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Ministry of Labor and Skills

Crop production

Level-III

Based on April, 2022Version1Occupational standard (OS)

Module Title: - Applying Field Crops Establishment and Management

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Table of Contents

Introduction to the Module

This module covers the knowledge, skills and attitude required to prepare basic machinery and equipment, assess field crop condition, growth and requirements, prepare for field crop establishment, seeding/sowing the crop, apply fertilizer and amendments, monitor crop maturity requirements, and complete cleaning and hygiene operations.

LG #1	LO #1 Prepare basic machinery and equipment

Instruction Sheet

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

- Introduction to the module
- Preparing basic machinery and equipment
- Assessing Field crop condition, growth and requirements
- Preparing for Field crop establishment
- Planting/sowing the crop
- Applying fertilizer and soil amendments
- Monitoring crop maturity requirements
- Completing cleaning and hygiene operations

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 basic machinery and equipment
- Assess Field crop condition, growth and requirements
- Preparing for Field crop establishment
- Planting/sowing the crop
- Apply fertilizer and soil amendments
- Monitor crop maturity requirements
- Completing cleaning and hygiene operations

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

Introduction

Field: An area of land used for crop production

Crops: Any plant which have a beneficial effect with man's need. E.g. forest plant, horticulture plant, ornamental plants, etc.

Field crops: Herbaceous plants which can be grow in an extended area since they have a very wide ecological adaptation.

Production: The action of growing plants and obtaining their products in a large quantity.

Field crop production: Is an art and science of producing herbaceous plants which can be grown in an extended area.

Prior to planting, the soil needs to be prepared, usually by some form of tillage or chemical "burn-down"

Objectives of tillage

In general tillage is considered to accomplish the following objectives.

1. To develop a desirable soil structure for a seedbed or root bed.
2. To control weeds or other unwanted vegetation (thinning)
3. To manage plant residue
4. Minimize soil erosion by following such practices as contour tillage, listing, and proper placement of trash.
5. The control of soil moisture, temperature and aeration.

Tillage methods can be divided into three major categories, depending on the amount of crop residue they leave on the surface.

- **Conventional tillage** - Until the last decade or so the standard tillage practice for corn was use of the moldboard plow for primary tillage followed by several secondary tillages and mechanical cultivation after the crop was up. Now about two-thirds of row crops are planted without use of the moldboard plow, and mechanical cultivation is often limited to one, or no operations.
- **Reduced tillage** is usually done with a chisel plow and leaves 15% to 30% residue coverage on the soil.
- **Conservation tillage** leaves at least 30% residue coverage on the soil. Conservation tillage methods include no-till, where no tillage is done at all and seeds are placed directly into the previous season's crop residue; strip-till, in which only the narrow strip of land needed for the crop row is tilled; ridge till; and mulch till.

1.1. Selecting and confirming basic machinery and equipment

1.1.1. Tillage equipment

- The equipment used by the farmer to break and loosen the soil for a depth of 6 to 36 in. (15.2 to 91.4 cm) is called primary tillage equipment
- Basic primary tillage tools include mould board plows, disk plows, rotary tillers, chisel plows, subsoiler plough and heavy-duty disc harrows.

Figure1.1. Farm tractor and tillage implement

Tractor - a machine that provides mechanical, hydraulic, and/or electrical power to implements to perform a wide range of crop production and handling operations. Tractors are most often used to perform drawbar work (pulling equipment through the field) and PTO (power take-off) (power to rotate equipment components) work. Tractors can be equipped with rubber tires,

rubber belts, or steel tracks. A modern farm tractor is almost always equipped with a diesel engine and tractor size is measured by the amount of power that the tractor can produce at the PTO. Tractor sizes range from those with less than 40 PTO horsepower to ones that produce more than 400 horsepower. The cost of a large modern tractor can be well over $200,000.

Plow - an implement used to perform primary tillage. A number of types of plows are in common use including the **moldboard plow**, the **chisel plow**, and the **disk plow**.

The **moldboard plow** has a large frame that is equipped with a series of "bottoms," each of which consists of a steel coulter to slice through residue followed closely by a steel share that cuts the soil and an attached moldboard that is used to raise and turn over the cut "slice" of soil.

Disk plows work in a similar manner to laterally displace and invert soil through the use of concave steel disk blades.

Chisel plows use curved shanks to penetrate and "stir" the soil without inverting a soil layer. Chisel plows cause less residue disturbance than moldboard plows and are often used in conservation tillage systems.

A close-up view of a disk harrow in the field
Figure.1.2 Disk harrow

Disk Harrows (or Disk) - are implements that uses steel blades to slice through crop residues and soil. Disk blades are mounted in groups or gangs that rotate as they move forward through the soil. Front gangs move soil toward the outside of the disk while rear gangs move soil back

toward the center of the disk. A disk can be used for primary or secondary tillage.

Figure.1.3. a field shot of a tractor and disk harrow at work

Figure.1.4. a tractor and row crop cultivator working in soybeans planted with a conservation tillage system

Field Cultivator -an implement used to perform secondary tillage operations such as seedbed preparation and weed eradication. Field cultivators are equipped with steel shanks that are typically spring mounted to permit the shank to move within the soil and shatter clods. Field cultivators are constructed similarly to chisel plows, but are more lightly built. Large chisel plows can exceed 50 feet in width in the field.

ROTARY TILLER

The rotary tiller is powered from the tractor power-take-off. The rotor is equipped with a series of "L" shaped shovels, which cut into the soil due to the rotation of the rotor. In doing so the surface residue is thoroughly incorporated into the tilled soil.

1. No open furrows exist after a rotary tiller has passed;
2. Usually a field is tilled in two trips; the first shallow and the second somewhat deeper;
3. Little or no secondary tillage is required;
4. Drawbar power requirements are nearly zero because the rotor tends to move the machine forward as it works.

Sowing implements

Planting is the art of placing seeds or tubers (such as potatoes) in the soil to obtain good germination and stand. Planting equipment is any power-operated device used to place seeds, seed pieces or plant parts in or on the soil for propagation and production of food, fiber and feed crops.

- There are variation in the shape and size of the seed for different crops. Some are small (like those of teff), some are medium-sized (for instance sorghum, wheat) and some are relatively large (for example, maize, groundnut).
- The recommended method of growing each crop also varies some are grown on ridges while others are best cultivated on the flat.
- There are also different methods of planting. While most crops are grown from seed, there are some that are reproduced by planting cutting from the stem of the previous crop.
- It is thus obvious that different methods of planting will require different types of planting equipment. A machine used for planting seeds will be quite different from one designed for planting cuttings.
- There are also differences in the recommended spacing between plants and even in the depth of placement,
- Planting equipment should attribute one or more of the following, depending on the type of crop to be planted.
  a. A means of regulating the seed rate, that is the quantity of seed to be planted per given area;
  b. Means of varying the depth of planting.

c. A means of varying the distance between rows and
d. A means of varying the distance Between plants along a row

If a machine has only the first of these features it is called a **broad caster**.

A. Broadcaster- is a machine used to plant crops by regulating the seed rate that is the quantity of seed to be planted per given area and can regulate the planting depth without regulating the distinct distance b/n rows and b/n plants.

Figure1.5.brodcaster

B. Drills -are implements used to plant crops in closely spaced rows (typically four to ten inches); drills are commonly used for cereal crops such as wheat and can be used to plant soybeans**.**

C. Planters - are implements used to plant row crops (typically in row spacing ranging from 10 to 40 inches or 25 to 100 centimeter). Planters open a seed trench, meter seeds one-at-a-time, drop seeds into the seed trench, and gently cover the seed.

1.1.2. Attaching and calibrating equipment securely

One of the best things you can do to make sure your equipment is in top shape is to do a complete, walk around inspection of the machine before you use it for the first time each day. This pre-operational check is essential to insure that your equipment is in good repair and is safe to operate. A breakdown with your machinery could cost you thousands of dollars in repair costs and could also cost you a lot of money in crop losses if a mechanical breakdown causes a harvest delay. If you find any problems during your pre-operational check, make sure you correct the problem before using the machine.

Good operators will have a daily checklist of items to look at as they perform the pre-operational check. These items to check can be on a printed form, and the operator will check off the items as they are inspected. Having a list such as this will help the operator to remember all the things that they should be checking as they perform the pre-operation check.

To perform a good walk around inspection of a tractor, start at one point and check things as you go all the way around it. As you walk around, look at all fluid levels such as engine oil, coolant, fuel, and hydraulic fluid.

Look underneath the tractor; do you see any big leaks or puddles of fluid that have accumulated under the tractor? Look closely at the tires. Do they look properly inflated? What is the condition of the tires? Do the tires have big cuts or gouges in them? Observe the lug nuts and see if they appear tight.

Check the batteries to make sure they are securely held down, the connections are clean and the electrolyte level is good.

Pre-Operation Checks; Things to be checked include:

- Fuel, oil, water & other fluid leaks.
- Battery condition.
- Lug nuts and wheels.
- Tire condition & inflation level.
- Loose or defective parts.
- Operators platform/steps
- Seat belt & Seat Adjustment
- Fire extinguisher
- Lighting, brakes & steering mechanism are all functioning well.
- Whether all gauges are giving proper reading.
- The three point link with the tractor.

1.1.3. Identifying existing and potential OHS hazards and their control

- **Risks** associated with the operation of machinery and equipment in different weather and difficult terrain conditions.

- **Hazards** associated with the operation of basic machinery and equipment.

a) Many tractor accidents are caused by environmental hazards. Tractor overturns in canals, ditches and washouts are common. Highway travel, blind corners, narrow bridges and culverts, sharp turns, steep terrain, and slippery and rough surfaces are other environmental hazards.

b) Inspect the environment in which tractor drivers must operate. Identify the hazards and take action to eliminate them. Implement the following suggestions to reduce the environmental hazards:

- Increase the turning area at row ends. Give the tractor operator room for safe turns without coming too close to ditches and canals.
- Move field roads further from canals and ditches.
- Control the vegetation and/or clearly mark the location of canals, ditches, and other hazards.
- Maintain field roads. Widen the roads, bridges, and culverts. Eliminate sharp, blind corners or curves and rough or slippery surfaces.
- Eliminate or reduce tractor travel on highways. Arrange the necessary highway travel during hours when travel is light and visibility is good.
- Prune or hedge trees to improve visibility and reduce the danger of accidents caused by tree limbs.
- Remove tree stumps and other field obstacles.
- Conduct walk-through inspections of hillsides for washouts before beginning tractor operations.
- Clearly mark or fill dangerous washouts.
- Inspect the farmstead or machinery storage and service area.
- Correct dangerous traffic patterns and hazards to safe travel.

The following are OSHA (occupational safety & health acts) Standards including:

- Keep all guards in place when the machine is in operation.

- Make sure everyone is clear of machinery before starting the engine, engaging power, or operating the machine.
- Lock out electrical power before performing maintenance or service on equipment.
- Use approved methods of guarding.
- Equip all tractors with an agricultural tractor master shield on the rear power take-off.
- Guard power take-off equipment to protect employees from contact with positively driven rotating members of the power drive system.

Consider implementing recommended safe work practices, including:

- Make sure employees who operate equipment are appropriately trained and physically able to operate it safely.
- Develop a "safety first" attitude. Follow safe work practices all the time and a good example for others.
- Make sure workers are physically and mentally fit to operate machinery. Fatigue, stress, medication, alcohol, and drugs can prevent workers from safely operating equipment.
- Allow workers to take frequent breaks. Fatigue, stress, and worry can distract them from safely operating equipment.
- Follow the manufacturer's instructions whenever maintenance or adjustments are performed on any farm machinery.
- Warn anyone who might come near an operating PTO about the entanglement hazard.
- Warn employees not to wear loose-fitting clothing or jewelry near operating farm machinery.
- Ensure machinery has proper machine guarding and shielding.
- Remember to replace machine guarding after servicing equipment.
- Provide appropriate personal protective equipment such as gloves, dust masks, and ear protection for employees.
- Properly maintain equipment to help reduce machinery noise.
- Ensure employees wear hearing protection during exposures to high-intensity noise.

1.1.4. Emergency operating procedures

What is a workplace emergency?

A workplace emergency is an unforeseen situation that threatens your employees, customers or the public. It may disrupt or shut down your operations. It may cause physical or environmental damage. Emergencies may be natural or manmade.

They include events such as the following:

- fire
- fuel spillage
- gas leaks
- explosions
- road accidents
- injury from machinery and equipment
- fall, climbing accident
- swimming or diving accident
- snake bite or poisoning
- electrocution, injuries
- equipment failure
- lost workmates
- emergency as a result of environmental conditions (e.g., heat, cold, wet, snow, wind, lightning, bushfires, floods, high seas, cyclones)
- emergencies requiring evacuation
- hazardous substances and chemical spills
- internal emergencies such as loss of power or water supply and structural collapse
- serious injury events or medical emergencies
- bomb threats

- civil disorder or criminal acts such as robberies and shootings
- hostage situations or terrorism

Probably the best advice in planning for an emergency is to plan for the unexpected. Plan for worst case scenarios, that will mean that all response plans are likely to be of sufficient scope to cope with the situation.

- Minimize immediate risk to self and casualty's health and safety by isolating the hazard.
- Assess the casualty's injuries and vital signs
- Reassure casualty in a caring and calm manner and made comfortable using available resources.
- Provide first aid care in accordance with established first aid procedures.
- Sought first aid assistance is from others as appropriate

1.1.5. Relevant policies, legislation and regulations

Although there is no a clear police, legislation and regulation regarding to agriculture as a whole, the content looks like the following.

- **Occupational safety and health act**

Employers are required to provide safety operating instructions to employees when they start an assigned job and annually thereafter. Employers are to require seatbelt usage by employees when they are operating a tractor equipped with a ROPS.

Training for employees should be comprehensive and cover topics about the tractor, safe operating procedures, and rules for tractor operation.

- **Worker's Compensation Laws**

Agricultural tasks to be hazardous for youth under the age of 16. With certain exemptions, employment of youth under the age of 16 for these tasks is illegal. The law does not apply to youth under 16 who are employed, either with or without compensation, by their parents.

- **Worker Protection Standard**

Although not a farm machinery safety regulation the Worker Protection Standard (WPS) regulations of the Environmental Protection Agency (EPA) require employers to take steps to

reduce the risk of pesticide-related illness and injury to those persons who use or are exposed to pesticides on farms, forests, nurseries, and greenhouses. No size of farm operation is exempt.
The regulation requires the following:

- Employer provides information to their workers about pesticide safety, emergency procedures, and recent pesticide applications.
- Employer must properly train their workers about pesticide safety when they begin work and at least every five years.
- Each handler and early-entry worker must be provided with appropriate personal protective equipment.
- In the event of an emergency, the employer must provide transportation for any employee who has been injured in a pesticide-related incident to an appropriate medical facility for treatment.
- Employers must provide notifications (e.g., oral, written, posted) to alert employees about restricted-entry intervals.
- Commercial handlers must provide the employer with complete details about the pesticide, warnings, and safety requirements prior to use.
- Employers must provide an accessible and complete decontamination area within ¼ mile of all workers and handlers.

Self-Check 1	Written test

Name…… ID…… Date…….

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

I. Short answer questions

1. What are tools used during establish field crops production?
2. List all equipment and machines used to establish field crops.
3. Explain the functions of each equipment and machines used in field crop establishment.
4. What is a workplace emergency?

II. Match the words in A with their definition in B

Column A	column B
1. Field	A. The action of growing plants and obtaining their products
2. Crops	B. Herbaceous plants which can be grow in an extended area
3. Field crops:	C. Any plant which have a beneficial effect with man's need.
4. Production	D. An area of land used for crop production

Operation Sheet 1

1.1. select and prepare tools, equipment and machines

A. Tools and equipment'

- tractor
- tillage implements
- farm tools
- harvesting tools and machine

B. Procedures

1. Select materials provided by your supervisor and then classify the materials based on their purpose.
2. Describe the name of the materials listed in your supervisors list.
3. Go to plant science department material store and identify all the materials physically one by one.
4. Describe the use or purpose of each material.
5. Check wear and tears of each material.
6. Separate a materials which broken, have hole on containers, or can't function relative to the purpose of the work.
7. Count the number of faulty, functional or material that can be maintained very easily.
8. Finally report to your supervisor the number of faulty materials & functional materials.

LAP Test 1

Name……..ID……Date……..

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **40** minutes. The project is expected to be done by each student.

Task 1: select and prepare tools, equipment and machines

LG #2	LO #2. Assessing field crop condition, growth and requirements

Instruction Sheet

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

- Monitoring crops moisture and their needs
- Identifying pest survey and control alternatives
- Establishing sites for regular soil moisture measurement
- Measuring moisture levels and calculating soil water moisture percentage
- Calculating and applying crop water requirements.

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:

- Monitor crops moisture and their needs
- Identify pest survey and control alternatives
- Establish sites for regular soil moisture measurement
- Measure moisture levels and calculating soil water moisture percentage
- Calculate and apply crop water requirements.

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 Monitoring crops moisture and their needs

2.1.1. Monitoring soil moisture and weather condition

Before sowing the soil and weather condition should be monitored. We should have to know whether or not the soil or the weather is optimal for growing the crop. If it is not suitable for growing we should have to monitor it. Soil and weather conditions are monitored for optimal seeding conditions.

2.2 Identifying pest survey and control alternatives

2.2.1 Pests

A **Plant Pest** is a creature that harms a plant by feeding on it in various ways and sometimes leaving byproducts or acting as carriers to even more diseases.

The most common plant pests

Ants – sudden wilting may be an indicator of colony building beneath plants removing soil and causing root damage.

Aphids – come in various colors and suck sap. Stunted growth and distortion of leaves and shoots. These reproduce exponentially.

Beetles – shiny armour like appearance. Some are beneficial but are notorious for spreading Dutch Elm disease by laying eggs.

Caterpillars – a larval stage of a butterfly or moth. Various species feed on different parts of a plant.

Eelworms – microscopic worm-like creatures that are vital in breaking down organic soil matter but also cause destruction by invading the internal path of a plant. Moist conditions are required as they travel along films of moisture.

Mealybugs – tiny and oval with a white fluffy wax, mostly found indoors. Usually infect inaccessible areas such as leaf axils and bark crevices. It feeds and excretes a sticky substance that becomes black after mould colonizes.

Mites – a relative of the spider and often beneficial to the garden but in other cases cause harm by sucking sap which causes speckling of leaves with a silken web in more severe cases.

Scale Insects – shell like scale which the eggs are laid under. Hatched insects go on a feeding frenzy and excrete sticky "honeydew" for mould to colonize.

Slugs and Snails – Mostly found in alkaline soils. These slimy culprits create irregular holes in plants and attack even below ground and on new growth. Eggs often survive the winter and have been known to "home' in areas so they will return to the crime scene even if you just kindly relocate them.

2.3 Establishing sites for regular soil moisture measurement

Establishing site for regular soil moisture measurement is an important step in optimizing agricultural management. By following the steps outlined in this document, farmers can obtain accurate and representative soil moisture measurements that enable them to make informed decision about crop selection and irrigation scheduling.

The following are the steps to be followed:

Step 1: analyzing the field before establishing measurement sites: it is important to analyze the field and identify areas where moisture levels can vary significantly. Factors to consider include soil type, topography, drainage, and proximity to water sources.

Step 2: define the sampling pattern to achieve representative measurements; it is important to define a sampling pattern that provides good field coverage while minimizing the number of measurement sites required.

The optimal sampling pattern depends on the field size and shape, but commonly used pattern include a grid, random points with in a field, or transects across a field.

Step 3: determine the measurement technique: there are several techniques for measuring soil moisture, including time domain reflactometery (TDR), capacitance probes, and tensiometers. The choice of technique will depend on factors such as accuracy requirements, budget, and ease of use.

Step 4: establish measurement sites: using the sapling pattern and measurement technique define in step 2 and step 3, establish measurement sites in the field. For each site, record the location, depth at which measurement will be taken, and any other relevant information.

Step 5: collect and monitor data: collect soil moisture data from each site on regular basis (e.g. weekly or biweekly). Monitor change over time and adjust irrigation schedule accordingly to crop growth and yield.

2.4 Measuring moisture levels and calculating soil water moisture percentage

The soil moisture content indicates the amount of water present in the soil. It is commonly expressed as the amount of water (in mm of water depth) present in a depth of one meter of soil. For example: when an amount of water (in mm of water depth) of 150 mm is present in a depth of one meter of soil, the soil moisture content is 150 mm/m.

The soil moisture content can also be expressed in percent of volume. In the example above, 1 m^3 of soil (e.g. with a depth of 1 m, and a surface area of 1 m^2) contains 0.150 m^3 of water (e.g. with a depth of 150 mm = 0.150 m and a surface area of 1 m^2). This results in a soil moisture content in volume percent of:

$$\frac{0.150\,m^3}{1m^3} \times 100\% = 15\%$$

Thus, a moisture content of 100 mm/m corresponds to a moisture content of 10 volume percent.

Note: The amount of water stored in the soil is not constant with time, but may vary.

One of the important methods for measuring soil moisture is gravimetric method (direct method), it's calculated by weighing the wet soil sampled from the field, drying it in an oven,

and then weighing the dry soil. Thus gravimetric water content equals the wet soil mass minus the dry soil mass divided by the dry soil mass.

2.5 Calculating and applying crop water requirements.

How much the soil is allowed to be depleted?

The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. In other words, it is the amount of water needed by the various crops to grow optimally.

The crop water need always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favorable soil conditions (including fertility and water). The crop thus reaches its full production potential under the given environment.

The crop water need mainly depends on:

- The climate: in a sunny and hot climate crops need more water per day than in a cloudy and cool climate
- The crop type: crops like maize or sugarcane need more water than crops like millet or sorghum
- The growth stage of the crop; fully grown crops need more water than crops that have just been planted.

Self-Check 2	Written test

Name…… ID…… Date…….

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

I. Short answer question

1. Define what pest is
2. List major pest that can harm field crops and explain their damages
3. List the factor to be seen to decide crop water need

Operation Sheet 2

2.1. Pest identification

A. Tools and equipment'

- Manual or book for reference
- Lens
- Camera for picture taking
- Note book
- Pest Infested field

B. Procedures of pest identification

Procedures typically used to identify pests in crop production:

1. Observe: Start by observing the crop and the area around it. Look for any signs of damage such as wilting leaves, chewed stems or leaves, or blackened spots.

2. Identify: Once you have identified signs of damage, try to find the pest responsible for it. Look for any visible pests such as insects or mites on the plant or in the soil.

3. Research: Use resources such as books or online sources to research the pests that commonly affect your crop.

4. Test: If you're still unsure of the pest's identity, you can take a sample of the pest or damaged plant to a laboratory for identification.

5. Diagnosis: Once you've identified the pest, you can determine the severity and potential impact on your crop. This will help you decide on an appropriate treatment method.

6. Treatment: Depending on the severity of the infestation, you may need to use chemical or non-chemical methods to control the pest and prevent further damage to your crop.

LAP Test 2

Name……..ID……Date……..

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **50** minutes. The project is expected to be done by each student.

Task 1: perform pest identification

LG #3	LO #3 preparing for field crop establishment

Instruction Sheet

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

- Monitoring soil and weather conditions for optimal sowing conditions
- Applying of soil and water conservation practices
- Identifying seed source and quality
- Confirming seeding, fertilizer, and pest control requirements.
- Identifying crop calendar
- Types and methods of irrigation
- Preparing contingency plans

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:

- Monitor soil and weather conditions for optimal sowing conditions
- Identify seed source and quality
- Confirm seeding, fertilizer, and pest control requirements.
- Identify crop calendar
- Types and methods of irrigation
- Prepare contingency plans

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
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6. Do the “LAP test”

Information Sheet 3:

3.1 Monitoring soil and weather conditions for optimal sowing conditions

3.1.1. Monitoring soil condition

Soil conditions that should be considered for crop production are nutrients and water, soil moisture, soil texture, soil structure, soil temperature, soil air, soil reaction (acidity or alkalinity).

Soil texture – relates to the proportions of sand (coarse), silt (medium) and clay (fine) particles (i.e. particle size distribution) and soil organic matter content.

Soil structure – is the overall relationship between solids and spaces and is determined by how the soil particles (sand, silt, clay and organic matter) are held together into aggregates (or structural units).

A well-structured topsoil has small, rounded aggregates associated with a dense, fibrous root structure and a range of pore shapes and sizes that form a continuous network, allowing good aeration, root proliferation (to access nutrients and water) and better drainage.

Compacted soils have restricted pore space and aggregates that are either large or angular, or absent (structureless or 'massive').

Impacts of poor soil condition

Soil compaction can impact on the efficiency and economics of production in a number of ways, resulting in:

- Poor rooting and reduced crop yield and quality
- Less crop uniformity
- Poor drainage
- Reduced timeliness (fewer days when land can be worked by machinery)
- Increased fuel use: 50%+
- Higher weed/disease pressure
- Higher irrigation costs

3.1.2. Monitoring weather conditions

Climate (R.F, temperature, light, etc.)

- Climate largely determines the type of vegetation that grows naturally in any part of the world and the kinds of agriculture that are possible.
- The three most important factors in climate from the standpoint of plant response are temperature, water supply/precipitation/ and light.
- There are also other factors like humidity, solar radiation, wind and atmospheric gases but generally they are of less influence than the three mentioned.

Temperature

- It is often the factor limiting the growth and distribution of plants.
- It influences the rate of growth, development and number of flower that produce seeds.
- When temperature is below 15 ^{o}c frost or pale-yellow color of the plant parts occur. In any given locality, the length of growing season is known to vary as much as 30 days for different years.
- The ranges of maximum growth of the plant are 15-32 ^{o}C.

Water supply/irrigation availability

- Water supply is the most important factor in determining the distribution of a crop plant.
- Although total annual precipitation is important, its distribution plays an essential role in crop production.
- In case of plant growth for their seed, the most critical period or the period of greatest need for moisture, is when fertilization of the flowers is taking place.
- Crop plants differ in their water requirements, even though they are almost all require an average amount of water.

Light

- Light affects the development of crop plants mainly through affecting their structural development, their food production and the time required for certain species or varieties to produce seeds.
- Many plants are influenced by the length of day, especially in regard to flowering, fruiting, and the production of seed. This effect of light on plants is known as photoperiodism.

Some plants are known as long day plants and other as short day.

The long day plants need a comparatively long day for flowering and their vegetative growth increases when the days short. Wheat and oats are among the long day plants. The short day plants such as maize, soybean and sorghum achieve their vegetative growth when the days are long and flower and produce seed when the days are short.

3.2 Application of soil and water conservation practices.

Conservation tillage practices are tillage practices where soil and moisture are conserved by tillage practices like minimum (reduced) tillage, no (zero) tillage, and ridge tillage.

Minimum tillage

Minimum tillage is the minimum soil manipulation necessary for crop production or for meeting tillage requirements under the existing soil conditions. Minimum tillage reduces some of the practices in conventional tillage. Instead of ploughing direct harrowing (cultivation) and then planting i.e. clearing is followed by cultivation, then planting by ignoring plowing.

No or zero tillage

No tillage is a procedure whereby a planting is made directly into unprepared seedbed. It is also called chemical fallow and often referred to as a no-till system. Of course, it is not actually zero but approaches zero. Here all the practices are accomplished once at the same time.

Ridge tillage (ridge planting)

This practice uses ridges; conserves moisture and plants are planted on the ridge. In dry land areas tying the ridge about every 3 – 6 meters along the furrow will conserve much moisture by keeping the water between the tied ridges.

Conservation tillage leaves at least 30% residue cover on the ground. This simple, low-cost practice can have a huge impact on the amount of soil eroded. Because of energy savings and obvious improvements in soil quality that can result from conservation tillage

Contour farming and strip cropping is the practice of planting along the slope instead of up-and-down slopes, and planting strips of grass between row crops.

Cover crops are crops such as rye that grow in late fall and provide soil cover during winter. By providing a cover to the soil, winter soil erosion from both air and water can be greatly reduced.

Terraces are structural practices that can reduce erosion by holding back the water and routing it along a channel at a lower velocity.

Windbreaks are the best way to protect soil from wind erosion. They can be in the form of rows of shrubs or trees.

3.3 Identification of seed source and quality

Here are some important points about identifying seed source and quality:

- Check the reputation of the seed supplier: only purchase seeds from reputable suppliers who have a good track record of providing quality seeds.
- Look for certification: check if the seed supplier provides certified seeds that have been tested and proven to be of high quality.
- Packaging: check if the seeds are clearly labeled with the variety, species and name of the supplier, as well as the germination rate, purity, and date of packaging.
- Germination rate: ask for the germination rate of the seeds you wish to purchase. This information can help determine how viable the seeds are and their likelihood of success.
- Seed size and weight: bigger seeds are often healthier and produce better plants than smaller ones.
- Seed colour: check if the seeds are uniform in color, as this can indicate quality.
- Purity: look for seeds that have a high level of purity, meaning there is minimal contamination by other plant species or impurities that can affect their growth.

3.4 Confirming seeding, fertilizer, and pest control requirements

Before sowing, applying fertilizers and controlling pest and weeds we should have to confirm each method. Alternatives to such chemical methods of controlling pest and weeds may include altering management methods, considering the way that water is supplied to the crop, and using mechanical methods. Fertilizers and other amendments used will be dependent on nutrient levels, trace elements, acidity, alkalinity, texture and other physical characteristics of the soil, and the growth stage of the crop.

Pests, plant diseases, and weeds control

Pests, plant diseases, and weeds can be serious threats to crops. Chemical companies say the only solution is to spray pesticides regularly. But chemicals may cause more problems than they solve. Sustainable farming works with nature to keep crops, pests, diseases, weeds, and soil life in balance. This is called natural pest management or integrated pest management (IPM).

3.5 Identifying crop calendar

Steps in identifying a crop calendar:

1. Determine your climate zone: the first step in creating a crop calendar is identifying the climate zone you live in. this is important because different crops grow better in different climates.
2. Identify the crop you want to grow: decide on the crop you want to grow and research their planting and harvesting times. This information can often be found on the seed packets or from online resources.
3. Determine the length of the growing season: knowing the length of the growing season in your area is crucial in determining when to plant and harvest each crop.
4. Consider succession planting: succession planting is when you plant new crops immediately after harvesting others. This can help maximize your yield and keep your garden productive all season long.
5. Plan for crop rotation: crop rotation is an important practice to maintain soil health and prevent soil-borne diseases. Make sure to plan for crop rotation in your calendar.
6. Account for pest and disease management: consider incorporating pest and disease management in to your crop calendar to minimize damage to your plants.
7. Keep notes and records: it is important to keep track of planting times, yields, and any issues that arise throughout the growing season.

3.6 Types and methods of irrigation

Reasons for using Irrigation

There are many reasons why farmers invest in and use Irrigation. Some of these reasons are:

- To facilitate crop production in areas where the rainfall is insufficient or unreliable

- To enable crops to be produced 'out of season' (in the dry season), or to extend the cropping season
- To maximize the return on investment in machinery, equipment, and inputs (improved varieties, fertilizer application, and pesticide use)
- To create a suitable climate for propagation (seed germination, rooting cuttings and budding or grafting) by regulation of water application, creation of a humid environment and provision of evaporative cooling
- To support and enhance crop establishment after transplanting
- To enable the production of crops in greenhouses, e.g. flowers, fruits and vegetables for export (in Ethiopia these crops include roses, strawberries and fresh herbs)
- Controlled use and placement of water also helps with weed and pest management and efficient use of fertilizer

Method of irrigation:

Surface irrigation

Surface irrigation is the most widely practiced method of irrigation used for field crop production in Ethiopia. Surface irrigation refers to the direct application of irrigation water to the irrigated area from a supply channel at the upper part of the field and allowing water to flow by gravity over the soil surface to the lower part of the field.

Basin Irrigation:

Basin irrigation, fig 2, involves dividing the field into smaller unit areas each having a nearly level surface. Bunds or ridges are constructed around the areas forming basins within which the irrigation water can be controlled.

- **Basin and Ring Irrigation**

This method is commonly used for fruit trees in an orchard or garden.

Basins and rings are constructing around trees. Basin is usually used for small trees, whilst a ring is used for bigger trees.

- **Furrow irrigation**

Furrows are small parallel channel made to carry the water that is used to irrigate the crop. The crop is usually grown on the ridges between the furrows and is irrigated when irrigation water flows in furrow and infiltrates into the soil.

- **Drip Irrigation**

Drip irrigation is the slow, precise application of water directly to the plants' root zone in a predetermined pattern using a point source. Water is pumped from a source into a header tank then moves to the cropped area via a network of mains and sub mains to the laterals bearing the emitters.

- **Sprinkler irrigation**

This is a method of applying irrigation water which is look likes rainfall and there are many different types of equipment in use e.g. hose with shower fitting, pipes with risers and center pivot. Sprinkler irrigation is easy to use and requires little labor for operation.

3.7 Preparing contingency plans

A contingency plan is a plan devised for an outcome other than in the usual plan. It is often used for risk management for an exceptional risk that, though unlikely, would have catastrophic consequences. Contingency plans are often devised by governments or businesses.

How to prepare Contingency Plan

A contingency plan is a plan, and like any plan, it requires a great deal of research and brainstorming. And like any good plan, there are steps to take to make sure you're doing it right.

1. **Identify and Prioritize Resources:** Research your company and list its crucial resources, such as teams, tools, facilities, etc., then prioritize that list from most important to least important.

2. **What Are the Key Risks?** Figure out where you're vulnerable by meeting with teams, executives and every other department in the organization to get a full picture of what events could compromise your resources; hire an outside consultant, if necessary.

3. **Draft a Contingency Plan:** If you can, write a contingency plan for each risk that you identified in the above steps, but start with what's most critical to the life of your organization. As time permits you can create a plan for everything on your list. Whatever the

plan, the thought behind each should be the steps necessary to resume normal operation of the company, thinking about communications, people's responsibilities, timelines, etc.

4. **Share the Plan:** When you've written the contingency plan and it's been approved, the next step is to make sure everyone in the organization has a copy. A contingency plan, no matter how thorough, is not effective if it hasn't been properly communicated.

5. **Revisit the Plan:** A contingency plan isn't chiseled in stone. It must be revisited, revised and maintained to reflect changes to the organization. As new employees, technologies and resources enter the picture, the contingency plan must be updated to handle them.

Project managers are adept at creating contingency plans, as the structure and actions are like many of the processes already familiar to their profession. For instance, a contingency plan breaks down tasks to get more detail and, in so doing, more control.

The following are the key steps in contingency planning:

- Note where there are resources that can be used in an emergency. Also, note where in your contingency plan these resources might be applied.
- Identify dates that if missed will negatively impact your plan, for example getting approval from a group or committee that only meets every now and then.
- Know your contingency plan. Check for any weak links and strengthen them. Identify any slack that you can find in it.
- See if you can find points in your plan where alternative routes can be taken, and think through each one's scenario to add flexibility to your plan.
- Use your experience to help you see patterns in your project's ebb and flow of activity to sharpen your plan.

Self-Check 3	Written Test

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

Test II: Write true if the statement is true or false if the statement is false

_____ 1.Contingency plan is not required if you plant your crop under irrigation

_____ 2. Minimum tillage is the practice of applying repeated tillage/ maximum soil manipulation

Test II: Short Answer Questions

1. Discuss soil conditions that should be considered during horticultural crop establishment
2. Describe the impact of poor soil condition
3. What is contingency plan
4. Explain weather condition that should be considered during crop establishment

Operation Sheet 3

3.1 Soil moisture testing

A. Materials used

- Hand book
- Plastic bag
- Augers
- Weighing balance
- Drying oven

B. procedure

1. Choose the appropriate location: Select the area of the crop field where you want to monitor the soil moisture content. This area should be representative of the crop field's soil type, topography, and soil management practices.

2. Determine the testing depth: Based on the crop's root depth, determine the depth of soil from which you want to collect the moisture samples. You can use soil probes or augers to collect soil samples.

3. Collect Soil samples: Collect soil samples from the selected depth at different locations in the field. Use a clean tool and avoid collecting stones, roots, or any other debris with the samples.

4. Weigh the samples: Place each collected sample in a drying oven and weigh it accurately. Record its weight.

5. Dry the samples: Dry each sample by using an oven at around 110 degrees Celsius until its weight no longer changes.

6. Record the soil dry weight: After drying each sample, weigh it again and record this weight.

7. Calculate soil moisture content: Subtract the dry weight of each soil sample from its wet weight to get a measurement of water content (wet – dry = water content). Convert this water content to a percentage by dividing with the dry weight of the sample.

8. Compare Results and Maintain Record: Record your findings and compare them over time.

LAP Test 3

Name……..ID……Date……..

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **2 hrs**. The project is expected to be done by each student.

Task 1: perform soil moisture testing

LG #4 LO #4. Planting or sowing crops

Instruction Sheet

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

- Selecting, using and maintaining suitable PPE
- Planting and fertilizer applications
- Planting pattern and calculating land equivalent ratio
- Coordinating pest control, seed treatment and fertilizer applications
- Identifying, assessing and controlling environmental implications.

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:

- Select, use and maintain suitable PPE
- Plant and apply fertilizer
- Planting pattern and calculating land equivalent ratio
- Coordinate pest control, seed treatment and fertilizer applications
- Identify, assess and control environmental implications

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 4:

4.1 Selecting, using and maintaining suitable PPE

4.1.1. Purpose of PPE

The purpose of PPE is to reduce employee exposure to hazards when engineering controls and administrative controls are not feasible or effective to reduce these risks to acceptable levels.

4.1.2. Types of PPE

Personal protective clothing and equipment may include:

- Boots
- Hat/hard hat Overalls
- Gloves
- Protective eyewear
- Hearing protection
- Respirator or face mask
- Sun protection, e.g., sun hat, sunscreen

Figure 4.1 Respiratory

Foot protection: Workers must wear closed-toe shoes at all times to protect feet from chemical spills and sharp objects.

Figure 4.2 Boot

Eye protection: Use safety glasses for minor splash hazards, goggles for moderate hazards, and goggles combined with a face shield for severe hazards.

Figure 4.3 Eye goggle

Hand protection: Hand protection is indicated for the possibility of severe cuts, lacerations, or abrasions, punctures, temperature extremes, and chemical hazards.

Figure 4.4 Hand glove

Body protection: Protective clothing includes lab coats, smocks, scrub suits, gowns, rubber or coated aprons, coveralls, uniforms, and pierce-resistant jackets and vests.

Head protection: Hard hats must be worn by electricians, construction workers, and any other workers when there is a danger of objects falling from above.

Figure 4.5 Hear Protectors

Hearing protectors come in two forms: plugs and muffs. Hearing protectors should always be considered “personal” equipment and should not be used by other individuals, except for muffs that are adequately cleaned and sanitized.

Figure 4.6 Ear protection

Key Points about PPE

- Do before going to worksite
- Use carefully – don't spread contamination
- Remove and discard carefully, after finishing work
- Immediately perform hand hygiene

4.2 Planting and fertilizer applications

4.2.1. Planting

There are two different methods of crop establishment. One is by directly sowing seeds in the main field and the second is by raising seedlings in the nursery and transplanting them to the main field when they reach at a desired stage.

1. **Direct sowing**

Direct seeding may be done by broadcasting, drilling and dibbling or planting.

Broadcasting: In broadcasting method, the seeds are spread uniformly over well prepared land. It may be done by hand or mechanical spreader. Broadcasting is suitable for close planted crops that do not require specific crop or plant geometry.

Disadvantages of broadcasting

Although broadcasting is simplest and popular sowing method to farmers and other seed multiplier bodies, it has number of disadvantages:-

- Seeds at shallow depth emerge early and seeds fallen deep in the soil may not germinate.
- There is a lot of wastage of seeds.
- Agricultural operations like weeding, hoeing, and ear thing-up and bullock-drawn implements cannot perform well.
- Plant population become sparse at some places and overcrowded at other.

Drilling: Drilling is the practice is of dropping seeds in rows or lines

Advantages of drilling

- It maintains uniform plant population per unit area.
- Reduce competition between plants.
- Reduce seed rate.

A disadvantage of drilling is it requires more time, energy and cost.

1. **Nursery raising and transplanting**

Seeds are sown in small area called nursery, to raise the seedlings. When seedlings attain proper size and age, these are pulled out from nursery and transplanted in well-prepared field. The nursery raising and transplanting is completed in three steps. i.e. nursery raising, uprooting or pulling-up of seedlings and transplanting.

Advantages of nursery raising and transplanting

- It is easy, convenient and consume less time and input to nourish the young and tender seedling in the small but compact area of nursery bed
- Weak and diseased seedling can be removed at the time of transplanting
- Easy to maintain desired plant density with pure, true to type, healthy, strong and stocky seedling
- Transplanting provide enough time for ripening, after maturity of previous crop in the field and land preparation for succeeding crop in intensive cropping

Disadvantages of Nursery bed and transplanting

- Total duration of the crop may be higher

- It increases labor and power requirement to raise the crop
- It increases cost of land preparation, uprooting and transplanting the seedling

4.2.2. Fertilizing

Fertilizers are compounds given to plants to promote growth; they are usually applied either through the soil, for uptake by plant roots, or by foliar feeding.

They can be naturally occurring compounds such as peat or mineral deposits, or manufactured through natural processes (such as composting) or chemical processes (such as the Haber process). Fertilizers typically provide, in varying proportions, the three major plant nutrients (nitrogen, phosphorus, and potassium), the secondary plant nutrients (calcium, sulfur, magnesium), and sometimes trace elements (or micronutrients) with a role in plant nutrition: boron, chlorine, manganese, iron, zinc, copper, and molybdenum.

Time of application

In an effort to obtain the best results from any fertilizer application, it is important to link the stages of application to critical times over the growing period, i.e. vegetative phase, reproduction phase.

Method of application

Manual

This method is used when applying fertilizers to a plantation where the fertilizer cannot be supplied through the irrigation system. Fertilizers are then measured in small quantities and applied by hand to individual plants.

- Time consuming;
- Labor intensive;
- root burn may occur if not evenly distributed; and
- The correct amount of fertilizer is not always applied.

Through irrigation system: This method called fertigation is used when the irrigation system is designed for fertilizer application. All top dressing of soluble fertilizers are applied through the irrigation system.

4.3 Planting pattern and calculating land equivalent ratio

Deciding recommended seeding rate

Seed rate is the amount of seed required to cover a specific area. It can also be the number of plants per unit of land. Optimum number of plants per unit area or plant population per unit area required to utilize efficiently the available light, water, and carbon dioxide for better yield.

Factors that influence plant population or seed rate

Size of cultivar: Crops having tillering characteristics require less seed, dwarf cultivars require more seeds and tall cultivars-less seed since they are subjected to lodging.

Size of seed: Large seed-more seeds/ higher seed rate where as less seed rate for small-sized seeds.

Amount of moisture available: For soil with good moisture status-less seed rate is recommended.

Fertility status of the soil: good fertility-less seed rate

Germination capacity of the seed: High germination capacity-less seed rate and vice versa.

Sowing time: timely sowing require less seed rate than delayed sowing

Relationship between spacing, seed rate, and plant population

If the spacing between rows and plants is more, the seed rate required and plant population is less. **For example**, if wheat is sown 30cm x 6cm, calculate the optimum plant population per hectare

Area occupied by single plant = (30/100) m x (6/100) m=0.018m2

If plant population for 0.018m2 = 1 plant

Plant population for 10,000m2 =? Note: 1 ha = 10,000m2

So that population for 1 ha = 10,000m2/ 0.018m2 =555555 plants

Calculation of seed rate

Seed rate (Kg/ha) =Area to be sown X test weight of seed X 100 x 100 / 1000 x 1000 X G% X P% X Spacing (m2).

Example: Calculate the quantity of maize seed required for sowing 1 ha from the following **given:**

(a) 60cm X 25cm (c) P% =95%

(b) G% =90% (d) Test weight of seed =300g

Seed rate (Kg/ha) =1000 X test weight of seed X 100 X 100/1000 X 1000 X G% X P% X spacing (m2) =1000 X 300g X 100 X 100 /1000 X 1000 X90 X 95 X 0.15m2 = 300/128.25 =2.3 Kg/ha

Exercise 1. Calculate the seed rate/ ha for wheat crop

G% =90% (c) Test weight of seed =50g

P% =90% (d) Plant spacing = 6cm

(f) Row spacing =30cm

4.4 Coordinating pest control, seed treatment and fertilizer applications

Maintaining planting materials

Seed treatment is the process of applying physical, chemical or biological treatment to the seeds to keep it viable and healthy.

Seed treatment

Seed treatment pesticides include

- Bactericides
- Fungicides and
- Insecticides.

Seed treatments can be applied to vegetative propagation materials, such as bulbs, corms, or tubers (such as potato seed pieces).

Seed Pre-sowing Treatments

Pre-sowing treatments are methods applied to overcome seed dormancy to ensure rapid, uniform and timely seed germination that facilitates seedling production. Pre sowing treatments are applied to seeds immediately before sowing.

Most methods require only a few minutes to 24hours. However some pre-sowing methods require a few to several days. Appropriate pre sowing treatment methods depend on the dormancy characteristics of the seed being treated.

The most common pre-sowing treatment methods are:

- Soaking in cool water
- Soaking in hot water
- Boiled water treatment
- Scarification (acid, mechanical, manual) methods
- Fire or heating methods
- Soaking in chemicals
- Alternate wetting and drying

Seedling disease and insect pest Management

The seedling stress symptoms like damping off, wilt, root rot, rust and powdery mildew are caused by pathogen infection and results in stunted growth of seedlings.

These pathogens may be soil, seed or air borne in nature. Nurseries established in the2recently cleaned land hardly invite parasitic organisms. Stunted growth of seedlings indicates the loss of soil fertility, excess watering and dumping of seedlings in shady areas. The seedling stress symptoms like damping off, wilt, root rot, rust and powdery mildew are caused by pathogen infection and results in stunted growth of seedlings.

As a preventive measure sterilization of nursery mixture, pre-treatment of seeds with fungicide such as captain can control the disease. If the disease occurs, the casual pathogen may be identified by expression of symptoms and accordingly fungicide may be applied. Be on a constant look-out for symptoms of plant disease. However do not wait for the plants to be affected and then take remedial action. – Prevention is better than cure**.**

Methods of Controlling disease and Insect Pests

There are many methods of control of disease and pest in fruit crops, but this method can be grouped under the following:-

1. Mechanical and cultural method

2. Biological

3. Chemical

4. Legislation

5. Resistance variety

6. Integrated

Weed Control methods

Weed control is aimed at the management of weeding crop plants and elsewhere on the farmlands.

Methods of weed control can be

A. Physical and cultural

B. Chemical

C. Biological

D. Integrated

A. Physical/Mechanical and cultural Methods

The common physical methods are as following.

I) Hand pulling
II) Hoeing
III) Machine Tillage
IV) Mowing
V) Fire
VI) Mulching

B. Biological weed control

Several bioagents such as

- Insect
- Herbivorous fish
- Other animals

Disease organisms

C. Chemical Control Methods

Chemical weed control the chemicals used to control the weeds are known as "**Herbicide".**

The **Herbicides** can be classified based on

1. Time of application
2. Selectivity
3. Site of herbicide action

Fertilizing

Time of application

In an effort to obtain the best results from any fertilizer application, it is important to link the stages of application to critical times over the growing period, i.e. vegetative phase, reproduction phase. The same principle applies to date palm fertilization and therefore the time of application is co-ordinate with certain growth phases during the year.

Method of application

Manual

This method is used when applying fertilizers to a plantation where the fertilizer cannot be supplied through the irrigation system. Fertilizers are then measured in small quantities and applied by hand to individual plants. The most important precaution when applying through this method is to ensure an even distribution of the fertilizer. However, the disadvantages are:

- Time consuming;
- Labor intensive;

- root burn may occur if not evenly distributed; and
- the correct amount of fertilizer is not always applied.

A product like phosphorus, which does not move well in the soil profile, should be applied though holes within the drip area to ensure contact with the roots.

Through irrigation system

This method called fertigation is used when the irrigation system is designed for fertilizer application. All top dressing of soluble fertilizers are applied through the irrigation system.

4.5 Identifying, assessing and controlling environmental implications.

Environmental implications

The environmental impact of agriculture varies based on the wide variety of agricultural practices employed around the world. Ultimately, the environmental impact depends on the production practices of the system used by farmers.

Negative environmental implications of crop establishment may include the

- Contamination of off-site ground water or soils from solids
- Debris, nutrients or chemicals
- Land disturbance
- Spread of noxious weeds, and water run-off.

The major environmental concern related to soil preparation is **erosion**. Soil erosion is a natural process that occurs when the actions of water and/or wind cause topsoil to be removed and carried elsewhere.

Soil erosion can be caused by either water or wind. In many agricultural areas, soil is eroding at a rate of several tons of soil per acre per year or higher.

One current controversy related to planting is the choice of seeds. More and more of the seeds planted in the U.S. are genetically modified **(GMO**s) to make crop production more efficient, to

better withstand environmental stresses such as drought, flood, frost, or extreme temperatures, to protect crops against pests such as weeds, insects, or diseases, and to be resistant to herbicides

Environmental concerns related to GMOs include increased pest resistance, development of weed tolerance, and decreased genetic diversity.

Generally environmental impacts during planting operation are classified as

Positive environmental impacts may result from the conduct of sustainable land use practices including

- Stubble retention,
- Minimum tillage and contour sowing to reduce erosion risks.
- It may also include the use of non-chemical alternatives for pesticides and cleaning agents, effective water re-use systems and the reduction of noise and exhaust emissions.

Negative environmental impacts may result from high activity vehicle traffic and over-cultivation practices causing erosion, increased water run-off speeds, soil compaction, soil disturbance and loss, soil degradation, dust, contamination of soil and water through the use of fertilizer and chemicals, spray drift, incorrect use and disposal of chemicals and residues, oils and containers, greases, and detergents used in cleaning and maintenance procedures.

Self-Check 4	Written test

Name…… ID…… Date…….

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

I. Multiple choice question

1. Which one of the following is false about manual application of fertilizer
   A. Time consuming;
   B. Labor intensive;
   C. root burn may occur if not evenly distributed
   D. The correct amount of fertilizer is always applied.

2. One of the following is not Negative environmental implications of crop establishment

   A. Contamination of off-site ground water or soils from solids
   B. Debris, nutrients or chemicals
   C. Land improvement
   D. Spread of noxious weeds, and water run-off.

II. Short answer question

1. Describe the most common pre-sowing seed treatment
2. List and discuss method of crop protection
3. List personal protective equipment used during horticultural crop establishment

Operation Sheet 4

4.1 Sowing seed

A. Tools and equipment'

- Measuring tape
- Rope,
- Peg
- Watering can or pump
- Fertilizer
- Seed
- Farming tools

B. Procedures

Procedures of sowing seed are:-

1. Measure the width and the length of the prepared seed bed.
2. Divide the seed bed in to rows depending on row to spacing of the crop to be sown
3. Mark the rows with pegs at seed bed edge.

4. Connect pegs with rope

5. Mark the line from pegs to pegs following the rope

6. Follow the line; mark the space between plant to plant depending on the recommended spacing of crops.

7. Make sowing depth at the pre-determined space depending on seed size, soil type and availability of moisture

8. Placement of the seed in to the pre-determined space and depth of the soil.

9. Apply fertilizer to the recommended distance from the seed.

10. Dress the seeds and the fertilizer with soil

11. watering the seed bed to the optimum amount by using water can or pump.

4.2. Transplanting of seedling

Procedures in transplanting seedling are:

1. Irrigate the seed bed with watering can.
2. Lift the young seedling with the help of transplanting trowel.
3. Remove lower leaves.
4. Keep the seedling under shade and sprinkle water over them.
5. Take the seedling to the planting site for transplanting.
6. Transplant during evening time or on cloudy day.
7. Plant in a prepared pit after treatment with Bordeaux pest or in a furrow in nursery at proper spacing for raising root stocks.
8. Watering after transplanting

LAP Test 4

Name……..ID……Date……..

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **50** minutes. The project is expected from each student to do it.

Task 1: perform sowing a seed

LG #5	LO #5 Applying fertilizer and soil amendments

Instruction Sheet

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

- Soil amendments and fertilizer application
- Economic threshold data and action targets
- Assessing, recording and reporting crop growth stages
- Principles and method of fertilizer application
- Types, time and amount of soil amendments

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:

- Soil amendments and fertilizer application
- Economic threshold data and action targets
- Assess, record and report crop growth stages
- Principles and method of fertilizer application
- Types, time and amount of soil amendments

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. Soil amendments and fertilizer application

Soil amendment

Soil amendment refers to any material mixed into a soil and improves the physical and chemical properties of the soil.

Soil amendments are the substances used for correcting the acidity or alkalinity of the soil. In high rainfall areas, there is considerable leaching of bases leading to the formation of acidic soil, while in low land areas, saline and alkaline soils occur.

Purposes of soil amendment

Soil amendment is a material added to soil to improve plant growth and health. A conditioner or a combination of conditioners corrects the soil's deficiencies in structure and/or nutrients.

The type of conditioner added depends on:-

- The current soil composition
- Climate and
- The type of plant.

Some soils lack nutrients necessary for proper plant growth. Some hold too much or too little water, with water conservation aided in the latter. They can be incorporated into the soil or applied to the surface

Types of soil problem

Broadly there are two sets of soils as:

Physical nature:-Highly eroded soils, ravines, soils on sloping land, Soil physical constraints

Chemical nature:-saline soil, alkali soil, saline alkali soil, acidic soil.

Acidity of soil comes from H^+ and Al^{3+} ions in the soil solution and sorted to soil surfaces, basic soil soils have a high saturation of base cations (K^+, Ca^{2+}, Mg^{2+} and Na+). This is due to an accumulation of soluble salts

- saline soils have high salt concentrations, with saline soils being dominated by Ca and Mg salts
- Alkaline soils are characterized by the presence of carbonates.
- sodic soils have high salt concentrations, with saline soils being dominated by Na

Reclamation of saline soil:-

Physical approaches:-By leaching with good quality water

Biological approaches:-Mulching helps to reduce soil salinity which reduce the upward movement of salt due to decline in evaporation loss. Addition of organic matter, grow tolerant crops.

Reclamation of alkali soils:-

Physical approaches:-deep ploughing is necessary to bring the soil in good physical condition& to make the soil pervious.

Heavy irrigation is applied after the addition of gypsum to facilitate the leaching of soluble salts of Na. There should be sufficient provision for drainage.

Reclamation of acid soil:-

First of all work out the lime requirement of the acid soil in the laboratory. The liming material commonly uses along with their neutralizing value are given below.

Table 5.1 lime material commonly used for acidic soil treatment

Liming material	**Chemical formula**
Burnt lime	**CaO**
Slacked lime	**$Ca(OH)_2$**
Dolomite	**$CaMg(CO_3)_2$**

5.2. Economic threshold data and action targets

Economic threshold refers to the point at which the cost of taking action to control pests or diseases in a crop becomes less than the potential revenue lost due to the damage caused by those pests or diseases.

Action targets, on the other hand, refer to the level of pest or disease activity at which action needs to be taken to prevent damage or economic loss to the crop.

To determine economic thresholds and action targets for a particular crop, a number of factors need to be considered, such as the pest or disease species, the crop variety, the stage of development of the crop, and the weather conditions.

Once these factors have been taken into account, a decision can be made regarding whether or not action needs to be taken, and if so, what type of action is required. For instance, if a certain pest species is present in a crop but is not causing economic damage at the moment, an economic threshold might be set at a certain level of pest activity that would trigger action if it were exceeded.

This could involve scouting for the pest on a regular basis to monitor its activity. Alternatively, an action target might be set at a lower level of pest activity where action must be taken immediately to prevent further damage to the crop.

5.3.Assessing, recording and reporting crop growth stages

Records are important to the financial health of your farm. Good records do not ensure your farm will be successful; however, success is unlikely without them. Farm records are like report cards students receive in school. With a farm report card, you can tell how well you are managing your operation compared with other producers in your "classes.

You also can see the strengths and weaknesses of your farm operation. Besides use as a management tool, farm records are essential for preparing income tax reports. Also, most banks require extensive records from farmers to formulate credit ratings. Finally, records are important in establishing eligibility for participation in government programs, determining the proper level of insurance coverage, and negotiating lease arrangements.

There are three basic types of farm records:

(1) Resource inventories

(2) Production accounts of livestock and crop operations, and

(3) Income and expense records.

5.4.Principles and method of fertilizer application

5.4.1. Principles of fertilizer application

Fertilizers are compounds given to plants to promote growth; they are usually applied either through the soil, for uptake by plant roots, or by foliar feeding, for uptake through leaves. Fertilizers can be organic (composed of organic matter), or inorganic (made of simple, inorganic chemicals or minerals).

They can be naturally occurring compounds such as peat or mineral deposits, or manufactured through natural processes (such as composting) or chemical processes (such as the Haber process). Fertilizers typically provide, in varying proportions, the three major plant nutrients (nitrogen, phosphorus, and potassium), the secondary plant nutrients (calcium, sulfur, magnesium), and sometimes trace elements (or micronutrients) with a role in plant nutrition: boron, chlorine, manganese, iron, zinc, copper, and molybdenum.

Part of the fertilization program starts at the time prior to transplanting, during the land preparation phase. At that stage, attention is to be given to the improvement of the soil which may have a direct influence on the utilization of certain nutrients which are necessary for plant growth.

5.4.2. Method of fertilizer application

Manual

This method is used when applying fertilizers to a plantation where the fertilizer cannot be supplied through the irrigation system. Fertilizers are then measured in small quantities and applied by hand to individual plants. The most important precaution when applying through this method is to ensure an even distribution of the fertilizer. However, the disadvantages are:

- Time consuming;
- Labor intensive;
- root burn may occur if not evenly distributed; and
- the correct amount of fertilizer is not always applied.

A product like phosphorus, which does not move well in the soil profile, should be applied though holes within the drip area to ensure contact with the roots.

Through irrigation system

This method called fertigation is used when the irrigation system is designed for fertilizer application. All top dressing of soluble fertilizers are applied through the irrigation system.

5.5.Types, time and amount of soil amendments

Soil amendments are materials that are added to soil to improve its physical or chemical properties. There are many different types of amendments, including organic materials like compost, manure, and straw, as well as inorganic materials like lime, gypsum, and vermiculite.

The exact type and amount of amendment needed will depend on the specific characteristics of your soil and the goals you have for improving it.

In general, a soil test can help determine the specific nutrient or pH imbalances that may be present in your soil and inform what type of amendment may be needed.

As for the amount of amendment needed, this will also vary depending on factors like the size of your garden or growing area and the specific amendment being used. In general, it's important not to over-apply amendments, as this can lead to nutrient imbalances or other issues. It's typically best to follow application recommendations provided on product labels or by a soil testing professional.

Self-Check 5	Written Test

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

I. short answer question

1. Discuss soil amendment
2. List the three basic types of farm records
3. Define Economic threshold
4. Discuss the approaches to reclamation of saline soil

Operation Sheet 5

5.1.reclamation of acidic soil using lime

A. **Tools and equipment'**

- Measuring tape
- Rope,
- Peg
- lime
- water
- Farming tools

B. Procedures

Procedures for treating acidic soil are:-

1. Test the soil to determine its pH level and the appropriate amount of lime needed.
2. Choose the correct type of lime to use. Agricultural lime is commonly used and is typically made of ground limestone or chalk.
3. Divide the farm land in to four equal parts, and divide the lime in to four equal part
4. Apply the lime to the soil in the recommended quantity and mix it into the topsoil, as determined by the soil test report.
5. Avoid applying excessive amounts of lime, which may lead to over-alkaline conditions and can inhibit plant growth.
6. Allow the soil to rest for several weeks while monitoring its pH level.
7. After a few weeks, test the soil again, and repeat steps 2-5 if necessary until the soil pH is effectively neutralized.

LAP Test 5

Name……..ID……Date……..

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **50** minutes. The project is expected from each student to do it.

Task 1: undertake reclamation of acidic soil

LG #6	LO #6. Monitoring crop maturity requirements

Instruction Sheet

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

- Assessing, recording and reporting crop growth stages
- Monitoring crop maturity
- Identifying the crop maturity indicators
- Time and method of harvesting

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, record and report crop growth stages
- Monitor crop maturity
- Identify the crop maturity indicators
- Time and method of harvesting

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 Assessing, recording and reporting crop growth stages

Assessing, recording, and reporting crop growth stages can be an important task for farmers or anyone involved in agriculture. Here are some steps you can follow to effectively assess, record, and report crop growth stages:

1. Know the plant species: Understanding the growth stages of the plants you're working with is key. Different plants have unique characteristics and growth patterns, so it's important to familiarize yourself with these details.

2. Use a reference guide: Many agricultural organizations provide reference guides that can help identify different growth stages for various crops. These guides typically include pictures, descriptions, and other helpful information.

3. Observe crop regularly: Regular observation is necessary to accurately track crop growth stages. Make sure to inspect crops frequently, so that you can catch any changes or developments as soon as possible.

4. Record growth stage: It can be helpful to maintain detailed notes about crop growth stages. These records might include information about when certain stages began, how long they lasted, and any relevant developmental milestones.

5. Report stage progression: Reporting crop growth stage progression can be important for tracking development over time. This might involve creating daily or weekly reports that detail specific changes or milestones, or providing periodic updates about overall progress.

By following these steps, you'll be better equipped to assess, record, and report crop growth stages accurately and efficiently. Remember that regular observation and note-taking are key!

6.2 Monitoring crop maturity

Crop maturity: It is as one of the stages of plant growth and development which indicates the time when a given crop has its own optimum flavor and texture for fresh eating or processing.

It is also defined as an indication of the crop's development and its progress toward becoming a marketable product.

Maturity type of a crop

A. Physiological maturity

It is the stage of development when maximum growth and maturation of the crop has occurred. A given crop is considered to be at physiological maturity when the translocation of photosynthesis is stopped to the economic parts and produce gains characteristic size and shape.

B. Commercial (horticultural maturity)

It is the stage of development required by the market. Commercial or complete maturity generally occurs 4-7 days after physiological maturity. After identifying the maturity status of a given crop, it is important to select the crop to be harvested depending on maturity level and enterprise market requirements which meets the consumer's need.

When identifying different horticultural crops for harvest depending on their maturity status and crop type, careful attention has to be given for:

- Types of crops to be harvested(fruit, vegetables, herbs, flowers, foliage, bulbs, tubers, nuts)
- Nature of crop to be harvested (perishable, stony, leafy…)
- consumers need
- enterprise market requirements which includes variety, size weight, length, shape, color, health and quality depending on seasonal and market forces
- quality of product to be harvested
- the health of plant to be harvested and
- methods of harvesting
- The level of maturity etc.

6.3 Identifying the crop maturity indicators

Maturity indicators are used to predict the maturity of crops. They can be classified into four types: haulm senescence (haulm maturity), skin set (physical maturity), dry matter content (physiological maturity), and sugar content (chemical maturity)

The way of determining crop maturity depends on different morphological changes and crop maturity parameter that indicates proper maturity stage of a given crop to be marketed or stored.

Some of these maturity parameters include size, weight, length, shape, color, ripeness, texture, skin condition, ease of removal and moisture content.

Color: losses of green color, development of red, yellow or purple color. For most fruits and some vegetables

Shape: Ex. For banana, angularity. For mango, “full cheeks”

Size: Too many vegetables.

Firmness: As fruit mature and ripen they soften by dissolution of the middle lamella of the cell walls

Chemical measurements: As fruits ripen the starch to sugar content decreases. Starch is converted into sugar and this alters the texture of the product and makes it softer.

Figure 6.1 Penetrometer Plate

Figure 6.2 Refractometer

6.4 Time and method of harvesting

Time of harvesting

The proper time of harvesting is ascertained from the type of crop (i.e. maturity, size, texture, color, sweetness, flavor etc), the weather condition when harvesting and the purpose of production. The optimum time for harvesting of succulent or fleshy vegetables;

- Early in the day
- During dark hours

The harvesting is usually carried out very early in the morning with following objectives;

- To maintain the full turgidity of leaves and other fleshy parts of the plant.
- Transpiration is minimum during dark hours and early in the day.

Method of harvesting

There are three essential methods of cutting the crop or harvesting.

1. **Hand Harvesting/Manual Harvesting:** Hand harvesting is a method of gathering grains, fruits, vegetables, leaves, etc., by hand or manually.

2. **Harvesting with Hand Tools:** Farmers use a few tools to harvest the crops. Small sickle, big sickle, darat, gandasa and a small axe, etc., are a few examples of harvesting with hand tools.

3. **Harvesting with Machinery:** Machine harvesting is the act or process of harvesting grains in large quantities by using modern harvesters. A modern harvester can combine with other huge machinery to cut and clean the grains at the same time.

Self-Check 6	Written test

Name…… ID…… Date…….

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

I. Answer the following question by saying TRUE or FALSE

_____**1.** Harvesting is best done when it is practiced in the afternoon

_____2. Corn can be harvested at commercial maturity while wheat has to be harvested at harvesting maturity

II. Short answer question

1. Explain the difference between physiological maturity and commercial maturity
2. List devices used for crop maturity test and explain how they work

Operation Sheet 6

6.1. Carry out harvesting activity

A. Tools and equipment

- Harvesting basket
- Sickle
- Maturity testing device
- Matured crop/ crop for harvesting
- Hand protection gaunt
- Cape
- mask

B. Procedures for field crop harvesting

1. Determine the maturity and readiness of the crops for harvest by monitoring factors such as color, growth stage, and yield estimates.

2. Make sure that all necessary tools and equipment are ready in advance such as harvesters, tractors, and wagons.

3. Begin by selectively harvesting the crops that have matured first.

4. Work systematically through the field, harvesting row by row or section by section to ensure that no parts of the field are neglected.

5. Use proper techniques depending on the crop type to avoid unnecessary damage and yield losses.

6. Transport crops to storage or processing areas as quickly as possible.

7. Monitor weather conditions throughout the harvesting process since the quality of crops can be affected by weather conditions.

LAP Test 6

Name……..ID……Date……..

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **30** minutes. The project is expected from each student to do it.

Task 1: perform harvesting of field crop

LG #7	LO #7. Completing cleaning and hygiene operations

Instruction Sheet

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

- Cleaning equipment
- Disposing off containers, waste and debris
- Completing required records and documentation

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:

- Clean equipment
- Dispose off containers, waste and debris
- Complete required records and documentation

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 7:

7.1 Cleaning equipment

Clearing and storing helps to decrease the damage of implements and to increase their shelf life. Storage also minimizes the risk of different chemicals and sharp instruments on human being as well as the environments.

- After completing of field crops establishment all farm implements should be collected from the field to the storage area.
- Implements which are used for clearing, ploughing and spraying should be washed, dried and polished with lubricant and anti-rust (if necessary) before storing. This should be done by separating all components or parts of the implements or tools. Then materials (such as volatile pesticides and fertilizers etc---) should be stored separately and keep the containers tightly closed.
- Stored chemicals and implements should be kept away from fire and flood.
- Inspection of chemical containers and implements should be done periodically.

7.2 Disposing off containers, waste and debris

Waste may include: Pots, discarded propagation material, media waste and chemicals.

Waste may be recyclable, re-useable, returnable, or require garbage or toxic handling procedures

Disposing of old crops and other unwanted materials once the site for the farm has been selected and acquired, the farmer proceeds with clearing.

This involves cutting down the vegetation that is growing on the land and then removing the dead plant material (old crops) from the area. In traditional practice, the plant material is cut down with, axes; saws

Removing and disposing waste materials from crop production site

Carrying out crop propagation activities, there different waste materials. So that, after completing crop production, these waste materials must be removed from crop site and disposed in proper manner.

Waste material may include:

- Small to medium branch
- Foliage
- Leaves
- Sticks
- Buds
- Flower
- Fruits
- Barkc
- Plant debris and chipped material

Recycling plastics, cardboard, glass etc., can lead to an extra income.

If recycling is not an option, discard of waste in a safe way. Away from animals and where children play.

7.3 Completing required records and documentation

Records may include Number of plants propagated, source material used, variety, clone, batch number, and treatments applied.

Recording is one of the principal tools used in controlling consulting assignments. With the exception of very short assignments, the assignment plan will foresee several progress or interim reports to be drafted and submitted by the consultant. The consultant may also produce technical reports on specific subjects treated by the assignment. These technical reports may even be the main tangible products of the assignment, e.g. in feasibility or sectoral studies, or in diagnostic surveys of training needs.

The design of progress reports must facilitate their use in assignment control and monitoring. A good progress report is short, concise, simply structured and clearly worded, drawing management's attention to the main achievements of the period under review and corrective measures required. A progress report is not a piece of literature, but a practically focused paper for managerial action.

Its essential elements cover:

- Work performed;
- Resources used;
- Progress made towards interim and final objectives and targets:
- Obstacles encountered;
- New problems discovered;
- New ideas and opportunities brought to the client's attention;
- Staffing and other difficulties;
- Suggestions for adjustments in the assignment schedule;
- Suggestions for any other action by the client and the consultant.

Record Keeping is an essential part of Agricultural activities.

Management of the farm is the first reason to keep a good set of records. Record keeping can aid in planning of your activities. Your records should contain the usage of materials on fields, crops, and other related resources along with fertilizer and restricted use pesticide applications, soil amendments, and resulting crop yields. The producer can use this recorded information to determine the best amendments for subsequent crop plantings as well as to meet certain governmental reporting requirements.

Record Keeping can play a major role in the success of your farm in reducing risks. A successful farm business needs records to monitor the progress of their business and help prepare financial statements. Keeping good records can determine if a farm operation is in a good condition and final evaluation of work results. Based on record kept, work out come is reported for supervisor of the work eventually.

Self-Check 7	Written Test

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

I: Short Answer Questions

1. What are the things to be recorded after completing crop planting
2. after completing crop production, these waste materials must be removed from crop site, list those waste materials
3. describe the benefit of record in agriculture

Reference Materials

Books:

- Plant Nursery Management: Principles and Practices. Central Arid Zone Research Institute, Jodhpur, 40
- PN10596 Version 3 Last updated January 2019 – Guide to machinery and equipment safety

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