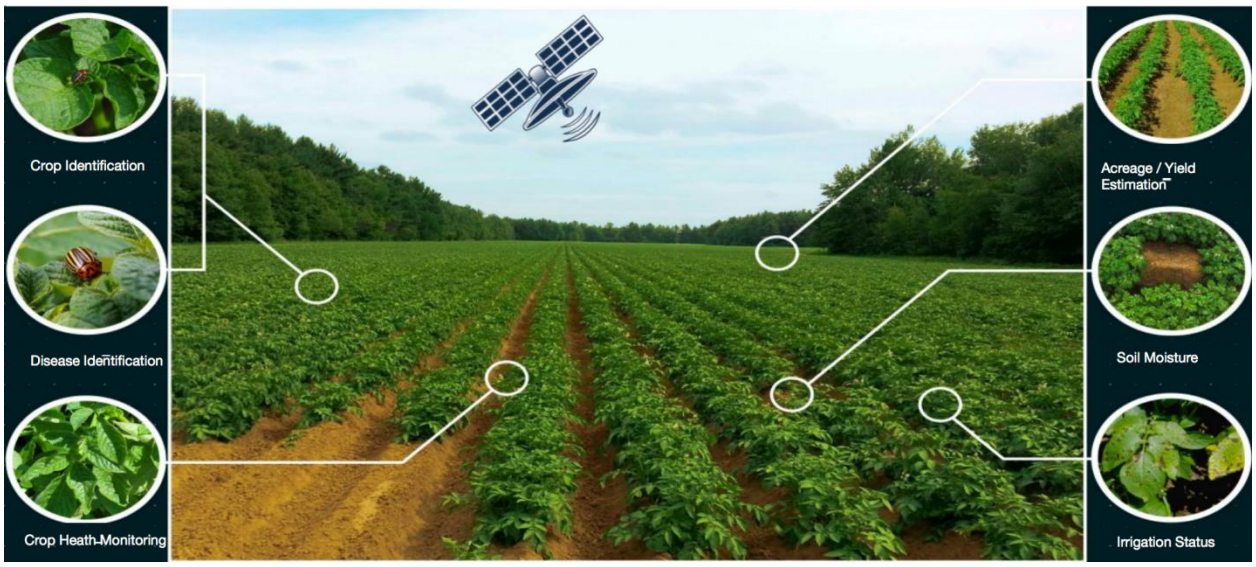
It is essential to consider the specific nutrient requirements of each horticultural crop and consult expert sources for guidance on the most appropriate fertilizer application method



4.3.5.Pest treatment of horticultural crop

Pest treatment of horticultural crops involves various methods and strategies to control pests without harming the environment or the crops them-selves. Here are some key aspects of pest treatment:

- Integrated Pest Management (IPM): IPM combines various strategies, such as cultural, biological, and chemical controls, to minimize pesticide use and maximize pest control
- Monitoring and Identification: Regularly monitor crops for pests and identify the type of pests present. This helps in determining the appropriate treatment methods and timing



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- Biological Control: Introducing natural predators or parasites of the pests can help control pest populations. This method relies on the balance between predators and prey to maintain pest populations at acceptable levels
- Cultural Control: Practices such as crop rotation, field sanitation, and weed management can help reduce the risk of pest infestations and minimize the need for chemical treatment
- Pheromone Traps: Using pheromone traps can help monitor and manage pest populations by attracting moths and other pests to the traps, reducing the need for broad-spectrum insecticides
- Botanical Control: Botanical control involves using plant-derived substances, such as extracts or essential oils, to repel or deter pests without harming the plants
- Chemical Control: When necessary, using specific miticides such as calmite, acequinocyl, Ecomite, abamectin, bifenazate, chlorfenapyr, etoxazole, and fenpyroximate can help control pest populations
- Organic Pest Management: Organic farming systems rely on prevention, monitoring, and suppression of pests through cultural, biological, and chemical controls. Monitoring and timely interventions are crucial for effective pest management in organic systems. By considering these aspects of pest treatment, growers can develop effective strategies for

managing pests in horticultural crops while promoting sustainable and environmentally friendly practices.

Pesticide Application

- Pesticide application should be done only when necessary and combined with other pest management practices in order to reduce need for frequent applications
- Minimizing the amount of pesticide use reduces cost and helps protect the environment

Pesticide Precautions

a. Observe all directions, restrictions and precautions on pesticide labels
b. Store all pesticides in original containers with labels intact
c. Keep pesticides out of reach of children
d. Use pesticides at correct label dosage and intervals to avoid building up resistance or injury to plants and animals
e. Apply pesticides carefully to avoid drift or contamination of non–target areas
f. Surplus pesticides and containers should be disposed of in accordance with label instructions
g. Follow directions on the pesticide label regarding restrictions as required by Laws and Regulations
h. Apply pesticides carefully to avoid drift or contamination of non–target areas
i. Surplus pesticides and containers should be disposed of in accordance with label instructions
j. Follow directions on the pesticide label regarding restrictions as required by Laws and Regulations

A. Applying Pesticides

Protective Clothing:

- A farmer should wear clothes that cover the body before spraying
- Recommended protective clothing are:
  - ✓ Overall
  - ✓ Boots/Shoes
  - ✓ Hat
  - ✓ Gloves
  - ✓ Eye cover and mask

- Have soap & water available to wash off pesticide that accidentally got onto skin
- Strongly recommended to rinse off the protective clothes and wash your hands and body very well after application
- Spray Volume:
- Many insects can survive under the “umbrella” of leaves if farmers only spray leaf tops by holding the nozzle above the crop
- In excessive applications, the spray runs down the tops of leaves and drips onto the soil
- Simple changes in farming practices like directing the nozzle to spray where the pest is located on the undersides of leaves or controlling spray pressure can improve crop protection product coverage and better control pests

4.4. Determining Optimum timing of planting, applications of input and preparing operational calendar

4.4.1. Time of planting for horticultural crop

For a higher plant production yield this harvest season, pay attention to when you plant your crops. Planting season is already underway, but it’s not over yet. Finding the ideal window for planting can be difficult as it shifts from season to season, crop to crop, and region to region. There is no single ideal window for planting crops, but you can predict the best time to plant for your farm. Finding the right planting dates can increase growth, development, and yield production. Here are some tips to help you find the ideal planting window for your farm.

What is the ideal planting date?

The ideal planting dates will vary due to a variety of factors, but optimum planting dates range from early April to late May. Different crops respond differently to planting dates, and weather can play a major role in planting dates and yields.

For guidance when determining this date based on regions, many local agricultural facilities have recommendations accessible to the public. As we’ve mentioned, ideal planting windows vary from state to state and year to year based on a variety of factors, so it’s important to do your research and understand the different factors that can affect yield.

Factors that impact ideal planting window

The ideal planting window for horticultural crops is impacted by several factors, including light, temperature, humidity, and the specific requirements of the plant varieties. Here are the key factors that impact the ideal planting window:

- Light: The amount of light, its intensity, duration, and quality are essential factors affecting plant growth and development. Understanding the light requirements of specific crops is crucial for determining the ideal planting window
- Temperature: Temperature plays a significant role in plant growth. Both excessively low and high temperatures can inhibit growth or cause damage to plants. Understanding the temperature requirements of horticultural crops is important for determining the optimal planting window
- Humidity: Atmospheric humidity can impact plant growth. Understanding the humidity requirements of specific crops is important for determining the ideal planting window
- Water: Adequate water supply is essential for plant growth. Understanding the water requirements of horticultural crops is crucial for determining the ideal planting window
- Nutrients: The availability of nutrients in the soil is a key factor in plant growth. Understanding the nutrient requirements of specific crops is important for determining the ideal planting window
- Horticultural Varieties and Planting Dates: Research on maize varieties emphasizes the importance of determining the best planting windows for specific crop varieties. This hybrid approach can guide farmers on the ideal planting dates for different maize varieties, contributing to informed decision-making in crop production. By considering these factors, growers can determine the ideal planting window for horticultural crops, ensuring that the plants have the best conditions for growth and development..

4.4.2. Application of input for horticultural crop

The application of input for horticultural crops, such as fertilizers, irrigation, and treatments, is increasingly being optimized through advanced technologies and precision horticulture. These approaches aim to increase yields with fewer inputs, making horticulture more sustainable and economically viable. Precision techniques, including variable-rate application of fertilizers, irrigation, and treatments, are being used to provide optimal growing conditions for horticultural plants, leading to increased economic returns and reduced environmental impact

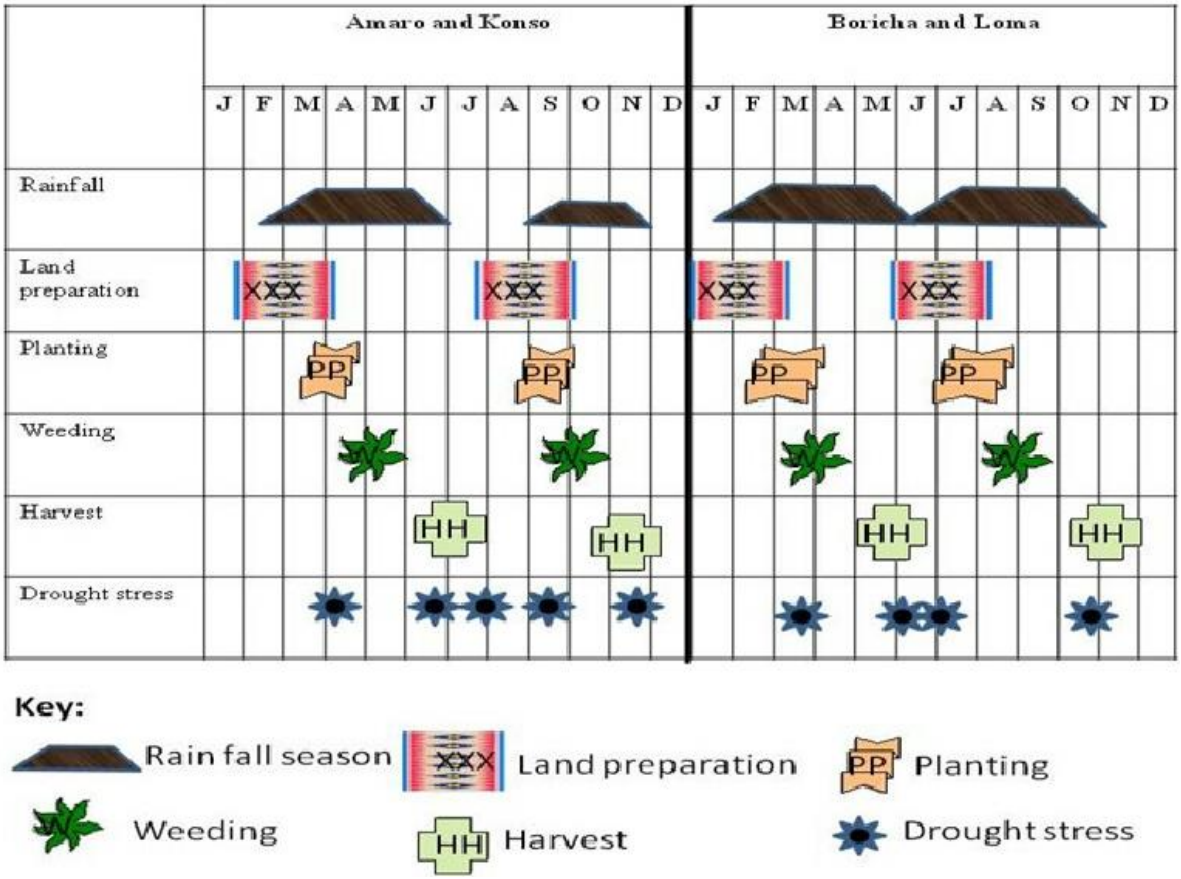
Additionally, the use of deep-learning approaches and advanced instruments and equipment is enabling the automatic identification of horticultural crops and the acquisition of planting and postharvest data, contributing to more efficient and sustainable horticultural practices

Overall, the focus is on enhancing input use efficiency in horticulture, which is essential for ensuring sustainable and productive crop production

3.1.1. Preparing operational calendar

Preparing an operational calendar for horticultural crops involves several steps to ensure successful crop production. Based on the provided search results, here are the key steps to create an operational calendar:

- Determine the best date to plant: Gather information on the best planting dates for specific crops from local experience, agricultural advisors, and leading farmers in the district
- Estimate the time from planting to harvest: The length of time from establishment to harvest is known for each variety. It may vary a little depending on the growing conditions, especially water availability and solar radiation
- Mark the planting date and other operations: Mark on the calendar the date of planting and then when each other operation needs to be done (weeding, fertilizing, harvesting)
- Determine labor, equipment, and finance requirements: Determine how much labor, equipment, and finance will be required at each step during the growing period
- List all crops and enterprises on the farm: Make a list of all crops and enterprises on the farm
- List all the operations in serial order from land preparation to harvest: List all the operations in serial order from land preparation to harvest
- Adjust the crop calendar: Adjust the crop calendar according to local climate, altitude, and specific crop requirements
- Use the calendar to guide farm activities: The crop calendar allows better planning of all farm activities and the cost of production. It can be used to plan input purchase and use, develop cash flow budgets, determine labor requirements, and organize contractors for land preparation and harvesting. By following these steps, growers can create an operational calendar for horticultural crops that takes into account local conditions and provides a roadmap for successful crop production.


Amaro and Konso
Boricha and Loma
J F M A M J J A S O N D
J F M A M J J A S O N D
Rainfall
Land preparation
Planting
Weeding
Harvest
Drought stress
XXX
PP
W
HH
Key:
Rain fall season
Land preparation
Planting
Weeding
Harvest
Drought stress

Crop	Planting Date	Harvesting Date	Planting Window
Tomatoes	Mid-May to Mid-June	Mid-September to Mid-October	June to August
Peppers	Mid-May to Mid-June	Mid-September to Mid-October	June to August
Eggplants	Mid-May to Mid-June	Mid-September to Mid-October	June to August
Lettuce	Mid-March to Mid-April	Mid-May to Mid-June	March to May
Cabbage	Mid-March to Mid-April	Mid-May to Mid-June	March to May

This table provides a general guideline for planting and harvesting horticultural crops in Ethiopia, taking into account the agricultural seasons (belg and meher) and the typical planting window for each crop. It is essential to consider local climate variations, altitude, and other factors to determine the most appropriate planting times for specific crops in different regions

3.2. Identifying and planning the requirements Labour, machinery and equipment

3.2.1. Requirements of labour

Labor requirement focuses on the amount of human labor needed for agricultural production. This measure includes a count of number of work hours, cost of labor, and seasonal supply and demand for labor.

What are tools and machinery used in horticultural production?

A hand cultivator, tractor, lawn mower, harrow, spade, secateurs, garden fork, sprinkler, rake, pruning saw spray pump, grass shear, and budding-cum-grafting knife are just a few examples of the various types of garden tools and equipment that have been developed as a result of the use of metals like iron, steel, and technology advanced

3.2.2. Machinery for Seed and Planting Material Production

i. Growing Media Siever

It is a motorized rotating screen-type media separator that may be used for farmyard manure, vermin compost, coco peat, sand, and soil. It removes any particles bigger than 1.5 mm in the form of stones, clods, straws, etc. The machine has a 1tonne/ha capacity and uses a 0.5HP engine to run.

ii. Growing Media Mixer

An electric motor-operated batch-type media mixer has been provided with peddle-type agitators cum conveyors on a shaft rotating at 9 rpm for thorough mixing. Sand, FYM, Vermi-compost, Coco-peat, etc. are thoroughly mixed in the mixer, which has a capacity ranging from 0.2 tons to 0.5 tons per batch, in 5 m

iii. Nursery Bag Filling Machine

This can fill 400 portrays, or 39,200 seedlings, every hour and is appropriate for large nurseries. The device mixes the medium and feeds it onto the bucket conveyor. The media are transported to the filling hopper by the bucket conveyor and the conveyor places the empty trays on the continuous belt.

A. Some Horticultural hand tools

Budding and grafting knife

A budding-cum-grafting knife combines two knives that are used for both grafting and budding procedures. It has two blades: one for grafting and the other for performing budding. These knives are fastened to the handle's ends. High-carbon or alloy steel is used to make both knives. The handles may be folded into the knives. The knife may be between 6.5 and 7.5 cm long and 1.5 cm wide.

i. **Pruning and Slashing knife**

It is mostly used to remove thick, unwelcome branches and twigs from plants. The carbon or alloy steel knife is snugly inserted into the wooden or plastic handle. For simple cutting or slashing of tiny branches, the knife's tip is slightly hooked or curved.

ii. **Tree Pruner**

The tree pruner is a manually driven pruning instrument used to trim branches and twigs off standing orchard trees and plants that are out of human reach in order to allow for appropriate airflow and form for easy harvesting and lighting. Essentially, it is made up of a socket, a spring-activated cutting blade, links, and an anvil with hooks.

To reach the high branches or twigs for cutting, a long wooden handle is fitted into the socket. To operate the cutting blade, a rope is fastened to the link. The blade is a crucial component of the tree pruner and is composed of alloy, tool, or high carbon steel.

3.3. Preparing Production plan

The preparation of a production plan for horticultural crops involves several key steps, including crop planning, scheduling, and resource allocation. Here are the insights from the provided search results:

- Crop Planning and Scheduling

Crop planning involves determining the best dates for planting, estimating the time from planting to harvest, and marking the calendar for each operation, such as weeding, fertilizing, and harvesting

- Scheduling planting patterns and determining the cropping pattern are essential aspects of production planning, aiming to reduce delays in work, processing time, and maximize available resources
- Resource Allocation

The production plan should consider the labor, equipment, and finance required at each step during the growing period. Pinning the calendar in a prominent place serves as a reminder of when each task needs to be done

- Calendar of Operations

Creating a calendar of operations involves listing all crops and operations in serial order from land preparation to harvest, ensuring a systematic and organized approach to crop production

- Pre-Cultivation Preparation

Market survey, soil sampling and analysis, composting, and securing quality seed/planting material are essential steps in pre-cultivation preparation, contributing to the development of a comprehensive production plan. In summary, the production plan for horticultural crops should encompass crop planning, scheduling, and resource allocation, aiming to optimize the use of labor, machinery, and equipment throughout the growing period.

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

A three bottom 40 cm M.B plough is working at a speed of 4 km/h. Calculate the effective field capacity if the field efficiency is 80 percent.

A four bottom 30 cm M.B plough is working at a speed of 4.5 km/h. Calculate the actual field capacity if the field efficiency is 70 percent.

Part I I: write True if the statement is correct and false if it is incorrect

1. Soil tillage consists of breaking compact surface of soil to certain depth and loosening the soil
2. Whenever a plough works round a strip of un ploughed land it is called casting
3. When a plough works round a strip of ploughed land it is called as Casting

Part II: Short Answer Questions

List the animal drawn primary tillage implements.

1. Define theoretical field capacity
2. Define effective field capacity
3. Define field efficiency
4. List the objectives of tillage
5. What do you mean by soil pulverization?
6. Define conservation tillage
7. Define mulch tillage

Part III. Fill in the black space

1. Preparation of soil in such a way that crop residues and other mulching materials are left on the surface is called----------?
2. The open trench left in between two adjacent strips of land after finishing the ploughing is called----------?
3. Theoretical field capacity of a double action disc harrow is 1.0 ha/h. Field efficiency is 80 %. The actual field capacity will be ----------?

LG #16	LO #5 implementing production plan

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Preparing logistical arrangement related to production, harvesting, transportation, marketing and other key operations based on the production plan.
- Preparing seed, fertilizer, pest treatments and other input requirements
- Planning and checking machinery, equipment and tools requirements for the horticultural crop production cycle.
- Implementing crops establishment and management based on the cropping calendar
- Establishing physical and financial record keeping system to provide data for the analysis of crop performance, and to meet other statutory requirements including records of chemical use.
- Reviewing and amending production plan

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Prepare logistical arrangement related to production, harvesting, transportation, marketing and other key operations based on the production plan.
- Prepare seed, fertilizer, pest treatments and other input requirements
- Plan and check machinery, equipment and tools requirements for the horticultural crop production cycle.
- Implementing crops establishment and management based on the cropping calendar
- Establish physical and financial record keeping system to provide data for the analysis of crop performance, and to meet other statutory requirements including records of chemical use.
- Review and amend production plan

Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the information Sheets 4. Accomplish the Self-checks 5. Perform Operation Sheets 6. Do the "LAP test"

Information Sheet 5

5.1.Preparing logistical arrangement of harvesting, transportation, marketing and other key operations based on the production plan

Logistics planning involves the systematic organization and management of various operations such as harvesting, transportation, and marketing based on the production plan. It is essential for companies involved in the production and movement of physical products through a supply chain. The process includes addressing distribution channels, refining processes to optimize system use, and creating contingencies to reduce waste and improve efficiency

The major functions of logistics include warehousing, inventory management, and transportation, all of which are crucial for ensuring the coordinated movement of products from manufacturers to consumers

Additionally, logistics planning aims to minimize costs, improve efficiency, and ultimately enhance customer satisfaction

For agricultural supply chains, there are optimization models available for harvest and production planning, which can provide valuable insights for effective logistical arrangements

Overall, logistics planning is a comprehensive strategy that organizes and manages goods transportation and storage throughout their lifecycle.

This definition covers the services which should be covered by the extension officer, such as providing information and advice. This role includes:

- Finding out what the customer wants
- Supplying him at a profit
- collection, evaluation and dissemination of market information;
- assistance in the planning and scheduling of production;
- securing the market for producers, e.g. through contracts with buyers;
- Advice on the best practical post-harvest practices;
- Coordination of inputs, transport, storage, credit and post-harvest facilities.

Although this definition is more comprehensive it still only describes the activities involved in marketing. The key activity of an extension officer, or any public servant concerned with improving agricultural marketing, is the commercialization of the rural economy. This involves:

finding out what the customer wants and helping to set up the production/marketing system which supplies that demand and maximizes the income of rural areas.

Progress is achieved by concerted effort. Very often the marketing officer's role is to take an overview and coordinate the efforts of others.

Why is marketing important?

The importance of good marketing can be conveniently considered from the four different perspectives of the national economy, the farmer, the product and the consumer.

At the national level as societies and countries develop there is a movement of people from the countryside into the towns and cities.

Populations in developing countries are expanding, normally at around three percent a year. Urban populations, however, are expanding on average at about four percent a year. This means that the number of people needing to be fed by the rural communities will double in 16 years. In addition, since the amount of food eaten by each individual normally increases as people become wealthier; the supply of food for the towns and cities will need to double approximately every 10 to 14 years.

This change in population distribution will create new or improved opportunities for both farmers and rural employment, particularly if new roads and improved transport are provided.

Subsistence farming (that is, just providing enough food for the farmer and the immediate family) will become less important. Although proportionately there will be fewer farmers, their role will become ever more important because their task will be to feed the growing urban populations. To do so will require the farmer to become more specialized and more skilled so that more food can be produced. The extension officer's first role in marketing is to guide and assist farmers in the process of change from subsistence farming to commercial farming. There is a role for him or her at each stage in the development of agriculture, encouraging farmers to develop new skills needed to market and sell their produce. Even in highly developed societies where farmers are acknowledged as highly skilled producers they are very often weakest at marketing.

The second important role is to try to secure and maximize rural incomes. The reasons why people move from the countryside into the town vary from country to country and from case to case. Possibly the most important factor is the high relative incomes that can be earned in the towns and on regular employment. An important part of the extension officer's role should be to

encourage and help the rural community to take control and develop the marketing of its food products. They should try to ensure that the maximum proportion of the retail price is circulated back to the rural areas.

At the farmer level the most disadvantaged farmers are those with small units of land. These farmers will find that they cannot generate sufficient funds from their small land area to support themselves and their families by growing only traditional crops, e.g. wheat and rice. They will find it difficult to compete with produce grown by large farms using mechanization.

In developed agriculture successful small farms can and do survive. We can learn lessons from their survival. Viable small farms tend to specialize in high output enterprises. These are crop or livestock systems which are capable of generating high incomes per unit of land. Typical examples in livestock are dairy and chickens, and in crops are fruit, vegetables and flowers. In the United Kingdom, for example, the average size of a cereal farm is around 120 hectares (300 acres), a dairy farm is 60 hectares (150 acres), a typical field vegetable farm would be about 30 hectares (75 acres), a fruit farm 25 hectares (63 acres) and a glasshouse holding 1.5 hectares (4 acres).

Importance of marketing for the country

The strengths and weaknesses of big and small farms are summarized in Table 1.

It is by understanding the strengths and weaknesses of both groups of farmers that it is possible to promote crops and cropping systems which favour the smaller farm. These growers need help in access to markets, by being provided with good production advice and market information to strengthen their ability to negotiate.

Horticultural products are mainly sold fresh; some are eaten raw while others are cooked. Some horticultural products have traditionally been processed when no other form of storage was available, e.g. dried fruit and jams. As society develops and becomes more affluent the market for processed and prepared horticultural products develops. A market also develops for horticultural products such as flowers and house and garden plants which are sold for purely aesthetic reasons. Increased wealth also brings with it an increased demand for product diversity in the form of new crops, off-season supplies and different flavours.

TABLE1. Strengths and weaknesses of large and small farms

Small Farms	
Strengths	Weaknesses
More labour available, especially family labour, therefore suitable for labour-intensive crops which cannot be mechanized, such as those requiring transplanting. Pruning, training and multiple hand harvesting	The need to generate high incomes from small areas
Crops requiring skilled management and attention detail	Education standards are often low, difficulty in obtaining, Information, capital and support
Growing for and servicing small specialized markets, e.g. direct sales of herbs, flowers and ornamental plants	Weak in negotiation
	Need income stability
Large Farms	
Strengths	Weaknesses
Mechanized, large-scale agricultural production for major crops like wheat, sugar cane and maize	High overhead cost
Crops which require a large capital investment	Poor at mobilizing and controlling labour
Selling produce in large volumes to major buyers	Low labour numbers per unit area necessitate avoiding time-consuming activities

Horticultural products are perhaps most easily defined as what they are not. They are not cereals or the major industrial crops. Generally, but not exclusively, they are not staple crops. Table 2 lists examples of some of the major horticultural products.

Important characteristics of horticultural crops are: that they are mainly eaten for their contribution to the flavour and interest of food and for the supply of minor but essential nutrients, especially vitamins; that they are not basic food commodities; people will put off buying if the price is too high; that consumption levels vary, depending on the selling price and the income of the buyer, that many of the crops are not traded in large volumes and there is a limited market; that the products are perishable, which means there is always a reduction in quality if they are not sold immediately, usually leading to a fall in value; that there is a wide range and variety of horticultural products (see Table 2). If one product is too highly priced the consumer will generally buy another; that the products are normally traded in a very free market where price is determined by supply and demand.

All these factors contribute to the crucial and reoccurring fact about horticultural crops: those prices, and especially the prices the farmers obtain, are variable and difficult to predict.

Take an extreme example, but one that occurs regularly:

A farmer who has high quality tomatoes to sell when few other crops are available may easily get a price equivalent to many times his growing cost. However, a farmer who is trying to sell tomatoes when the market is oversupplied and his fruit is two days old may not be able to sell his produce at all.

Wholesale prices may double or halve in the same day, depending on the skill of the salespeople and on consumer demand.

Horticultural crop prices can fluctuate widely: from year to year; from the start of the season to the main supply period; from day to day; and from market to market.

This extreme variance in price makes horticultural production potentially both very profitable and very risky. Often, success depends on marketing skills and on obtaining good prices rather than on production expertise. Table 3 gives an example of the effect that price differences can have on farmer profitability.

TABLE2. Some major horticultural products

I. Tree fruit
Orange, lemon, lime, mandarin, grapefruit, apple, mango, banana, guava, soursop, lichee, peach, apricot, pear, plum, rambutan, fig, quince, persimmon, durian, chichu, pawpaw, pomegranate, mangosteen, loquat, carambola, cherimoya, cherry, date, mulberry.
II. Vine fruit
Grape, passion fruit, kiwi fruit (or Chinese gooseberry).
III. Other fruit
Strawberry, pineapple, Cape gooseberry, watermelon, sweet melon, raspberry, blackberry, blackcurrant, gooseberry, cranberry, blueberry, rhubarb, loganberry.
IV. Tree nuts
Cashew, walnut, hazelnut, macadamia, pistachio, pecan, coconut, almond, Brazil.
V. Fruit that are normally considered as vegetables
Breadfruit, avocado, tomato, egg plant (brinjal or aubergines) hot pepper, sweet pepper, karella (or bitter gourd), squash, marrow, gourd, cucumber, luffa, pumpkin, plantain, christophine or choyote.
VI. Vegetables derived from seeds and flowers
Broccoli, cauliflower, artichoke, pea, bean, lentil, chickpea, broad bean, okra, mangetout pea, asparagus pea, yardlong bean, sweetcorn.
VII. Leaf and stem vegetables
Lettuce, cabbage, spinach, chard, brussels sprout, endive, watercress, celery, asparagus, celeriac, green onion, leek, amaranthus, bean sprout, bok choy, Chinese cabbage, Chinese celery, spinach, chicory, kohlrabi, fennel.
VIII. Root vegetables
Arrowhead, onion, potato, sweet potato, cassava, yam, taro, garlic, radish, carrot, turnip, parsnip,
beetroot, Jerusalem artichoke, dasheen, eddoe.

IX. Herbs
Parsley, mint, coriander, dill, basil, rosemary, thyme, sage.
X. Spices
Black pepper, chili pepper, cardamon, ginger, clove, cinnamon, bay leaf, turmeric.
XI. Cut flowers
Rose, chrysanthemum, carnation, gladiolus, tulip, narcissus, orchid.
XII. Cut follage
Asparagus tern, leather feat fern, soft ruscus.
XIII. Tropical plants for house and garden
Dieffenbachia, coleus, yucca, cordyline, dracaena, monstera, fatshedera, ficus, maranta.
XIV. Temperate plants for garden
Roses, ornamental shrubs, herbaceous flowers, bedding plants, conifers, flowering bulbs.

Table3. Effect of different prices farmer profit

Item	Farmer A	Farmer B	Farmer C		Farmer D
Income					
Yield/Ha (Kg)	10 000	10 000	9 000		12 000
Price/Kg	1.0	1.5	2.0		0.3
Sales	10 000	15 000	18 000		3 600
Costs					
Production	5 000	5 000	5 500		5 500
Marketing	5 000	5 000	4 500		6 000
Gross profit	-	5 000	8 000	Loss	7 900

NOTE: Marketing costs will include harvesting, packaging, grading, transport and market commissions.

As Table 3 demonstrates, farmer B made a profit because he was able to sell his produce at a 50 percent higher price than farmer A who just broke even. The example of farmer C shows that sometimes even higher profits can be obtained when lower yields are achieved, for example by off-season production. Sometimes, in situations of over-supply, prices fall so low that farmers are best advised to minimize their loss by not harvesting their crops. Farmer D would have made a lower loss if he had not bothered to harvest and market his produce.

This manual will look at some of the techniques which can be used to maximize farmer prices. These include:

- Improving the quality and presentation of the produce;
- Identifying the highest price buyer,
- Negotiating from strength;
- Scheduling production when there is limited competing supply

Equally important is the extension offficer's role in helping farmers to minimize risks. Generally, risk and profit are related. In other words highly profitable crops are often very risky. We will further explain some of the techniques available to minimize risk, such as:

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

The importance of good marketing for the consumer

In effect the extension officer has a role as the farmers' lousiness adviser. Very often farmers will already carry out some of these strategies but with discussion the techniques can be improved and new strategies introduced.

The consumer is particularly important. Finding out what the consumer wants and satisfying his demand is the key to successful marketing and, in itself, is a valuable service to society.

Fruit and vegetables are universally considered as vital elements in a healthy diet. Not only do they provide crucial vitamins and proteins, but an increasing weight of medical evidence is demonstrating broader health giving qualities. Some of these are set out below:

The fibre content of horticultural products is believed to be valuable in preventing heart disease and bowel complaints.

Vitamin C can help prevent stomach cancer and gum disease.

Vitamin D, in the vegetable-derived carotene, may reduce the incidence of lung cancer.

Lack of vitamin A causes children to go blind. Research in Indonesia showed that even well-nourished children who lack Vitamin A had greater risk of illness and even death than undernourished children with an adequate Vitamin A supply. Vitamin A is available from dark green leafy vegetables, tomatoes, carrots, pumpkins, papaya and sweet potatoes.

Generally the amount of fruit and vegetables eaten is relatively low in the developing world. The low consumption levels are normally blamed on high prices. An efficient marketing system which minimizes transport costs and particularly wastage will significantly lower retail prices. It is the challenging task of the extension officer to accelerate the introduction of more efficient marketing processes which will lead to the lowering of consumer prices. As a result of lower prices, consumption will increase, which will offer the potential for expanded production.

5.2.Preparing seed, fertilizer, pest treatments and other input requirements

To prepare for horticultural crop production, you should consider the following steps for seed, fertilizer, and pest treatment preparation:

- Seed Preparation: Select high-quality seeds and consider seed treatment methods to improve planting material, such as biological or chemical enhancement methods. Seed treatment can enhance seedling vigor, protect against pests, and improve germination rates
- Fertilizer: Test the soil for available plant nutrients before adding fertilizers. Fertilize only as needed based on the soil analysis to avoid over fertilization, which can lead to decreased flowering, fruit development, and increased pest susceptibility. Follow the recommendations on your soil analysis and consider additional fertilization for crops with long growing seasons
- Pest Treatment: Implement cultural control methods, such as proper crop selection and rotation, sanitizing the soil, and using resistant varieties to make the site unattractive to pests. Additionally, consider using flowering plants that support beneficial insects to control pests and aid pollination. Regularly monitor the crop for specific needs, such as pest outbreaks, throughout the growing season. By following these steps, you can effectively prepare for

horticultural crop production, ensuring the use of high-quality seeds, appropriate fertilization, and effective pest management.

5.3.Planning and checking machinery, equipment and tools requirements for the horticultural crop production cycle.

To plan and check machinery, equipment, and tools requirements for the horticultural crop production cycle, you can follow these steps:

- Identify the necessary equipment and tools: Determine the equipment and tools required for plant propagation, soil preparation, planting, pest and weed control, irrigation, harvesting, and post-harvest handling. Consider the scale of your operation and the specific needs of your crops
- Check equipment and tool condition: Inspect all equipment and tools to ensure they are in good working condition. Check for any damage, wear and tear, or missing parts. Repair or replace any damaged or worn equipment or tools
- Ensure proper maintenance: Regularly maintain all equipment and tools to ensure they remain in good working condition. Follow the manufacturer's instructions for maintenance and storage
- Train personnel: Train personnel on the proper use and maintenance of all equipment and tools. Ensure that all personnel are aware of safety procedures and are trained to use equipment and tools safely. By following these steps, you can effectively plan and check machinery, equipment, and tools requirements for the horticultural crop production cycle, ensuring that all equipment and tools are in good working condition and that personnel are trained to use them safely.

5.4.Implementing crops establishment and management based on the cropping calendar

Implementing crop establishment and management based on the cropping calendar involves the following steps:

- Identify the target crops: Determine the crops you want to grow and their specific requirements, such as planting time, soil type, and nutrient needs.
- Create a cropping calendar: Develop a schedule for planting, harvesting, and other management activities based on the target crops and their requirements. Consider factors such as climate, soil conditions, and labor availability
- Allocate labor and resources: Distribute labor and resources according to the cropping calendar to ensure that each crop receives the necessary attention and care. This includes allocating time for soil preparation, planting, irrigation, pest and weed control, and harvesting
- Regularly monitor and adjust: Monitor the crops regularly to ensure they are growing as planned and adjust the cropping calendar as needed. This includes adjusting planting times, irrigation schedules, and pest and weed control measures based on weather conditions and other factors. By following these steps, you can effectively implement crop establishment and management based on the cropping calendar, ensuring that each crop receives the necessary attention and care at the appropriate time. This can help maximize yields, minimize losses, and improve overall farm productivity.

5.5.Establishing physical and financial record keeping system to provide data for the analysis of crop performance, and to meet other statutory requirements including records of chemical use.

Establishing a physical and financial record-keeping system for the analysis of crop performance and to meet statutory requirements, including records of chemical use, involves several steps:

- Choose a record-keeping system: Select a suitable record-keeping system that meets your specific needs. This could be a digital platform, a spreadsheet, or a physical ledger. Consider factors such as ease of use, scalability, and integration with other tools
- Track crop performance data: Collect and record data on crop performance, including yield, planting and harvesting dates, soil type, and agronomic practice

- Use digital maps to compare critical field data layers and determine how agronomic practices can impact yield
- Monitor chemical usage: Keep detailed records of chemical applications, including fertilizers, pesticides, and herbicides. Include information on the product name, application rate, and any related safety measures
- Maintain financial records: Keep track of all financial transactions related to crop production, such as input costs, labor expenses, and sales revenues. This will help you monitor profitability and make informed decisions about future investments
- Regularly analyze data: Analyze the collected data to identify trends, patterns, and areas for improvement. Use insights from the analysis to optimize crop performance and make better decisions for future seasons
- Ensure compliance with regulations: Stay informed about any statutory requirements related to crop production and chemical use. Ensure that your record-keeping system complies with these regulations and is readily available for inspection. By following these steps, you can establish a robust physical and financial record-keeping system that provides valuable insights into crop performance and helps you meet statutory requirements related to chemical use.

Good record-keeping practices video

In this video you can learn about creating and maintaining good record-keeping practices in your business.

This video covers:

- What records you need to keep
- The best practices for record keeping
- How to keep your business's records secure.

How to keep financial records?

There are certain record-keeping requirements for businesses in Queensland, and there may be specific laws and requirements related to your industry sector.

a. Electronic record keeping

An electronic record-keeping system, such as accounting software, makes it easier to capture information, generate reports, and meet tax and legal reporting requirements.

b. Manual record keeping

You may prefer to use a simple, paper-based record-keeping system.
How long to keep records?

You must keep your records for a certain period. The length of time will depend on the type of record and your business type or industry

5.6.Reviewing and amending production plan

Production plan changes are inevitable in manufacturing operations, but they can also cause delays, waste, and inefficiencies if not managed properly. How do you handle the challenges of adjusting your production schedule, resources, and processes to meet changing customer demands, market conditions, and internal factors? In this article, we will share some tips and best practices to help you manage production plan changes effectively and efficiently.

i. Assess the impact

Before you implement any production plan changes, you need to assess the impact of the change on your current and future operations. How will the change affect your capacity, inventory, quality, costs, and delivery? What are the risks and benefits of the change? How will the change align with your strategic goals and customer expectations? You can use tools such as what-if analysis, scenario planning, and simulation to evaluate the potential outcomes of different options and compare them with your baseline plan.

ii. Communicate the change

Once you have decided on the best option for the production plan change, you need to communicate it to all the relevant stakeholders, both internally and externally. This includes your production team, suppliers, customers, and management. You need to explain the reason, scope, and timeline of the change, as well as the roles and responsibilities of each party. You also need to provide clear and consistent instructions, feedback, and support to ensure everyone is on the same page and ready to execute the change

iii.Monitor and control the change

After you have implemented the production plan change, you need to monitor and control the change to ensure it is working as expected and delivering the desired results. You need to track and measure the performance indicators, such as throughput, utilization, quality, costs, and customer satisfaction, and compare them with your original and revised targets. You also need to identify and resolve any issues, deviations, or gaps that may arise during the change process. You can use tools such as dashboards, reports, and alerts to keep track of the change progress and performance.

iv. Learn and improve from the change

Finally, you need to learn and improve from the change to enhance your production planning and scheduling capabilities and readiness. You need to review and analyze the change outcomes, feedback, and lessons learned, and identify the strengths, weaknesses, opportunities, and threats of your production plan change process. You also need to document and share the best practices, recommendations, and action plans for future improvement and optimization. You can use tools such as post-mortem analysis, root cause analysis, and continuous improvement methods to learn and improve from the change.

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part I: write true if the statement is correct and false if it is incorrect

1. Good financial record keeping maximize profits.
2. The first step in controlling any pest is the proper identification of the pest.
3. The pest method you choose should only take into consideration the cost of the pest control product
4. IPM defines the important pest management practices. 4. Biological control entails the use of natural enemies to control or suppress pests.
5. Biological control attempts to locate the native home of the pest and then find natural enemies that suppress the pest in that environment prior to introducing the enemies as a biological control program.
6. Cultivation provides long-term control of all weed species.

Part I: Short Answer Questions

1. List the benefits of good financial record keeping?
2. What should the inspection cover?
3. What is the pest treatment method in horticultural crop?

LG #17	LO #6 Monitor, evaluate and learning of crop production plan

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Determining ,monitoring and evaluation standards
- Selecting appropriate monitoring, evaluation and learning techniques
- Implementing monitoring and evaluation is at every production stage as indicated in the production plan
- Preparing and submitting feedbacks and reporting for appropriate personal.
- Modifying or amending production plan, based on the monitoring and evaluation feedbacks and reports.
- Implementing record keeping and documentation for future use

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Determine monitoring and evaluation standards
- Select appropriate monitoring, evaluation and learning techniques
- Implement monitoring and evaluation is at every production stage as indicated in the production plan
- Prepare and submit feedbacks and reporting for appropriate personal.
- Modify or amend production plan, based on the monitoring and evaluation feedbacks and reports.
- Implement record keeping and documentation for future use

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 6

6.1.Determining monitoring and evaluation standards

Determining monitoring and evaluation standards involves setting criteria to assess the effectiveness, efficiency, and quality of programs, projects, policies, and interventions

Here are some key steps to establish monitoring and evaluation standards:

- Identify program goals and objectives: Clearly define the objectives and goals of the program or intervention you are monitoring and evaluating
- Define indicators: Choose indicators that will be used to measure progress towards the program goals and objectives. These indicators should be specific, measurable, and relevant to the program
- Establish a timeline: Determine the time intervals for data collection and analysis to monitor progress and make adjustments as needed
- Develop a monitoring and evaluation plan: Create a plan that outlines the indicators, data collection methods, and roles and responsibilities for the monitoring and evaluation process
- Ensure data quality: Ensure that the data collected is accurate, reliable, and valid. This includes using appropriate data collection methods and tools, and minimizing errors and inconsistencies
- Analyze data: Regularly analyze the collected data to assess the program's progress and identify areas for improvement. Use the analysis to inform decision-making and program adjustment
- Ensure transparency and accountability: Make sure that the monitoring and evaluation process is transparent, accountable, and inclusive. Engage key stakeholders in the evaluation process and use the findings to inform future program design and implementation. By following these steps, you can establish monitoring and evaluation standards that provide valuable insights into the performance of programs and interventions, helping to inform decision-making and improve overall outcomes.

- What is Monitoring and Evaluation?

Monitoring and Evaluation is a process of continued gathering of information and its analysis, in order to determine whether progress is being made towards pre-specified goals and objectives, and highlight whether there are any unintended (positive or negative) effects from a project/ programme and its activities.

- What is a Monitoring?

Monitoring is a continuous process of collecting, analyzing, documenting, and reporting information on progress to achieve set project objectives.

It helps identify trends and patterns, adapt strategies and inform decisions for project or programme management.

- What is Evaluation?

Evaluation is a periodic assessment, as systematic and objective as possible, of an ongoing or completed project, programme or policy, its design, implementation and results. It involves gathering, analyzing, interpreting and reporting information based on credible data. The aim is to determine the relevance and fulfillment of objectives, developmental efficiency, effectiveness, impact and sustainability.

I. Purpose/Importance of Monitoring and Evaluation

Timely and reliable M&E provides information to:

Support project/programme implementation with accurate, evidence-based reporting that informs management and decision-making to guide and improve project/programme performance.

Contribute to organizational learning and knowledge sharing by reflecting upon and sharing experiences and lessons.

Uphold accountability and compliance by demonstrating whether or not our work has been carried out as agreed and in compliance with established standards and with any other stakeholder requirements Provide opportunities for stakeholder feedback. Promote and celebrate project/program work by highlighting accomplishments and achievements, building morale and contributing to resource mobilization.

Strategic management in provision of information to inform setting and adjustment of objectives and strategies

Build the capacity, self-reliance and confidence stakeholders, especially beneficiaries and implementing staff and partners to effectively initiate and implement development initiatives.

II. Characteristics of monitoring and evaluation

Monitoring tracks changes in program performance or key outcomes over time. It has the following characteristics:

- Conducted continuously
- Keeps track and maintains oversight
- Documents and analyzes progress against planned program activities
- Focuses on program inputs, activities and outputs
- Looks at processes of program implementation
- Considers program results at output level
- Considers continued relevance of program activities to resolving the health problem
- Reports on program activities that have been implemented
- Reports on immediate results that have been achieved

Evaluation is a systematic approach to attribute changes in specific outcomes to program activities. It has the following characteristics:

- Conducted at important program milestones
- Monitoring and Evaluation
- Provides in-depth analysis
- Compares planned with actual achievements
- Looks at processes used to achieve results
- Considers results at outcome level and in relation to cost
- Considers overall relevance of program activities for resolving health problems
- References implemented activities
- Reports on how and why results were achieved
- Contributes to building theories and models for change

- Attributes program inputs and outputs to observed changes in program outcomes and/or impact

III. Key benefits of Monitoring and Evaluation

a. Provide regular feedback on project performance and show any need for 'midcourse' corrections

b. Identify problems early and propose solutions

c. Monitor access to project services and outcomes by the target population

d. Evaluate achievement of project objectives, enabling the tracking of progress towards achievement of the desired goals e. Incorporate stakeholder views and promote participation, ownership and accountability

f. Improve project and programme design through feedback provided from baseline, mid-term, terminal and ex-post evaluations

g. Inform and influence organizations through analysis of the outcomes and impact of interventions, and the strengths and weaknesses of their implementation, enabling development of a knowledge base of the types of interventions that are successful (i.e. what works, what does not and why.

h. Provide the evidence basis for building consensus between stakeholders

6.2.Selecting appropriate monitoring, evaluation and learning techniques

6.2.1. Selecting monitoring techniques

Monitoring tools

- ✓ Beat sheet
- ✓ Sweep net
- ✓ Visual
- ✓ Suction
- ✓ Cut-and-bash
- ✓ Bucket
- ✓ Sticky trap (lucerne flea)
- Shelter trap

What technique should I use?

The table below indicates the most appropriate monitoring technique(s) for various pests at different crop stages.

Pest/s	Crop/s	Recommended monitoring technique
Establishment crop stage		
Earthmites	all seedling crops – winter	Visual
Lucerne flea	all seedling crops – winter	Visual
False wireworms	canola, sorghum, maize, sunflower	Soil sampling (Germinating seed baits, quadrats)
Cutworms	pulses, canola, cereals	Visual
Blackheaded pasture cockchafer	winter cereals, pasture	Soil sampling

Pest/s	Crop/s	Recommended monitoring technique
Vegetative crop stage		
Cereal Aphids *Rhopalosiphum maidis* *Rholpalosiphum padi* *Rhopalosiphum rufiabdominalis* *Metapolophium dirhodum* *Sitobium miscanthi*	winter cereals	Visual
Green peach aphid	Canola	Visual
Pulse-infesting aphids Cowpea aphid Blue green aphid	Pulses, pasture	Visual
Flowering – crop maturity stages		
Armyworm species	barley, wheat, oats, triticale, pasture	Sweep net Visual for damage, frass and larvae on ground.
Brassica-infesting aphids Cabbage aphid Turnip aphid Blue green aphid	canola	Visual
Cotton bollworm/corn earworm *Helicoverpa armigera*	chickpeas, lentils, lupins, canola summer pulses	Sweep net Cut-and-bash, Bucket Beat sheet

Pest/s	Crop/s	Recommended monitoring technique
	sorghum, maize, wheat/barley	Sorghum – Bucket
Diamondback moth	canola	Sweep net
Lucerne seed web moth	lentil, peanuts, Nato soybeans, field peas	Light trap Visual – check for eggs and larvae Visual – splitting pods to check for larvae
Mirids	summer pulses	Beat sheet
Native budworm *Helicoverpa punctigera*	chickpeas, lentils, lupins summer pulses wheat/barley canola	Sweep net Beat sheet Cut-and-bash Bucket
Pea weevil	Field peas	Sweep net
Podsucking bugs	Summer pulses	Beat sheet
Rutherglen bug	Sunflower, sorghum, canola	Bucket
Slugs	All crops	Shelter trap
Sorghum midge	Sorghum	Visual

Beat sheet

A standard beat sheet is made from yellow or white tarpaulin material with heavy dowel on each end. Beat sheets are generally between 1.3-1.5 m wide by 1.5-2.0 m deep, the larger dimensions being preferred for taller crops. The extra width on each side catches insects thrown out sideways when sampling and the sheet's depth allows it to be draped over the adjacent plant row. This prevents insects being flung through or escaping through this row



1.2m wide x 1.5 m long beat sheet and 1 m stick made from yellow plastic tarpaulin material.

How to use the beat sheet

Place beat sheet with one edge at the base of plants in the row to be sampled.

Drape the other end of the beat sheet over the adjacent row. In crops with wide row spacing (1 metre +) use inter-row space and up against base of the next row.

Using a one metre stick, shake the plants in the sample row vigorously in the direction of the beat sheet 5-10 times. This dislodges insects onto beat sheet.

Use a datasheet to record type, number and size of insects found on the beat sheet.



Note:

Reducing the number of beat sheet shakes per site greatly reduces sampling precision. The use of smaller beat sheets, such as small fertilizer bags, reduces sampling efficiency by as much as 50%.

One beat does not equal one sample. The standard sample unit is five non-consecutive one-meter long lengths of row, taken within a 20 m radius, i.e. 5 beats = 1 sample unit. This should be repeated at six locations in the field (i.e. 30 beats per field).

The more samples that are taken, the more accurate is the assessment of pest activity, particularly for pests that are patchily distributed such as pod-sucking bug nymphs



Standard sweep net with fine mesh bag

Sweep net

A sweep net is a large cloth net (about 60 cm deep) attached to a round aluminium frame (about 40 cm in diameter) with a handle (1 m in length).

The manner in which this sweep net is used can influence its effectiveness for collecting insects and, consequently, treatment decisions based on the number of insects caught.

To use a sweep net, swing it in a 180° arc so that the net rim strikes the top 25-30 cm of the canopy. Hold the net slightly less than vertical to facilitate getting the insects into the net. Each 180° arc counts as one sweep. A common practice is to take a sweep from right to left, walk a step, and take another sweep, left to right.



After taking the desired number of sweeps, quickly pull the net through the air to force all insects into the bottom of the net bag and grasp the net bag with a hand at about the mid-point. Slowly invert the net bag while releasing your grasp on the bag allowing the insects to escape and count the numbers of key species. Many slow-moving insects, such as weevil larvae, aphids, and caterpillars can be counted by turning the net onto a white pan or even the hood of a vehicle.

Divide totals by the number of sweeps to get the average number of insects per sweep. To get a good representation of insect numbers in the field, take sweep net samples in different areas of the field.

If the numbers are so large that counting in the field is difficult, the bag contents can be placed into a plastic or paper bag and the counting done after cooling the sample to slow down the insect movement. Pest management decisions, however, are generally made before such high numbers occur. Collect samples from all portions of the field but avoid unusual parts of the field, such as field edges, except where required for insects than tend to invade field from the edge e.g. aphids, pea weevils, mites.

Visual monitoring

Finding pests can sometimes be difficult for the inexperienced observer because of their small size, inconspicuous colours and/or because they hide by day.

The following tips will assist with monitoring;

Check the whole plant**.** When checking plants ensure you:

- Separate leaflets or flowers when looking for eggs or small larvae.
- Check under leaves and on stems
- Ensure that pests or beneficials present in the lower canopy are not overlooked.
- Visual checking of plants in a crop is also important for estimating how the crop is going in terms of average growth stage and other agronomic factors.
- Have a good sample size to give more accurate estimates of insect numbers
- Take a representative sample – lush areas near waterways may be more attractive to insects but this may not be representative.
- A good handlens will assist in finding small insects

Digging over the upper soil surface to uncover hidden pests (e.g. cutworm larvae, false wire worms and cockchafers) A suitable-sized soil sieve can be useful to separate insects from the soil.

Inspect underground root systems and soil beneath poorly growing plants – for underground species (e.g. Desiantha larvae or adult African black beetle which feed on cereal root systems).

Physically uncover – sift through plant material such as stubble and leaf litter for ground-dwelling insects (e.g. wireworms, weevils, earwigs and slugs) and also in the inter-row spaces (e.g. armyworms). Turn over bits of wood, stones and soil clods to find sheltering pests (e.g. weevils and slugs).

Spraying small patches of crop, such as two square metre areas, with an insecticide can kill off whatever pests are in the sample area. Inspection of this sprayed area early on the following day may expose hidden pests (e.g. weevils, false wireworms and cutworm). Laying trails of poison baits overnight and checking early on the following morning will reveal areas of a paddock where snails and slugs are most prevalent.



Suction sampler (modified vac-blower) being used to sample a vegetative crop

Suction sampling

Suction sampling (sometimes called D-vac) is a sampling method that uses a vacuum machine. Suction sampling is most effective in dry, upright vegetation less than 15 cm tall. This method is not effective for larger pests (e.g. some beetles) or those species that live below the soil surface.

A standard petrol-powered garden blower/vacuum machine may be used for suction sampling. A gauze bag or mesh container must be fitted into the suction tube to collect invertebrates while the motor is running at full speed. Place the suction tube opening directly over plants bare soil areas should be avoided. Invert the suction machine while on full revs before stopping to withdraw the sample bag or mesh container. Transfer samples into a tray where the species collected can be identified and counted.

Main species targeted with suction sampling include: earth mites, lucerne flea, weevils, mirids and predatory mites.

Cut and bash

Select individual plants – picked at random. Cut plants near ground level with secateurs. Bash plants over a large plastic rubbish bin (or similar) ,to dislodge insects. Record individual results to get average numbers per plant This can also be used to calculate the number of larvae per square meter if the plant numbers per known area or row-length are counted.

Bucket sampling

Sometimes using a beat sheet or sweep net is not suitable to check for pests in some crops. Sampling for native budworm in canola may be more effectively done by using a bucket.

- Heads can be beaten into a container to dislodge pests.
- Sample 10-20 plants
- Determine pest density according to the average crop density

Bucket sampling can also be used in other crops e.g. sorghum, and sunflowers for pests such as Helicoverpa and Rutherglen bugs.

Lucerne flea (LF) sticky trap for sampling in pastures

Cut a piece of 90mm diameter PVC pipe (140mm length) in half – length ways.

- Tape the two halves together on one side to create a hinge.
- Smear the inside of the pipe with a sticky substance (e.g. Rentokil 'Birdrid'), to a height of 80mm.
- Hold the cylinder closed and place it quickly over an area of pasture
- lucerne flea will spring up and become trapped on the inside of the cylinder
- Blowing air, in short blasts, into the top of the cylinder will disturb any remaining lucerne flea
- Remove the trap and open, counting the trapped lucerne flea as they are removed from the trap.
- Repeat the sampling and counting at 10 sites across the paddock.

After using the trap 3-10 times it needs to be cleaned and re-treated with sticky trap. The area sampled by the trap is approximately 63 cm^2 (convert the estimate of LF density to a per meter basis by multiplying by 158). Sampling should be avoided during heavy dew and cold, damp conditions.

Shelter traps

Shelter traps are useful for monitoring slugs which are active at night and difficult to locate during the day. The shelter traps provide a cool, moist, dark environment for slugs to shelter in during the day, and are easily monitored.

Shelter traps can be made from anything that provides a cool, dark, moist shelter.

Commonly carpet squares, hessian bags, terracotta tiles are used.

- Place the traps in the field when the soil is moist.
- Use traps from sowing through to establishment.
- A number of traps are required to get a good indication of slug activity as slugs can be patchy through the field.
- If seedlings are being damaged, place traps in the areas where the damage is occurring.
- Leave the traps in place and check them every few days.
- Placing a small amount of bait under each trap can increase the attractiveness of the traps.

6.3.Implementing monitoring and evaluation

The Seven Steps of Action Planning

- Define the Problem(s)
- Collect and Analyze the Data.
- Clarify and Prioritize the Problem(s)
- Write a Goal Statement for Each Solution.
- Implement Solutions: The Action Plan.
- Monitor and Evaluate.
- Restart with a New Problem, or Refine the Old Problem.

6.4.Preparing and submitting feedbacks and reporting for appropriate personal.

How do I give feedback to peers?

- Ask the person if they're in the right headspace to hear the feedback.
- Remain objective.
- Keep it constructive.
- Be clear.
- Whenever possible, lead with what the person is doing well.
- Avoid “you” statements and share your perception.
- Explain the impact of their growth.
- Offer meaningful suggestions

6.5.Modifying or amending production plan, based on the monitoring and evaluation feedbacks and reports.

How to improve the efficiency of your production planning

- Testing and defining workflow
- Establish a strategy for ordering materials
- Spot potential bottlenecks
- Implement regular personnel training
- Improving production efficiencies via automation
- Keep your company data safe and under your control

6.6.Implementing record keeping and documentation for future use

How can you improve your product documentation and record keeping?

Implementing record-keeping and documentation for future use involves several steps, including:

- Identifying the records to be kept: Determine which records need to be kept for future use, such as financial records, production records, and chemical use records.
- Developing a record-keeping system: Develop a system for organizing and storing records, such as a digital platform, a spreadsheet, or a physical ledger. Ensure that the system is easy to use, scalable, and integrates with other tools.
- Establishing retention schedules: Establish retention schedules for each type of record, based on legal, fiscal, and administrative requirements. This will help ensure that records are kept for the appropriate length of time and are available when needed.
- Ensuring data quality: Ensure that the data collected is accurate, reliable, and valid. Use appropriate data collection methods and tools, and minimize errors and inconsistencies.
- Regularly reviewing and updating records: Regularly review and update records to ensure that they remain accurate and up-to-date. This includes adding new records, removing outdated records, and making any necessary corrections. By following these steps, you can implement a record-keeping and documentation system that provides valuable information for future use. This can help you make informed decisions, improve productivity, and meet statutory requirements related to record-keeping..

Self-Check 6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part I: write true if the statement is correct and false if it is incorrect

1. Sampling should be avoided during heavy dew and cold, damp conditions.
2. After using the trap 3-10 times it needs to be cleaned and re-treated with sticky trap.
3. Suction sampling (sometimes called D-vac) is a sampling method that uses a vacuum machine.
4. Evaluation is a systematic approach to attribute changes in specific outcomes to program activities

Part II: Short Answer Questions

1. How can you improve your product documentation and record keeping?
2. How to improve the efficiency of your production planning?
3. How do I give feedback to peers?
4. What are the seven steps of action planning?

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