Crop production

Level-IV

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Introduction to the Module

This module covers the knowledge, skills and attitude required to select crop type and variety, determine crop yield potential, prepare production plan for individual crop and the whole farm, implement production plan and also monitor, evaluate and learning of crop production plan

LG #7	LO #1- Select crop type and variety

Instruction sheet

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

- Assessing and selecting crop types and varieties for their market potential and gross margin returns for the farm environment
- Selecting most profitable cultural practices
- Identifying production risks for each crop and determining strategies to address the risks
- Identifying and developing appropriate strategies for environmental risks
- Selecting crop types and varieties based on their potential for import substitution, raw material for agro industry and small-scale processors

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

- Assess and select crop types and varieties for their market potential and gross margin returns for the farm environment
- Select most profitable cultural practices
- Identify production risks for each crop and determine strategies to address the risks
- Identify and develop appropriate strategies for environmental risks
- Select crop types and varieties based on their potential for import substitution, raw material for agro industry and small-scale processors

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the information Sheets
- Accomplish the Self-checks

Information Sheet 1

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

Crop types and varieties vary in their market potential and gross margin returns, hence careful assessment and selection is required.

1.1.1. Understanding crop types and varieties

Crops: - in agriculture typically refer to plants that are grown and harvested for human or animal consumption, as well as for various industrial uses.

Crop type: refers to different species of crops including those produced for foods like wheat, barley, maize or industrial crops like cotton, etc.

Crop types are diverse and can be categorized based on various characteristics, including their use, growth cycle, and botanical classification.

Common categories of crop types:

- **Cereal Crops:** Examples: Wheat, Rice, Corn (Maize), Barley, Oats Primarily grown for their edible grains, which are used as staple foods.
- **Pulse Crops:** Examples: Lentils, Chickpeas, Peas, Beans Leguminous crops grown for their edible seeds, high in protein.
- **Oilseed Crops:** Examples: Soybeans, Sunflower, Canola, Sesame, Peanut Grown for the extraction of oils used in cooking, food processing, and industrial applications.
- **Root and Tuber Crops:** Examples: Potatoes, Sweet Potatoes, Cassava, Carrots, Beets Edible roots or tubers that serve as important food sources.
- **Fruit Crops:** Examples: Apples, Oranges, Bananas, Grapes, Mangoes Grown for their edible fruits, often consumed fresh or processed into various products.
- **Vegetable Crops:** Examples: Tomatoes, Cabbage, Broccoli, Spinach, Peppers Edible plant parts, including leaves, stems, roots, and flowers, grown for culinary use.
- **Leafy Greens**: Examples: Lettuce, Kale, Swiss Chard, Spinach Leafy vegetables rich in nutrients, often consumed fresh or cooked.
- **Spice Crops:** Examples: Basil, Thyme, Cumin, Coriander, Pepper Grown for culinary, medicinal, or aromatic purposes.

- **Fiber Crops:** Examples: Cotton, Flax, Hemp, Jute Grown for fibers used in textiles, ropes, and other materials.
- **Industrial Crops:** Examples: Rubber Trees, Bamboo, Sugarcane Grown for industrial purposes, such as rubber production, construction, or biofuel.
- **Forage Crops:** Examples: Alfalfa, Clover, Bermuda Grass Grown for animal feed, providing nutrition to livestock.
- **Beverage Crops:** Examples: Coffee, Tea, Cocoa Grown for the production of beverages.
- **Cover Crops:** Examples: Legumes, Grasses Planted to cover and protect the soil, prevent erosion, and improve soil fertility.
- **Cash Crops:** Examples: Coffee, Cocoa, Tobacco, Sugarcane Grown for sale rather than personal consumption, often for export.

These categories provide a broad overview, and many crops may fall into multiple categories depending on their use and characteristics. Agriculture is diverse, with farmers cultivating a wide range of crops to meet various needs, from food and fiber to industrial and commercial purposes.

Crop Variety: refers to the various cultivars or types within a particular crop species. Different varieties of a crop often exhibit distinct characteristics such as growth habits, disease resistance, yield potential, taste, nutritional content, and adaptability to specific environmental conditions. Crop varieties are developed through selective breeding or genetic modification to enhance desirable traits and meet the diverse needs of farmers and consumers.

Characterization of crop variety:

Varieties differ from one another in various traits either through heredity or through breeding or genetic engineering. The following are some of the varieties characterization:

- **Adaptation**

Different crop varieties are often bred to thrive in specific climates, soil types, and growing conditions. This ensures that farmers can choose varieties that are well-suited to their local environment.

- **Yield Potential**

Varieties may differ in their yield potential, influencing the amount of harvest a farmer can obtain per unit of land. High-yielding varieties are often sought to increase overall agricultural productivity.

- **Disease Resistance**

Some crop varieties are bred to be resistant to certain diseases or pests, reducing the need for chemical inputs and improving crop health.

- **Quality Traits**

Varieties may differ in taste, texture, nutritional content, and other quality traits. For example, certain varieties of fruits or vegetables may be preferred for their flavor or appearance.

- **Harvest Time**

Varieties may have different maturation periods, allowing for staggered or extended harvest times. This can be important for managing labor and ensuring a continuous supply to the market.

- **End-use Specificity**

Some crop varieties are developed for specific end uses. For instance, there are wheat varieties bred for bread-making (bread wheat), while others are better suited for pasta production (durum wheat).

- **Genetically modified (GMO) Varieties**

In some cases, genetic engineering is used to develop genetically modified (GMO) crop varieties with specific traits, such as resistance to pests or tolerance to herbicides.

- **Local Varieties**

In many regions, farmers cultivate local or traditional varieties that have been adapted to local conditions over generations. These varieties often play a crucial role in preserving biodiversity.

- **Hybrid Varieties**

Hybrid varieties are produced by crossing two different parent varieties to create a new, often more vigorous, hybrid. Hybrid varieties are commonly used in crops like corn and vegetables.

The availability and adoption of diverse crop varieties contribute to sustainable agriculture by promoting resilience, resource efficiency, and adaptation to changing conditions. Additionally, it allows farmers to select the best-suited varieties for their specific needs and circumstances.

1.1.2. Assessing and selecting crop types and varieties for their market potential

In developing production plan for field crops, assessing which crop types to produce and which variety may has the highest market potential is crucial.

Steps to determine market potential for crops

Market potential is a crucial element in planning crop production. It will help you estimate the amount of money you can expect to make from the products you plan to market. It is the total demand for a product in a given business environment. Keep in mind the estimate is only as good as the information being used.

Five steps to identify market potential of the crop or variety:

I. **Verify Market Size**
   a. Volume – total number of potential customers of the crops to be produced
   b. Value – total financial value consumers are able to pay for our crop products

II. **Market Growth: Short term and long-term forecasts**
   a. Track financial trends in similar crops a few years back
   b. Look at growth dynamics that will stimulate the market currently and in the future

III. **Competition**
   a. Determine the number of competing companies in your market area
      - Identify their strengths and weaknesses
      - Evaluate whether your product offer a competitive advantage or not
   b. What barriers need to be overcome for your enterprise to break into the market?

IV. **Analyzing Potential Customer Base**
   a. Create a potential client profile
      - Primary client base
      - Secondary client base
   b. How will you reach your client base?

V. **Profitability**
   a. Profit potential from initial investment
   b. Balance between the size of the financial outlay and potential profit

1.1.3. Assessing and selecting crop types and varieties for their gross margin returns

The term gross margin refers to a profitability measure that looks at a company's gross profit compared to its revenue or sales.

In short **gross margin in crop production** is the amount of money a crop producer retains after incurring the direct costs associated with producing the crop product it sells. Gross margin is expressed as a percentage.

Gross Margin Formula and Calculation

A company's gross margin is the percentage of revenue after cost of production. It is calculated by dividing a company's gross profit by its sales. Remember, gross profit is a company's revenue minus the cost of goods sold

$$GM = \frac{\text{Gross Profit}}{\text{Revenue}} \text{ X } 100$$

Gross profit = Revenue --- COP

Where, GM = Gross Margin, COGS = Cost of production

Example: A farmer produced groundnut and sold in local market with 200000 ETB, the total cost he incurred for its production was 100000ETB. Calculate its gross margin.

To find out the gross margin, we should first calculate Gross Profit (GP).

Gross Profit = Revenue – Cost of Production

= 200000 ETB --100000ETB

= 100000 ETB

$$\text{Gross Margin} = \frac{\text{Gross Profit}}{\text{Revenue}} \text{ x } 100$$

$$= \frac{100000}{200000} \text{ X } 100$$

= **50%**

In selecting crop type as well as variety, predicting its possible gross margin should be given due consideration.

1.2 . Selecting most profitable cultural practices

1.2.1 Understanding crop cultural practices

Cultural practices refer to all the crop production and management techniques which are utilized by the farmers to maximize their crop productivity and farm income. It includes decisions on crops to be grown, time and manner of planting, tillage, field and crop sanitation, application of fertilizers and irrigation, harvesting times and procedures and even off-season operations in fallow/cropped fields.

1.2.2 Selecting profitability of cultural practices

Profitable cultural practice: is any cultural practice that results in higher revenue over costs of production.

To select any cultural practice, one should ask the following questions:

- Can I add revenue by selecting the cultural practice?
- Can I reduce the production cost by selecting it?

Analyzing some cultural practices for their profitability

I. Time of sowing

Crops differ in their temperature preference. To be profitable, heat loving crops should be grown during higher temperature and heat sensitive crops should be grown in relatively lower temperature season. Therefore, selecting appropriate time of sowing for each crop results in higher yield, thereby higher revenue and hence profit.

II. Types of sowing:

- **Broadcasting: -** scattering the seeds with no defined space between plants as well as between rows.
- **Drilling: -** sowing the seeds in a rows with no defined space between plants
- **Dibbling: -** putting the seeds in a defined spaces between plants as well as between rows

- ✓ Among the three sowing methods, dibbling is the most profitable, particularly, for large seeded field crops.
- ✓ Since space between plants and rows are defined in dibbling method, no wastage of seeds occur, hence seed cost is reduced. Moreover, there will no competition for nutrients, air, light and etc. between plants that leads to more crop yield resulting in more revenue, and then profit.

III. Cropping system

Broadly cropping system can be classified into three

a. Multiple cropping: refers to growing two or more crops on the same field in one year. There are two types of multiple cropping:

- **Sequential cropping** - growing two or more crops in sequence on the same filed per year. i. e. the second crop is planted after the first crop is harvested.
- **Intercropping:** refers to growing of two or more crops simultaneously on the same field. There are four common **types of intercropping**:

✓ Mixed inter-cropping: mixing two or more species



Figure 1.1 Maize haricot bean mixed intercropping

✓ Row inter-cropping: - growing two or more crops in separate rows



Figure 1.2 Row intercropping

✓Strip inter-cropping – growing two or more crops in different strips wide enough for independent cultivation and narrow enough to interact agronomically.



Figure 1.3 Strip intercropping

✓Relay inter-cropping - planting a second crop inside a stand of an existing sole crop at some time before the first crop is harvested.



Figure 1.4 Relay intercropping

b. **Mono-cropping**: - is cropping system in which the same crop is produced year after year.

c. **Crop rotation: -** growing two or more crops one after the other on the same piece of land.

Therefore, to select profitable cropping system:

- Careful observation and analysis are required
- In crop rotation**,** rotating leguminous crops with high market potential with cereals of highest gross margin returns makes profitability at its peak.
- Land equivalent ratio (LER) and Monetary advantage index (MAI) should be calculated in intercropping to know whether intercropping leads to more benefits or not.

Two important indicators telling us whether intercropping leads to benefit or loss

Land equivalent ratio (LER) is a most widely used indicator of yield advantage of multi-crop farms over sole-crop farms, and usually measured using crop yield per unit area. Most often, crop yields are compared between both systems using the same area.

The land equivalent ratio is a concept in agriculture that describes the relative land area required under sole cropping (monoculture) to produce the same yield as under intercropping (polyculture)

LER > 1 indicates intercropping advantage.

Land equivalent ratio (LER) can be calculated by using the following formula:

$$\text{LER} = \frac{i1}{s1} + \frac{i2}{s2}$$

Where LER = Land equivalent ratio

i1 = Yield of crop 1 when intercropped

s1 = Yield of crop 1 when sole cropping

i2 = yield of crop2 when intercropped

s2 = Yield of crop 2 when sole cropping

Example: A farmer wants to compare yield advantage of maize and haricot bean when intercropped and produced solely. Consequently, he first grows both crops solely and got 100 q/ha maize and 50 q/ha haricot bean, and then he grows the two crops on one hectare of land as intercropping and got 90 q maize and 40 q haricot bean. Now, the question is 'does intercropping leads the farmer to a yield advantage?'

Formula to calculate LER is as follows:

$$\text{LER} = \frac{i1}{s1} + \frac{i2}{s2}$$

In this case:

$$\text{LER} = \frac{\text{yield ofmaize (intercropped)}}{\text{yield of maize (sole)}} + \frac{\text{yield of haricot bean(intercropped)}}{\text{yield of haricot bean (sole)}}$$

$$\text{LER} = \frac{90}{100} + \frac{40}{50} = 1.7$$

An interpretation of this result would be that a total of 1.7 ha of sole cropping area would be required to produce the same yields as 1 ha of the intercropped system. Therefore, the farmer got a yield advantage from intercropping.

Monetary advantage index (MAI)

LER compares only yield advantage of intercropping over mono-cropping. However, more yield may not always mean more price because of the highest price of some crops. Hence, evaluating the market price of the two crops and comparing their price is important.

MAI is an important index in determining economic viability of intercropping.

The most important part of recommending a cropping pattern is the cost: benefit ratio more specifically total profit and monetary advantage index because farmers are mostly interested in the monetary value of the return. The yield of all the crops in different intercropping systems and also in the sole cropping system and their economic return in terms of monetary value were

evaluated to find out whether intercropping is profitable or not. This is calculated with the monetary advantage index (MAI). It is expressed as

$$\text{MAI} = (\text{Pab} + \text{Pba}) * \frac{\text{LER} - 1}{\text{LER}}$$

Where; Pab = Pa ×Yab; Pba = Pb×Yba; Pa = Price of crop 'a' and Pb = Price of crop 'b'.

Positive and higher MAI indicates intercropping advantage over mono-cropping.

IV. Fertilizer application

Applying fertilizer based on soil test results and plant requirements helps to reduce costs of fertilizer by preventing buying of excess fertilizers.

V. Irrigation

Types and timing of irrigation plays important role to reduce cost of irrigation**.**

Watering in a condition of high sunlight results in evaporation, this leads to wastage of water.

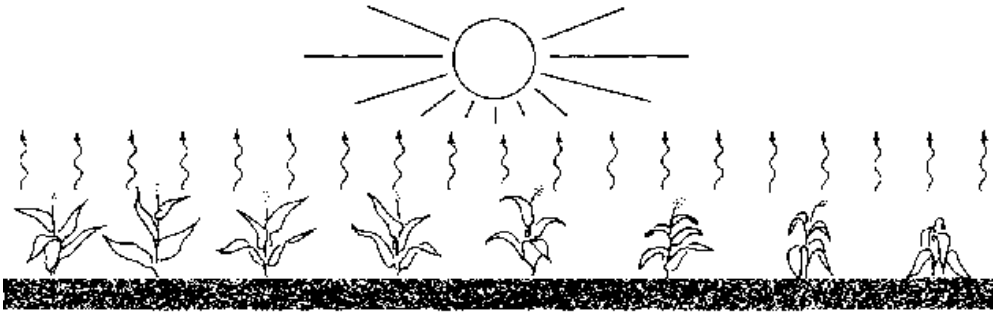


Figure 1.5 Irrigating in heavy sunlight resulting to water evaporation

VI. Pest management

Diagnosing and understanding target pests and selecting effective pest management measures aids not to buy blindly different non-effective chemicals. By doing so, we can reduce chemical costs.

1.3 . Identifying production risks for each crop and determining strategies to address the risks

Several factors pose significant risk to crops leading to yield reduction when they are not correctly monitored and well managed.

Crops vary in their requirements for soil type, temperature, soil pH, etc.

Some crops are highly sensitive to acidity, and some are tolerant. Anything that goes against optimal range of crop requirements put the crop at risk.

Production (agronomic) risks include:

- Untimely planting
- Incorrect plant spacing
- Wrong method of planting
- Poor sowing depth
- Delayed weeding
- Ineffective pest and disease control
- Inappropriate use of fertilizers
- Untimely harvesting
- Use of low yielding varieties

✓ All these faults always significantly reduce crop yields. Therefore, investigating production risks for each crop separately and determining strategies to address it is important.

✓ Training farmers' proper agronomic practices is good strategy to solve the problems

Table 1.1) Some production risks, their effects and possible solutions

Factor	Effect	Possible impact	Possible solutions
Seeds			
Seed shortages (local Seeds)	Lack of local seeds carried- over from previous harvest is a concern for heavy seed rate cereals/pulses, e.g. wheat, barley, oats and all pulses (90 kg to 180 kg per ha). NOT usually a problem for low sowing rate cereals such as sorghum, pearl millet	Reduced sowing rates will probably reduce yields; Less seed selection means poorer quality seeds, poorer germination followed by reduced yields. Sowing dates slip as farmers search for seeds, missing the optimum sowing rate and leaving plants more vulnerable.	Selecting and setting aside promising local seeds
Seed shortages (improved seeds (hybrid and composite))	Late arrival or overall shortage of hybrid seeds will increase seed prices/ reduce uptake and so reduce area sown to hybrids	Commercial farmers affected may use local seeds resulting in reduced yields or they may switch crops	Early questioning and following up improved seed suppliers prior to cropping season

	Late arrival of composite seeds	Subsistence+ and commercial farmers affected, they may adjust sowing rates with possible reduced yield effect. Poorer quality seeds used leading to poor germination and reduced yield	
Seed failure	Replanting (maybe more than once) - Untimely sowing	Increased pressure on seeds reduced sowing rates, untimely sowing all leading to reduced yields.	Using seeds with high purity percentage for the future
	Possibly no alternative seeds	Increased fallow areas	
Fertilizer			
Late availability of basal dressing fertilizer Price increases	Shortages at sowing time- insufficient to meet demand. Prices increase and a black market flourishes. Less basal dressing used esp. by subsistence/subsistence + farmers	Reduced application by peasants who cannot afford parallel prices leads to reduced use and reduced yields	Formal questioning of government before cropping season. Establishing farmers right institution
Late availability of top dressing fertilizer	Shortages occur with price increases and a black market flourishes for commercial farmers	Top dressing window missed, commercial farmers reduce use	
Price increases		Subsistence farmers stop using top dressing with a possible reduction in yields of grain but a definite	

		reduction in straw yield	
Labour			
Labour shortages (early Season)	Land clearing affected, increased weed growth later	Weed induced yield reduction unless weeding frequency is increased later in year	Pre-planning labour requirements
Labour shortages mid-season	Wages increased, commercial farmers reduce weeding frequencies	Weed induced yield reduction is to be expected	
Labour shortages late- season	Wages increased, delayed Harvesting, increased in- field pre-harvest losses	Poor quality harvesting means yields may be reduced	

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1.4 . Identifying environmental risks and developing appropriate strategies

Environmental risks can have significant impacts on crop yields, posing challenges to global food production.

1.4.1. Environmental risks affecting crop yields

The environmental factors affecting crop yields can be classified into:

Abiotic: - include soil properties (soil physicochemical and biological properties), and climatic stresses (drought, cold, flood, heat stress, etc.).

Biotic: - include pests (pathogens, weeds, insects, birds, rodents, etc.)

1.4.1.1. Abiotic constraints include:

A. Climatic stresses

i **Drought: -** refers to a situation in which the amount of available water through rainfall and/or irrigation is insufficient to meet the evapotranspiration needs of the crop.

Effects of drought on plants:

- Induce abscisic acid (ABA) accumulation in guard cells to trigger stomatal closure
- Results in abnormal metabolism that may reduce plant growth, and/or cause the death of entire plant
- Has different effects at different stages of plant growth with the most sensitive growth stage being flowering period



Figure 1.6 Drought affected crop field

ii **Heat stress: -** is the rise in temperature beyond a threshold level for a period sufficient to cause permanent damage to plant growth and development.

Effects of heat stress on plants:

It affects:

- the percentage of seed germination
- photosynthetic efficiency
- crop phenology
- reproductive biology
- flowering times
- pollen viability
- pollinator populations
- Under reproductive growth stage, it prevents the swelling of pollen grains, which results in poor release of pollen from the anther at dehiscence.



Figure 1.7 Maize leaves wilted due to heat stress

iii Cold stress

- **Freezing injury: -** occurred at a temperatures below 0^0C as ice crystals form within the tissue
- **Chilling injury**: refers to an injury caused by a temperature drop to below 15 ^{0}C but above the freezing point. It leads to major crop losses

Effects of chilling injury on plants:

- ✓ Poor germination
- ✓ Stunted seedlings
- ✓ Chlorosis
- ✓ Growth retardation
- ✓ Reduced leaf expansion

- ✓ Wilting and necrosis

iv **Floods:**

Flood refers to overflow of water that submerges land that is usually dry. Flooding usually occurs with heavy rainfall, poor soil drainage and poor irrigation practices. The first constraint for plant growth under flooding conditions is the immediate lack of oxygen necessary to sustain aerobic respiration of submerged tissues



Figure 1.8 Flood affected maize crops

B. Soil stress

Soil salinity and acidity stress are the major soil stresses affecting plant growth and development Under salt stress conditions, the high concentration of salts in the soil solution prevents absorption of water and essential minerals but will facilitate the entry of Na+ and Cl− ions into the cells, which will have direct toxic effects on cell membranes as well as on metabolic activities in the cytosol

Low soil pH (acidity) also significantly affects crop growth and therefore decreases yield

1.4.1.2. Biotic Constraints

This includes different crop pests.

Pest is defined as any species, strain, or biotype of plant, animal, or pathogenic agent injurious to plants or plant products

Major crop pests include:

I. Disease (of pathogens)

It can be defined as any physiological disturbance of the normal functioning of a plant as a result of a detrimental interaction between the pathogen, the environment, and the host. Diseases affect

the production and utilization of trees and crops by reducing the health of the plant and directly reducing yield, quality, or storage life.

Major crop pathogens include: fungi, bacteria, virus etc. that cause plant disease



Figure 1.9 Wheat crop affected by yellow rust fungi

II. **Weeds:** - are plants that grow in undesired places. Weeds compete with trees and crops for water, light, and nutrients. Many weed species also serve as alternative hosts of plant pathogenic organisms and nematodes.



Figure 1.10 Wheat field affected by weeds

III. **Insect pests:** are insects that destroy or harm crop plants. They have an impact on the crop's basic health as well as on its productivity. They damage plants by cutting their roots, stems, and leaves. They also absorb the plant's cell sap from its diverse parts.



Figure 1.11 Locust flocks affecting sorghum crops

IV. **Rodents: -** are mammals characterized by upper and lower pairs of ever-growing rootless incisor teeth. If not controlled, they pose serious damage on field crops, especially, at storage.



Figure 1.12 Rodents grinding maize grain

V. **Birds:** - birds can affect crop yields, particularly small-grained cereals such as wheat, barley, etc.



Figure 1.13 Bird flocks attacking wheat crops

Table 1.2 Summary of some key environmental risks, their immediate effects and impact on crops:

Environmental risks	Effects	Impact on crops
Climate Change	**Temperature Extremes**	Increased frequency of heatwaves or cold spells can affect crop growth and development.
	Altered Growing Seasons	Changes in temperature patterns may disrupt traditional planting and harvesting seasons.
Water Scarcity	**Drought**	Reduced water availability can lead to water stress, affecting plant health and limiting crop yields.
	Changes in Rainfall Patterns	Irregular rainfall patterns or prolonged dry spells can impact water availability for crops.
Extreme Weather Events	**Floods**	Excessive rainfall or severe storms can lead to flooding, causing soil erosion, waterlogging, and crop damage.
	Hurricanes and Cyclones	Strong winds and heavy rains associated with tropical storms can destroy crops.
Soil Erosion	**Wind and Water Erosion**	Erosion removes fertile topsoil, reducing soil quality and affecting nutrient availability for plants.
Pests and Diseases	**Increased Incidence**	Changes in climate conditions can influence the distribution and prevalence of pests and diseases, impacting crop health.

	Altered Life Cycles	Warmer temperatures can affect the life cycles of pests and pathogens, potentially leading to increased infestations.
Air Pollution	**Ground-Level Ozone**	Elevated levels of ozone near the surface can damage plant tissues and reduce photosynthesis.
Pollinator Decline	**Loss of Pollinators**	Declines in bee populations and other pollinators can affect the pollination of many crops, leading to reduced yields.
Soil Degradation	**Salinization**	Accumulation of salts in the soil can reduce water uptake by plants and hinder crop growth.
	Desertification	Soil degradation due to overexploitation and poor land management can lead to reduced arable land.
Invasive Species	**Competition for Resources**	Invasive plant species can outcompete crops for resources like water, sunlight, and nutrients, affecting yields.
Wildfires	**Smoke and Ash Deposition**	Wildfires can release smoke and ash, impacting air quality and potentially harming crops.
Rising of Carbon Dioxide Levels	**Altered Plant Physiology**	Elevated levels of carbon dioxide can affect plant growth and nutrient content, influencing overall crop quality.
Climate Variability	**Unpredictable Weather Patterns**	Erratic weather conditions, such as sudden temperature fluctuations or unseasonal frosts, can disrupt crop development.
Land Use Changes	**Deforestation**	Clearing land for agriculture or other purposes can lead to habitat loss and alter local climate conditions.

1.4.2. Strategies to overcome environmental risks

Mitigating these environmental risks requires a combination of sustainable agricultural practices, technological innovations, and global efforts to address climate change. Developing resilient crop varieties, implementing water-efficient irrigation systems, and promoting agro-ecological approaches are essential for building a more sustainable and resilient agricultural system.

I. Climate smart agriculture (CSA)

For climatic risks, climate smart agriculture (CSA) is now widely accepted as the best approach for addressing the effects of climate change in agriculture.

It is defined as: agriculture that sustainably:

- ✓ **increases** productivity and resilience (adaptation),
- ✓ **reduces/removes** greenhouse gases (mitigation) and
- ✓ **enhances** the achievement of national food security and development goals

CSA promotes the transformation of agricultural systems and requires the transformation of agricultural policies to increase food production, to enhance food security, to ensure that food is affordable (low input-cost) while ensuring sustainable natural resource management and resilience to a changing climate.

(357) Climate Resilient Agriculture Technology / Climate Smart Agriculture Technology - YouTube (Accessed date January 20, 2024)

II. Weather forecasting

Weather forecasting and crop yield prediction or simulations are relevant tools that provide a warning to farmers in preparation of the upcoming season. From the simulation results, farmers can change the crop planting date, use appropriate genotypes, and adjust the fertilization and the irrigation cycles to obtain reasonable yields, thus reducing the risk of unexpected events

III. Development of new adapted crop genotypes

Breeding is routinely conducted to increase levels of durable resistance to specific pests, diseases and different abiotic stresses using conventional crop improvement methods. However, there is now an increased use of modern biotechnology techniques such as marker-assisted selection, and transgenic approaches that involve genetic modification and high-throughput sequencing of both plant and pathogenic micro- organisms.

IV. Crop rotation:

Crop rotation practice prevents development of particular crop pest species in contrast to mono-cropping which initiates development and proliferation of particular pest species.

V. Using appropriate pest management techniques

For biological risks implementing relevant pest management techniques, particularly, integrated pest management (IPM) is the best strategy to overcome biological constraints.

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

Crop production needs careful selection of crop types and varieties based their intended destination. We can categorize crops to be produced based on their intended use and final destination as:

- Import substitution
- Raw material for agro industry
- Small scale processors

I. Crops grown as import substitution:

Import substitution crops refer to crops that are grown domestically to replace or reduce the need for importing specific agricultural products. The goal is to enhance national self-sufficiency and reduce dependency on foreign sources for particular commodities. Countries often pursue import substitution policies to strengthen their economies, promote agricultural development, and ensure food security.

Some examples of import substitution crops:

Wheat and Rice: Many countries aim to produce sufficient quantities of wheat and rice domestically to reduce reliance on imports for staple foods.

Maize (Corn): Countries may prioritize the cultivation of maize to substitute imported corn-based products, such as animal feed, corn oil, and corn starch.

Soybeans: Soybeans are grown as a major protein source for both human and animal consumption. Countries may focus on cultivating soybeans to reduce the need for importing soy products and soybean meal.

Edible Oils: Various oilseed crops, including sunflower, canola, and palm oil, may be cultivated to substitute imported cooking oils and fats.

Sugar Cane and Sugar Beet: Countries may promote the cultivation of sugar crops to reduce dependence on imported sugar.

Pulses (e.g., Lentils, Chickpeas, Beans): Cultivating pulses domestically can substitute imports of these protein-rich crops, contributing to food security.

Coffee and Cocoa: Some countries aim to develop domestic coffee and cocoa industries to reduce dependence on imports of these popular commodities.

Spices and Herbs: Growing spices and herbs domestically can help substitute imports of these culinary ingredients.

Fruits and Vegetables: Governments may encourage the domestic production of fruits and vegetables to reduce reliance on imported fresh produce.

Cotton: Cultivating cotton domestically supports the textile industry and reduces the need for importing raw cotton.

Rubber Trees: Countries may grow rubber trees to produce natural rubber domestically, reducing reliance on imported rubber.

Tea: Some countries focus on cultivating tea to meet domestic demand and reduce the need for importing this popular beverage.

Import substitution strategies are often part of broader economic and agricultural policies aimed at fostering self-sufficiency, supporting local industries, and enhancing food and economic security. However, the success of these strategies depends on various factors, including climate conditions, agricultural practices, and market dynamics.

Currently, government of Ethiopia is focused on import substitution, particularly through irrigated wheat production.

Benefits of import substitution

- Generating employment
- Reducing foreign exchange demand
- Stimulating innovation
- Making the country self-reliant in critical areas
- Helping in the growth of local and small-scale businesses

Factors to be considered in selecting crops for import substitution

When selecting crops for import substitution, various factors need to be carefully considered to ensure successful and sustainable agricultural practices. The followings are some of the factors to be considered in selecting crops for import subistitution:

- **Climate and Soil Suitability:**

Choosing crops that are well-suited to the local climate and soil conditions. Understanding the agro-ecological zone and ensuring the selected crops can thrive in that environment is crucial.

- **Water Availability:**

Considering the water requirements of the crops and ensure that there is adequate water availability for cultivation. Water scarcity can be a limiting factor for certain crops.

- **Market Demand:**

Analyzing the domestic market demand for various crops, focus on crops that are in high demand locally to ensure a ready market for the produce.

- **Infrastructure and Logistics:**

Evaluate the existing infrastructure for transportation, storage, and distribution. Efficient logistics and transportation networks are critical for the success of import substitution strategies.

- **Input Availability:**

Ensure that necessary inputs such as seeds, fertilizers, and pesticides are readily available. Availability of these inputs can affect crop yields and overall productivity.

- **Technology and Research Support:**

Consider the level of technological support and research available for the selected crops. Access to modern agricultural practices, improved seeds, and research-based knowledge can enhance productivity.

- **Farmers' Capacity and Training:**

Assess the capacity of local farmers to cultivate the selected crops. Provide training and support to ensure that farmers have the necessary skills and knowledge to effectively grow and manage the crops.

- **Land Availability:**

Evaluate the availability of suitable land for cultivation. Consider factors such as land tenure, land use regulations, and potential conflicts to ensure a stable and secure environment for farming.

- **Government Policies and Support:**

Understand the existing agricultural policies and government support for import substitution. Government incentives, subsidies, and supportive policies can significantly impact the success of the initiative.

- **Risk Management:**

Assess potential risks, including pest and disease susceptibility, and have strategies in place to manage these risks effectively. Diversification of crops can also be a risk mitigation strategy.

- **Environmental Impact:**

Consider the environmental impact of cultivating specific crops. Sustainable and environmentally friendly farming practices should be prioritized to ensure long-term viability.

- **Competitive Analysis:**

Analyze the competition from imported crops. Understanding the strengths and weaknesses of both local and imported crops can guide decision-making.

- **Cultural and Dietary Preferences:**

Take into account local cultural preferences and dietary habits. Choosing crops that align with local tastes and preferences can enhance market acceptance.

- **Economic Viability:**

Evaluate the economic feasibility of cultivating specific crops. Consider factors such as production costs, potential revenue, and overall profitability.

II. Crops grown as raw materials for agro industry

Numerous crops are grown as raw materials for various industries, providing essential resources for manufacturing processes. These crops contribute to the production of materials used in textiles, biofuels, pharmaceuticals, chemicals, and other industrial applications.

Common crops grown for industrial purposes include:

Cotton: Used in the textile industry to produce fabrics and clothing.

Flax and Hemp: Fibers from these plants are used to make textiles, ropes, and various composite materials.

Jute: Another fiber crop used for making burlap and other coarse fabrics.

Sugarcane and Sugar Beet: Used in the production of sugar, ethanol, and other biofuels.

Oilseeds (e.g., Soybeans, Canola, Sunflower): These crops produce oil that is used in cooking, and as raw material for industrial processes, including biofuel production.

Corn (Maize): Used in various industries for ethanol production, as well as in the production of starch and other chemical derivatives.

Bamboo: A versatile plant used in construction, furniture making, and paper production.

Rubber Trees: Grown for latex, the primary raw material for rubber production.

Kenaf and Ramie: Fibrous plants used as alternatives to traditional textiles and for making paper.

Castor Bean: The seeds of this plant are a source of castor oil used in various industrial applications, including the production of lubricants and biodiesel.

Buckwheat: Used in the production of gluten-free flour and has various industrial applications.

These crops play a crucial role in supporting industries, and ongoing research and development focus on sustainable and environmentally friendly practices in their cultivation and processing.

In selecting such crop, bear in mind the following considerations:

- Availability of factory around your production area and ease of transportation
- Demands of industry for the crop as raw material
- Strength and weakness of the competitors
- Profitability of crops to be produced

III. Crops grown for small scale processors

Small scale processors refer to the production of a commodity with a small plant size firm or homemade processing. It requires less amount of capital and is labour intensive in nature.

Small-scale processors often focus on crops that can be efficiently processed and transformed into value-added products. The choice of crops can depend on factors such as local demand, climate, and the processing capabilities of the small-scale operation.

Examples of crops produced for small scale processors

- **Corn:** processed into cornmeal, popcorn, and corn-based snacks.
- **Wheat:** small-scale flour mills can produce various types of flour for local markets.

- **Rice:** depending on the region, rice processing can include milling, packaging, and parboiling.
- **Peanuts:** processed into peanut butter, roasted peanuts, or used in snack products.
- **Sunflower seeds:** processed for sunflower oil.
- **Soybeans:** can be used to produce soybean oil, tofu, and other soy-based products.

In selecting crops for small scale processors consider the following:

- Demands of small scale processors
- Their processing capacity and size of their customers
- Profitability and gross marginal returns
- Strength and weakness of the competitors
- Availability of raw materials, processing equipment, and the potential for value addition in the form of unique or specialized products
- Sustainable and organic options may appeal to certain market segments.

Self-check -1	

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

Part I Write 'True' for correct statements and 'False' for incorrect statements

1. Crop variety refers to different plant species within the given genus.
2. Blind application of fertilizer leads to maximum profitability.
3. In selecting crop type, assessing market demand is required to be successful.
4. Making the country self-reliant in critical areas is one of the benefits of import substitution.
5. Considering demands of small scale processors is not necessary in selecting crops for small scale processors.

Part II Choose the best answer

1. Which one is not production (agronomic) risk? (3pts)

   A) Wrong method of planting B) Poor sowing depth

   C) Delayed weeding D) Chilling injury

2. Which sowing method is profitable for big grained crops like maize? (3pts)

   A. Dibbling B. Drilling C. Broadcasting D. None

3. _____ refers to growing two or more crops one after the other on the same piece of land.

   A. Mono-cropping B. Crop rotation C. Inter-cropping D. Alley cropping

4. One of the following is not produced as raw materials for factory

   A. Cotton B. Durum wheat C. Sesame D. Cabbage

5. One of the following is not a consideration in selecting crops for small scale processors.

   A. Demands of small scale processors

   B. Their processing capacity and size of their customers

   C. Profitability and gross marginal returns

   D. Strength and weakness of the competitors E. None

Part III Give short answers

1. Define crop variety
2. Enumerate steps to determine market potential for crops
3. When does cultural practice considered profitable?
4. What is gross margin?
5. What do we mean by heat stress?

LG #8	LO #2- Determine crop yield potential

Instruction sheet

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

- Sourcing relevant benchmark for yield to assist setting target yields
- Analyzing past production records to determine the key determinants of yield
- Using available models for calculating water, nutrients and agronomic use efficiency
- Establishment of quality specifications and target yields for the selected field crop

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

- Source relevant benchmark for yield to assist setting target yields
- Analyze past production records to determine the key determinants of yield
- Use available models for calculating water, nutrients and agronomic use efficiency
- Establish quality specifications and target yields for the selected field crop

Learning Instructions:

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

Information Sheet 2

2.1. Sourcing relevant benchmark for yield to assist setting target yields

Crop yield benchmarking is a process of comparing and evaluating the performance of crop yields on a particular farm or region against established standards or benchmarks.

Advantages of benchmarking:

- **Performance Evaluation:**

Comparing Actual Yields with Benchmarks: Farmers or agricultural businesses compare the actual yields of their crops with benchmark yields to assess how well they are performing in terms of productivity

- **Identification of Best Practices:**

Learning from High-Performing Entities: Benchmarking allows farmers to identify best practices used by high-yielding farms or regions. This information can be used to improve cultivation techniques, resource management, and overall efficiency.

- **Goal Setting:**

Setting Realistic Production Goals: By understanding benchmark yields, farmers can set realistic and achievable production goals for their crops. This helps in planning and resource allocation.

- **Resource Optimization:**

Identifying Areas for Improvement: Benchmarking helps in pinpointing areas where improvement is needed. This may involve optimizing the use of fertilizers, irrigation, pest control, or other inputs to enhance yield.

- **Risk Management:**

Understanding Variability and Risks: Benchmarking provides insights into the variability of crop yields and helps farmers understand the potential risks associated with their current practices. This information can be valuable for risk management and decision-making.

- **Industry Standards:**

Comparing with Industry Standards: Farmers may use industry or regional benchmarks to understand how their yields compare with broader standards in their sector.

- **Data-Driven Decision Making:**

Informed Decision-Making: By using data on benchmark yields, farmers can make more informed decisions about crop selection, planting techniques, and other aspects of farming.

- **Continuous Improvement:**

Encouraging Continuous Improvement: Benchmarking is a tool for fostering a culture of continuous improvement in agriculture. It encourages farmers to constantly seek ways to enhance their practices and increase productivity.

Overall, crop yield benchmarking is a valuable tool for farmers and agricultural stakeholders to gauge their performance, learn from successful practices, and make data-driven decisions to optimize crop production.

How to conduct benchmarking?

Benchmarking is an ongoing, systematic process that involves four main steps:

- Planning
- Collecting
- analyzing
- implementing

The followings are considered as **relevant source** for benchmarking crop yields:

- **Local Agricultural Extension Services:**

Contact your local agricultural extension office or agency. They often provide valuable data, reports, and insights on average yields for various crops in your region. Extension services may conduct field trials and collect data from local farmers, making their information relevant to your area.

- **Agricultural Research Institutions:**

Universities and agricultural research institutions frequently publish research findings on crop yields. Look for publications, research papers, or annual reports that provide data on average yields for specific crops in your region.

- **Farmers' Associations and Cooperatives:**

Connect with local farmers' associations or cooperatives. These organizations may collect and share data on crop yields among their members. Farmers within your community can provide valuable insights based on their experiences.

- **Government Agricultural Agencies:**

National or regional agricultural departments often compile and publish crop yield statistics. Check government agricultural websites or request information directly from these agencies.

- **Industry Reports and Surveys:**

Industry reports and surveys conducted by agricultural organizations, commodity boards, or market research firms may provide benchmarks for crop yields. Look for reports specific to your crop and region.

- **Field Trials and Demonstrations:**

Attend agricultural field trials, demonstrations, or workshops organized by agricultural research institutions or extension services. These events often showcase best practices and provide data on crop yields.

- **Online Databases and Platforms:**

Explore online agricultural databases or platforms that compile and share crop yield data. Some organizations provide interactive tools that allow users to access regional or global crop yield information.

- **Collaboration with AgTech Companies:**

AgTech companies and precision agriculture platforms may offer data-driven insights and benchmarks based on advanced monitoring and analytics. Explore partnerships or collaborations with such entities.

- **Peer Networks:**

Engage with local farmers and join peer networks. Discussing crop yields with other farmers in your region can provide practical insights into realistic target yields based on similar farming conditions.

- **Crop Insurance Companies:**

Crop insurance companies often collect data on yields to assess risks. While this data may not be openly available, you can inquire with local insurance providers for information or insights.

2.2. Analyzing past production records to determine the key determinants of yield

Field crop records provide information needed to know key determinants of yield. Looking at past production records enables to follow the promising cultural practices of the past, and abstain from risky cultural practices.

Crop production records may include:

Crop establishment records

- Type of crops grown
- The planting date
- Size of the cultivated area

Irrigation records

- Type of irrigation
- Frequency of irrigation

Plant nutrients record

- Fertilizer type used (organic or inorganic)
- Date of fertilizer application
- Quantity of fertilizer applied
- Dose per ha
- The unit price of fertilizer
- Costs of fertilizing the cultivated area
- The average cost per ha

Pest control records

- The treatment type applied to control pests
- Date of applying the pesticide for controlling pests
- Herbicide for controlling weeds
- Quantity of pesticide and herbicide used
- Dose of the pesticide or herbicide used per ha
- Unit price of each treatment
- Costs incurred to apply the pest control on the cultivated area

Harvest records

- The quantity of the yield

- Selling unit price of the yield per kg (for example 60 etb per kg of maize)
- Revenue generated from harvest sales and revenue per ha
- Remarks on the yield obtained such as aspects that may have contributed to a low yield

Storage

- Storage type used
- Storage duration
- Storage losses (if any) and causes of losses

✓ Analyzing past crop production records is a valuable process to identify key determinants of yield and gain insights into factors influencing crop performance.

General stepwise guide on how to conduct past production records analysis:

- Collecting Relevant Data: Gathering historical data on crop production, including yield records, planting dates, harvest dates, and any relevant agronomic practices. Ensure that the data is accurate, complete, and covers multiple growing seasons.
- Organizing Data: Organizing the data in a structured format, such as a spreadsheet. Each row could represent a specific crop production instance, and columns could include variables such as yield, planting date, fertilization, irrigation, pest control, and weather conditions.
- Statistical Analysis: using statistical analysis tools to identify patterns and relationships within the data.

  Common statistical methods include:

  ✓ Descriptive Statistics: Calculating mean, median, and standard deviation for each variable

  ✓ Correlation Analysis: Assessing the correlation between different variables (e.g., yield and fertilizer application)

  ✓ Regression Analysis: Conducting regression analysis to model relationships between yield and various factors
- Identifying Key Variables: Identifying variables that consistently show a significant correlation or impact on crop yield. These could include:

- ✓ Environmental Factors: Weather conditions (temperature, rainfall, humidity), sunlight.
- ✓ Agronomic Practices: Planting date, spacing, fertilization, irrigation.
- ✓ Pest and Disease Management: Pesticide applications, disease control measures.

- Temporal Trends: Analyzing temporal trends in yield data. Look for patterns related to specific years, seasons, or climate conditions. Understanding temporal trends can help in predicting future yields.
- Spatial Variability: If applicable, analyze spatial variability within your field or farm. Variability in soil characteristics, drainage, or microclimates may impact crop performance.
- Evaluating Crop Varieties: Assessing the performance of different crop varieties over time, some varieties may show better adaptation to specific conditions or higher resistance to pests and diseases
- Economic Analysis: Conducting an economic analysis to understand the cost-effectiveness of different practices and evaluating the return on investment for inputs such as fertilizers, pesticides, and irrigation.
- Document Anomalies: Identifying any anomalies or outliers in the data, these could be instances where unexpected high or low yields occurred. Investigate these anomalies to understand contributing factors.
- Integration of Technology: If applicable, integrate technology and precision agriculture tools for more detailed insights. Remote sensing, drones, and sensors can provide real-time data on crop conditions.
- Learning from Failures: Analyze instances of lower-than-expected yields or crop failures. Understanding the reasons behind these failures is crucial for making informed decisions in future planting seasons.
- Continuous Monitoring: Establishing a system for continuous monitoring and record keeping; regularly updating your database with new data from each growing season to refine your understanding of key determinants of yield

By systematically analyzing past crop production records, you can develop a comprehensive understanding of the factors influencing yield variability on your farm. This information is

valuable for making informed decisions, optimizing agronomic practices, and improving overall crop management strategies.

2.3. Using available models for calculating water, nutrients and agronomic use efficiency

Calculating water, nutrients and agronomic use efficiency helps to compare the products (outputs) we get from our farm with costs we incurred during production process.

2.3.1. Water use efficiency (WUE)

WUE can be described as: (a) crop water use efficiency and (b) field water efficiency

I. **Crop Water Use Efficiency:** is the ratio of yield of crop (Y) to the amount of water depleted by crop in evapotranspiration (ET).

$$\text{CWUE} = \frac{Y}{\text{ET}}$$

Where,

CWUE = Crop water use efficiency

Y = Crop yield

ET = Evapotranspiration

CWUE is otherwise called consumptive water use efficiency. It is the ratio of crop yield (Y) to the sum of the amount of water taken up and used for crop growth (G), evaporated directly from the soil surface (E) and transpired through foliage (T) or consumptive use (Cu)

$$\text{CWUE} = \frac{Y}{\text{G} + \text{E} + \text{T}}$$

Where,

(G + E + T) = Cu

In other words ET is Cu since water used for crop growth is negligible.

$$\text{CWUE} = \frac{Y}{\text{CU}}$$

It is expressed in kg/ha/mm or kg/ha/cm

II. **Field Water Use Efficiency:**

It is the ratio of yield of crop (Y) to the total amount of water used in the field.

$$\text{FWUE} = \frac{Y}{WR}$$

Where,

FWUE = field water use efficiency

WR = water requirement

This is the ratio of crop yield to the amount of water used in the field (WR) including growth (G), direct evaporation from the soil surface (E), transpiration (T) and deep percolation loss (D).

$$\text{FWUE} = \frac{Y}{\text{G} + \text{E} + \text{T} + \text{D}}$$

G + E + T + D = WR

It is expressed in kg/ha/mm (or) kg/ha/cm

Deep percolation is important for rice crop. For other crops seepage is important.

Of the two indices defined, the crop water use efficiency is more of research value whereas the field water use efficiency has grater practical importance for planners and farmers.

2.3.2. Nutrient utilization efficiency (NUE)

Nutrient utilization efficiency is the product of physiological and apparent recovery efficiency. It can be calculated as:

$$\text{NUE (kg kg}^{-1}) = \text{PE X ARE}$$

Where**:**

PE is Physiological efficiency

ARE is Apparent recovery efficiency

Physiological efficiency (PE) is defined as the biological yield obtained per unit of nutrient uptake. It can be calculated as:

$$\text{PE (kg kg}^{-1}) = \frac{\text{BYf} - \text{BYu}}{\text{Nf} - \text{Nu}}$$

Where,

- BYf is the biological yield (grain plus straw) of the fertilized pot (kg)
- BYu is the biological yield of the unfertilized plot (kg)
- Nf is the nutrient uptake (grain plus straw) of the fertilized plot
- Nu is the nutrient uptake (grain plus straw) of the unfertilized plot (kg).

Apparent recovery efficiency (ARE) is defined as the quantity of nutrient uptake per unit of nutrient applied. It can be calculated as:

$$\text{ARE (\%)} = \frac{\text{Nf} - \text{Nu}}{\text{Na}} \text{ x } 100$$

Where:

- Nf is the nutrient uptake (grain plus straw) of the fertilized plot (kg)
- Nu is the nutrient uptake (grain plus straw) of the unfertilized plot (kg)
- Na is the quantity of nutrient applied (kg)

- ✓ To calculate NUE, first Physiological efficiency (PE) and apparent recovery efficiency (ARE) have to be calculated separately, and then multiplied by each other.
- ✓ NUE (kg kg−1) = PE X ARE

2.3.3. Agronomic efficiency (AE)

Agronomic efficiency (AE) is defined as the economic production obtained per unit of nutrient applied. It can be calculated by:

$$\text{AE (kg kg}^{-1}) = \frac{Gf - Gu}{Na}$$

Where,

- Gf is the grain yield of the fertilized plot (kg)
- Gu is the grain yield of the unfertilized plot (kg)
- Na is the quantity of nutrient applied (kg)

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

Quality specifications are detailed requirements that define the quality of a product, service or process. Quality includes **tangible elements** such as measurements and intangible elements such as taste.

2.4.1. Establishing quality specifications for the selected field crop

Establishing quality specifications for a field crop involves defining specific criteria and standards that the crop must meet to be considered as high quality. These specifications are crucial for ensuring consistency, meeting market demands, and satisfying consumer preferences.

Important activities to establish quality specifications for a selected field crop:

- **Defining End-Use Requirements:**

Understand the intended use of the crop. Different end uses may have distinct quality requirements. For example, wheat for bread making has different quality specifications than wheat for animal feed.

- **Reviewing Market Standards:**

Research industry and market standards for the selected crop. This includes grading systems, quality parameters, and any certification requirements. Standards may be set by agricultural boards, regulatory bodies, or industry organizations.

- **Consulting with Buyers and Processors:**

Communicate with potential buyers, processors, and other stakeholders in the supply chain. Understand their quality expectations and any specific requirements they may have. This collaboration helps align your specifications with market demands.

- **Considering Physical Characteristics:**

Define the physical attributes that contribute to quality. This may include factors such as size, color, shape, texture, and uniformity.

- **Nutritional and Chemical Composition:**

Specify the desired nutritional and chemical composition of the crop. This is particularly important for crops used for food or animal feed. Parameters may include protein content, oil content, sugar levels, and absence of harmful substances.

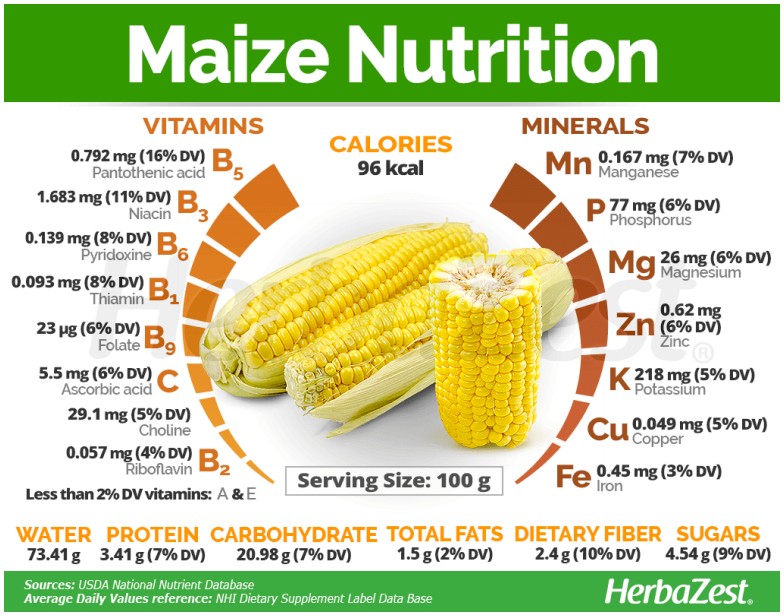


Figure 2.1 Nutritional composition of maize

- **Purity and Uniformity:**

Establish criteria for purity and uniformity. This involves ensuring that the crop is free from contaminants, impurities, or foreign materials. Uniformity in size, maturity, and color may also be important.

- **Harvesting and Handling Practices:**

Include specifications related to harvesting and post-harvest handling practices. For example, specifying the appropriate harvest maturity, storage conditions, and transport methods can impact crop quality.

- **Testing and Inspection Protocols:**

Develop testing and inspection protocols to assess quality. This may involve laboratory tests, visual inspections, or sensory evaluations. Specify acceptable tolerances for variations in quality parameters.

- **Establishing Grading System:**

Create a grading system to categorize the crop into different quality classes. Grading helps communicate the quality of the crop to buyers and facilitates price determination.

- **Certification Requirements:**

If applicable, define certification requirements for organic, non-GMO, or other special designations. Compliance with specific certifications can enhance the marketability of the crop.

- **Documenting Quality Specifications:**

Document the quality specifications in a clear and comprehensive manner. This documentation should be easily accessible to everyone involved in the production and marketing of the crop.

- **Monitoring and Continuous Improvement:**

Implement a system for monitoring the adherence to quality specifications. Regularly review and update the specifications based on feedback, changing market conditions, or advancements in agricultural practices.

- **Compliance with Regulations:**

Ensure that your quality specifications comply with local and international regulations. Familiarize yourself with any legal requirements related to the crop and its intended use.

- **Educating Stakeholders:**

Educate farmers, workers, and other stakeholders involved in the production process about the established quality specifications. This promotes awareness and encourages compliance.

By establishing clear and comprehensive quality specifications, you contribute to the production of high-quality crops, enhance market competitiveness, and build trust with buyers and consumers. Regularly reviewing and updating these specifications ensures that they remain relevant and aligned with industry standards and market expectations.

Table 2.1) Example of quality specification for wheat grain

Moisture	14.0 % max
Organoleptic	Bright, clear appearance, natural smell and color
Shrunken and broken kernels	5.0% max
Insect damaged kernels	1.5% max
Ergot	0.05% max
Sprouted kernels	2.0% max
Total damaged kernels	6.0% max
Edible grain other than wheat	2.0% max

Organic matter (other than edible grains of cereal)	1.5% max
Inorganic matter	0.05% max
Filth	0.1% max
Live insect	Nil

2.4.2. Yield target setting

Yield target setting in crop production refers to the process of establishing a realistic and achievable goal for the amount of a specific crop that a farmer aims to produce per unit of land. This target is essential for making various production decisions, such as:

- Selecting crop species
- Determining seeding rates
- Making fertilizer recommendations

The yield goal should be based on factors such as the specific field's historical performance, prevailing environmental conditions, and the economic implications of the target yield. It is important to set a goal that is both attainable and challenging, as it directly impacts the cost of production and, ultimately, farm profitability

Several methods can be used to set a realistic yield goal, including:

- Using the maximum yield produced in the past on a specific field or a neighboring field with similar conditions.
- Basing the yield goal on the five- to ten-year yield average, aiming for a goal within 105% to 110% of the average and not exceeding the attainable yield potential

The yield goal is not only a production target but also a key factor in determining the economic and environmental implications of crop production, as it directly influences fertilizer use, plant population decisions, and the cost of production

Setting target yields for crops involves considering various factors such as local conditions, crop varieties, farming practices, and climate patterns.

The yield target you set directly affects the fertilizer recommendations and other agronomic practices. Higher yield targets will require higher levels of nutrients and efforts in agronomic

practices. It is therefore essential that you set accurate yield targets for your crops in tons of produce per hectare.

To calculate a yield target for your farm or field, aim for above average yields, so crop yields will slowly increase over time. Keep a good production record of each field on the farm for at least five years. Some fields may produce more than others because of differences in soil quality and other factors. Adjust the past average to set a yield target.

Regardless of the method you employ, it is important to be consistent from one year to the next.

If you set a very high yield target that is not realistic under the current farming system or environment, you will end up wasting money on fertilizers if the yield target is not reached.

Self-Check – 2	

Directions: Answer all the questions listed below.

Part I. Write 'True' for correct statements and 'False' for incorrect statements.

1. Performance evaluation is one of the advantages of benchmarking
2. Collecting relevant data is the first activity in past production records analysis.
3. By establishing clear and comprehensive quality specifications, you contribute to the production of high-quality crops
4. Local Agricultural Extension Services are considered as relevant source for benchmarking crop yields
5. Setting too high yield target is required to be successful in crop production.

Part II. Choose the best answer

1. _____ is defined as the economic production obtained per unit of nutrient applied.
   A. Nutrient utilization efficiency B. Agronomic efficiency
   C. Apparent recovery efficiency D. Physiological efficiency
2. _____ is defined as the biological yield obtained per unit of nutrient uptake.
   A. Nutrient utilization efficiency B. Agronomic efficiency
   C. Apparent recovery efficiency D. Physiological efficiency
3. _____ are detailed requirements that define the quality of a product, service or process.
   A. Quality control B. Quality specification
   C. Quality assessment D. None
4. _____ involves determining what yield objectives need to be achieved within a certain timeframe and outlining the actions and resources required to reach this goal.
   A. Quality assessment B. Yield target setting C. Quality specification D. All

Part III. Give short answers

1. Define crop water use efficiency
2. What are benefits of using crop records?
3. What do we mean by field water use efficiency?
4. What should be included in pest control records?
5. Mention important activities required to establish quality specifications for a selected field crop.

Operation Sheet -2

Preparing crop benchmarking template

Objective: To prepare crop benchmarking template

Materials Required

- Notebooks
- Pen/pencil
- Smartphones and Tablets (if available)
- Papers for questionnaire
- Surveying equipment

Procedures

Step 1 Start by defining the purpose, scope, and objectives of benchmarking, as well as selecting the key performance indicators (KPIs) you want to compare.

Step 2 Identify relevant sources of data and information and choose benchmarking partners

Step 3 Gather the data and information from the selected sources and partners, using standardized methods and tools such as surveys or questionnaires.

Step 4 Compare your data with those of your benchmarking partners to identify gaps and differences in performance, processes, and practices.

Step 5 Highlight the best practices from your benchmarking partners and develop an action plan to close the gaps.

Step 6 Prioritize the actions based on their feasibility, impact, and urgency.

Step 7 Assign responsibilities and resources to implement them, then communicate and share the results with stakeholders.

Step 8 Finally, monitor and evaluate the outcomes of the actions.

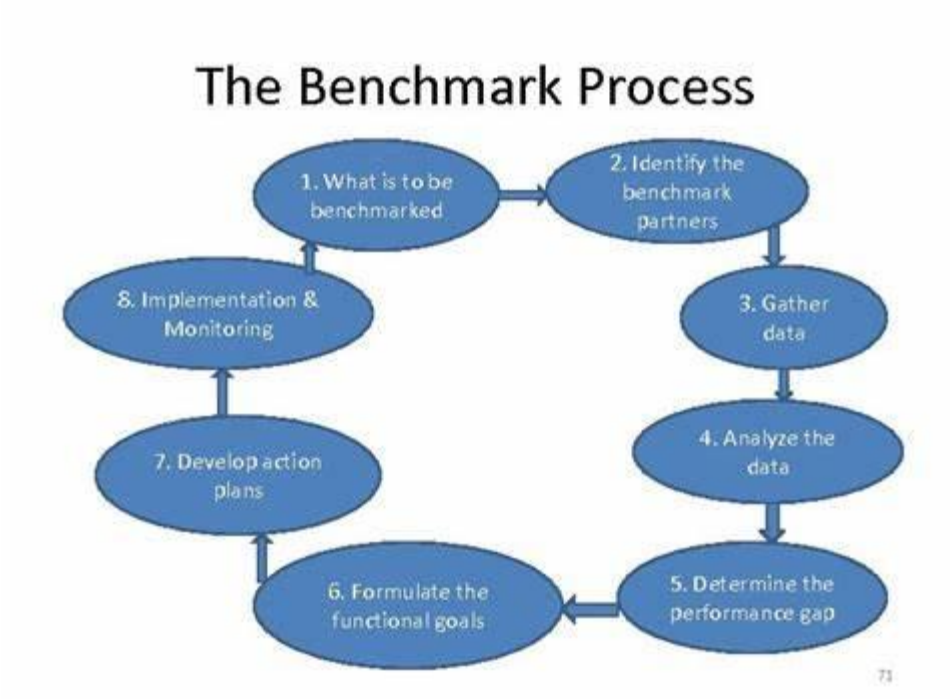


Figure 2.2 Benchmarking process

https://www.youtube.com/watch?v=SRx1pq2ky6A (Accessed date 15/01/24)

Benchmarking potential yield of barley in higher rainfall zones - YouTube (Accessed date 17/01/24)

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 **3** hour.

1. Develop a sample benchmark for wheat

LG #9	LO #3- Prepare production plan for individual crop and the whole farm

Instruction sheet

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

- Assessing crop field before selecting crop type and variety
- Using records of chemical use to assist planning and reduce chemical residue
- Selecting crop variety and planning agronomic practices
- Determining optimum timing of planting and applications of input and preparing operational calendar
- Identifying and planning labour, machinery and equipment requirements
- Determining resources and budget for cropping program

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 crop field before selecting crop type and variety
- Use records of chemical use to assist planning and reduce chemical residue
- Select crop variety and plan agronomic practices
- Determine optimum timing of planting and applications of input and preparing operational calendar
- Identify and plan labour, machinery and equipment requirements
- Determine resources and budget for cropping program

Learning Instructions:

Read the specific objectives of this Learning Guide.

Follow the instructions described below.

Read the information written in the information Sheets

Accomplish the Self-checks

Perform Operation Sheets

Do the “LAP test”

Information Sheet 3

3.1. Assessing crop field before selecting crop type and variety

Analysis of the various factors to consider in site selection should be the first step to undertake before going into actual farming.

Factors to be considered in crop field selection

I. Soil, topography, and climatic conditions of the field

a. **Soil conditions** include:

- **Physical Properties of Soil**
  - ✓ Texture
  - ✓ Structure
  - ✓ Color
  - ✓ Porosity
  - ✓ Water holding capacity
  - ✓ Bulk density
  - ✓ Particle density
  - ✓ Infiltration
  - ✓ Depth
- **Chemical properties of soil**
  - ✓ Soil pH
  - ✓ Cation Exchange Capacity
  - ✓ Salinity
  - ✓ Organc matter
  - ✓ Nutrient

Biological Properties of Soil

These include soil microorganisms and other living organisms like bacteria, viruses, fungi, nematodes, protozoa, rodents living in the soil.

All the physical, chemical, and biological properties of soil should be tested and analyzed before selecting crop type and variety, and based on the soil test results crops and varieties that best suits to the soil are selected.

b. **Topography**

Topography refers to land features such as elevation, slope, and terrain.

Topographic requirement of a crop varies from one another due to natural adaptation or tolerance.

To select crop type, topography of the field needs to be checked.

c. **Climatic factors**

Climatic factors that can influence the growth and yield of crops include:

- Temperature
- Water or rainfall
- Light (including photoperiod or light duration)
- Relative humidity, and wind

These factors may vary with geographical location and, microclimate, from farm to farm. Plants are also distinguished into various classifications according to climate adaptation such as temperate, sub-tropical, and tropical crops.

II. Biotic factors and the prevalence of pests and diseases

Site selection may consider the natural population of certain organisms like bees and other pollinators.

Places with a long history of the presence of serious pests and diseases may be avoided.

III. Cost of acquisition or lease and in preparing the land

Where financial feasibility or affordability is a consideration, the cost of procuring or leasing the farmland is a limiting factor.

This may take into consideration also the cost of modifying the physical features of the land such as in flattenning or modifying the landscape if so desired, the removal of barriers like unwanted trees, clumps, stumps, and boulders, diversion of floodways, construction of drainage, roads and fire lanes.

In preparing the land for crop growing including the eradication of major weeds and disease-causing organisms, soil amendment, and provision of irrigation water

IV. Frequency of calamities

The frequency of possible occurence of calamities like floods, drought, and volcanic eruptions are always considered in both location and site selection because they can cause severe loss in investment or total crop failure.

V. Accessibility

A farm that is managed as a business must have access to supplies, equipment, and the market.

It must be provided with infrastructures (e.g. roads) and, if the product is intended to be marketed elsewhere, shipping facilities or airports.

Moreover, there is a general preference for farms in familiar locations which are easily accessible to owner-managers.

VI. Labor supply and cost

Skilled labor must be available at a **reasonable cost**. Otherwise, laborers from other parts of the country may have to be imported.

This factor should be the main consideration for those individuals who may entertain the idea of spending hard-earned money to acquire a low-cost but raw farm to be developed, at the least, into a family retreat or a quiet place to entertain friends.

A thorough dissect should be undertaken and the analysis ought to start with the community surrounding the prospected farmland from where labor may be hired.

The honesty and dishonesty of the general populace, their lawfulness or lawlessness, their helpfulness or indifference in eliminating thievery, their work ethics, their sincerity to educate the young, their diligence or lack of it in achieving self-sufficiency, their customs, and traditions, their attitude towards newcomers and the reach of the law, all of these should be considered.

The same ought to apply to the engagement of farm caretakers.

The bottom line is to be able to live in peace and to continue development works without having to worry so much about untrustworthy workers and neighbors.

VII. Security and political stability

The farm should be **secure** from thieves and astray animals. Otherwise, additional investment may be provided for fencing or security personnel.

In addition, farms are preferred in locations where the local and regional populace is compliant with the rule of law and where there is stable existence of peace and order.

Conversely, places with a history of unrest, interfamily, inter-clannish and intertribal feud, political turmoil, banditry, and lawlessness tend to be avoided in site selection.

VIII. Bureaucracy and investment benefits

Site selection favors those locations where bureaucratic red tape is minimal so that business permits and other papers if so required can be processed with haste

3.2. Using records of chemical use to assist planning and reduce chemical residue

Various chemical products used in agriculture are called agrochemicals or agricultural chemicals. Chemicals such as pesticides, insecticides, natural herbicides, fungicides chemicals, and natural nematicides, all fall under the category of agrochemicals.

Utilizing records of chemical use is a valuable practice for planning and minimizing chemical residues in agricultural production. Effective management of chemical inputs involves careful monitoring, record-keeping, and strategic decision-making.

Using chemical use records:

Observe detailed records of all chemical inputs used on the farm. Carefully look for information such as the type of chemical, application rates, dates of application, target crops, and specific field locations.

Table 3.1) Example of chemical use record

Applicator Name & Permit. No.	Date M/D/Y	Crop	Pest Controlled	Number of acres	Chemical Brand Name and Formulation	Name of Manufacturer	Registration	Rate	Total amount

The following are how you can use chemical use records to assist in planning and reduce chemical residues:

- **Crop rotation planning:**

  Analyze chemical use records to plan crop rotations effectively. Crop rotation can help break pest and disease cycles, reducing the need for continuous application of specific chemicals.

- **Monitoring Residue Levels:**

  Regularly monitor crop and soil samples for chemical residues. Use this information to assess the persistence of residues and adjust future chemical applications accordingly.

- **Calibration and Precision Application:**

  Use chemical use records to calibrate application equipment and ensure precise application rates. Accurate application reduces the risk of overuse and minimizes chemical residues.

- **Document and Analyze Incidents:**

  Document any incidents of pest or disease outbreaks and chemical failures. Analyze these incidents to identify potential improvements in management practices or the need for alternative chemicals.

  By using chemical use records strategically, farmers can optimize their input management, minimize environmental impact, and produce crops with lower chemical residues. This approach not only supports sustainable agricultural practices but also aligns with consumer preferences for food safety and environmental responsibility.

  Using records of past chemical use enables to reduce application of excess chemicals and chemical residues in the soil.

3.3. Selecting crop variety and planning agronomic practices

Selection of appropriate crop variety and planning good agronomic practices for the selected variety plays crucial role for profitability of crop production.

3.3.1. Selecting crop variety

Selecting good variety is a key in success of crop producer. Various factors should be considered to select crop variety

Characteristics of good crop variety

- **High yielding:** high yielding variety is selected unless there are other draw backs on it.
- **Resistance to pests and diseases**

Regardless of the purpose of farming, it is important to be able to select a crop and variety with wide resistance to important pests and diseases.

The use of susceptible varieties may result to high cost of production or, worst, total crop

- **Marketability and profitability**

For those who want to engage in cash crop farming or, at the least, ensure financial sustainability, variety selection must consider marketability and profitability.

In general, marketability and profitability means that the crop to be selected must be:

✓ High yielding and

✓ The product must have an accessible, stable, and robust market.

✓ Likewise, certain crop varieties are preferred because technical assistance is available locally.

3.3.2. Planning agronomic practices

Agronomic practices are the techniques, strategies, and practices used in the cultivation of crops. These include methods of planting, fertilization, pest control, irrigation, and harvest. The goal is to maximize crop yields while minimizing damage to the environment and ensuring the sustainability of the system.

Agronomic practices range from site preparation to the final harvesting and storage of crops

This practice includes all the activities that are required to maintain and produce crops.

Listed below are some agronomic practices in crop production.

- Preparation of soil
- Sowing of seeds
- Irrigation
- Application of manure, pesticides, and fertilizers to the crops
- Protecting and harvesting crops
- Storage and preserving the produced crops

Table 3.2) Plan for agronomic practices could be done as follows by listing the activities (tasks) and assigning their consecutive dates

No.	Agronomic Practices	Date
1.	Site clearing	
2.	First tillage (plowing)	
3.	Second tillage (pulverizing, disking, harrowing, leveling, etc)	
4.	Pre-planting soil amendment or fertilizer applications	
5.	Seed sowing	
6.	Fertilizer application during seed sowing	
7.	Post emergence fertilizer application	
8.	Critical weeding days	
9.	Spraying pesticides	
10.	Checking maturity indices	
11.	Harvesting	
12.	Drying	
13.	Threshing	
14.	Transportation to temporary storage	
15.	Transporting to a market	

3.4. Determining optimum timing of planting and applications of input and preparing operational calendar

In crop production, timing is a key for every activity. Seed sowing, application of fertilizers and pesticides, and all other activities are performed at their critical time. Failure of proper timing for the activities leads to yield reduction or total loss.

3.4.1. Determining optimum timing of planting and applications of input

The optimum time of sowing for crops depends on various factors such as the type of crop, local climate, soil conditions, and the specific requirements of the crop in question.

The followings are some general guidelines to help determine the optimum time of sowing for crops:

- **Climate and Weather Conditions:**
  - ✓ Consider the climate of your region, including temperature, rainfall, and humidity patterns.
  - ✓ Different crops have specific temperature and moisture requirements for germination and growth. Ensure that the sowing time aligns with these needs.
- **Frost Risk:**
  - ✓ Be aware of the last expected frost date in the spring and the first frost date in the fall. Sowing too early may expose crops to late spring frosts, while sowing too late may expose them to early fall frosts.
- **Growing Season Length:**
  - ✓ Know the length of the growing season in your area. This is the period between the last spring frost and the first fall frost. Choose crop varieties with maturity dates that fit within this timeframe.
- **Soil Conditions:**
  - ✓ Assess soil temperature and moisture levels. Different crops have different soil temperature requirements for optimal germination.
  - ✓ Ensure that the soil is adequately prepared and has the right structure for proper root development.
- **Crop Specifics:**
  - ✓ Understand the specific requirements of the crop you are planting. Some crops may be more resilient to adverse conditions during germination, while others may require more precise conditions.
- **Local Agricultural Extension Services:**
  - ✓ Consult local agricultural extension services or experts for advice tailored to your specific region. They can provide information on local conditions, best practices, and crop recommendations.
- **Crop Rotation:**

- ✓ Practice crop rotation to avoid disease and pest buildup in the soil. Consider the crops that were planted in the previous seasons when deciding the timing for sowing.

- **Market Demands:**
  - ✓ Consider market demands and the timing of harvesting periods. Aim to align your sowing time with peak market demand for your crops.
- **Risk Management:**
  - ✓ Factor in some buffer time for unexpected weather events or delays in planting. This can help mitigate risks associated with unfavorable conditions.
- **Technology and Data:**
  - ✓ Utilize modern technologies and data-driven approaches, such as satellite imagery, weather forecasts, and precision agriculture tools, to optimize sowing times.

It's important to note that these are general guidelines, and the specific conditions in your region may vary. Local knowledge and experience often play a crucial role in determining the best time to sow crops.

3.4.2. Preparing operational calendar (cropping calendar)

A cropping calendar: is a schedule that outlines the key activities and timings involved in the cultivation of crops throughout the year. It serves as a guide for farmers to plan their farming operations, taking into account factors such as climate, soil conditions, and the specific requirements of different crops. Here's a general outline of what a cropping calendar might include:

- **Preparation Phase (Before Planting Season):**
  - ✓ Land preparation: Clearing, plowing, and leveling.
  - ✓ Soil testing and amendments: Assess soil fertility and make necessary adjustments.
  - ✓ Irrigation system check: Ensure proper functioning of irrigation infrastructure.
- **Planting Season:**

- ✓ Choose the crops to be planted based on market demand, soil conditions, and climate.
- ✓ Determine the optimal time for sowing each crop based on local conditions.
- ✓ Begin planting according to the recommended sowing dates for each crop.

- **Growing Season:**
  - ✓ Monitor crop growth regularly.
  - ✓ Implement pest and disease control measures as needed.
  - ✓ Provide necessary fertilizers and nutrients at appropriate stages.
  - ✓ Manage irrigation to meet the water requirements of the crops.
- **Harvesting Season:**
  - ✓ Harvest crops at their peak maturity to ensure quality.
  - ✓ Use appropriate harvesting techniques to minimize damage.
  - ✓ Implement post-harvest handling practices to preserve the quality of the produce.
- **Post-Harvest Activities:**
  - ✓ Threshing, cleaning, and sorting of harvested crops.
  - ✓ Storage of crops in appropriate facilities.
  - ✓ Marketing and sale of the harvested produce.
- **Fallow Period or Crop Rotation:**
  - ✓ Allow the land to rest or practice crop rotation to maintain soil fertility.
  - ✓ Prepare the soil for the next planting season.
- **Off-Season Activities:**
  - ✓ Repair and maintenance of farming equipment.
  - ✓ Training and education for farmers on new techniques or technologies.
  - ✓ Planning for the next planting season, including crop selection and input procurement.
- **Record Keeping:**
  - ✓ Maintain records of crop yields, expenses, and other relevant data.
  - ✓ Evaluate the performance of different crops and farming practices.
- **Weather Monitoring:**

- ✓ Keep track of weather forecasts to anticipate and prepare for extreme conditions.

- **Government Programs and Subsidies:**
  - ✓ Participate in government-supported programs, subsidies, or extension services.

It's important to customize the cropping calendar based on the specific crops grown, local climate, and soil conditions in a particular region. Additionally, flexibility is crucial, as unexpected events such as weather fluctuations or pest outbreaks may require adjustments to the schedule. Farmers often use their experience and local knowledge to fine-tune the cropping calendar for optimal results.

Benefits of using a cropping calendar

- A crop calendar is a planning (budgeting) tool to allocate time, money and labor for production and marketing of crops
- It is a tool of formal and efficient farm management especially for commercial farmers.
- It is a key tool for loan and funding negotiations with bankers and creditors in the distribution realization of the loans
- It can improve your farm profits by sourcing farm inputs before the rainy season and enjoy higher selling prices by delaying or planning for earlier harvests.
- Helps farmers, workers and managers in actual preparation and executing of sowing, applying fertilizer and pesticides, harvesting and marketing of different crops.
- It assists in efficient farm management of crops and animals like crop rotation or breeding
- It helps farmers to keep records the results of different agricultural practices.

Table 3.3) Sample cropping calendar (Produced by the International Rice Research Institute (IRRI))

Activity	Timing DAS=Days after sowing; DAT=Days after transplanting; DAP=Days after planting (nursery)	Anticipated date	Comments
Variety Selection		30Nov	NSIC Rc 218
Plan sowing method: transplant (manual v. machine) or direct (dry seed drill v. drum seed v. broadcast)		30Nov	Manual Transplanting
Planning of fertilizer application using Nutrient Manager		30Nov	14-14-14 20kg at 0-14 DAT Urea 12kg at 26-32 DAT Urea 15kg at 43-47 DAT
Planning of weed management		30Nov	1) Wet land preparation with deep cultivation and puddling; 2) Continuous flooding 2-4 cm depth; 3) clean bunds
Planning of pest and disease management		30Nov	Snails – Hand picking and bait leaves Rats – bait traps and clean bunds Insects and disease – To be determined
Planning of field preparation		30Nov	wet preparation
Fallow (glyphosate spray if applicable)	~-30 DAS/DAT	3 Dec	
Fallow (plough stubble if applicable)	~-30 DAS/DAT	13Dec	4wheel tractor with disc plow 2x
Bund – maintenance and repair	-20 to 0 DAS/DAT	13 Dec	Clean bunds, fill holes
Nursery Soil Preparation	-7 to -1 DAP	15Dec	Prepare wet bed nursery
Breaking seed dormancy	-2 DAP	20Dec	Soak seeds for 24hrs, then dry for 24hrs
Seeding Nursery/Sowing field	0DAP	**22Dec**	**Sow seeds in wet bed nursery**
Wet prep: Land soaking	-30 to -14DAT	13Dec-27Dec	14 days of flooding to decompose stubble and soften soil
Wet prep - Puddling, harrowing, levelling: apply water, puddle 2-3x, harrow 2-3x, level	-14 to -4 DAT	27Dec-4Jan	27Dec - 2 wheel power tiller with rotavator 2x 30Dec - 2 wheel power tiller with harrow 2x 4Jan - Third harrow with plank leveler
Dry prep: sufficient time for drying is needed if machine sowing	-5DAT		
Herbicide-apply Pretilachlor/Butachlor (if applicable)	-2 to 2 DAS/DAT		No need – managing weeds with water
Transplant	14-20 DAP	**10Jan**	**Transplant 19 day old seedlings**
Apply water	~ DAS/DAT	10Jan-25Jan	Maintain water at 2-5cm
Basal fertilizer	0-14 DAS/DAT	15Jan	20kg 14-14-14
Golden Apple Snail- check control	0-30 DAS/DAP	10Jan-21Jan	Hand pick until seedlings are 30 days old
Water Management 3-10cm	0 DAS to 10-14 days before harvest	25Jan-28Apr	Maintain 3-10cm water
Post emergent weed control	14 to 21 DAS/DAT	24-31Jan	If weeds, apply post emergent herbicide
Pest and disease monitoring and control	Early tillering to harvest	25Jan – 10May	monitor
Nitrogen topdressing, Nutrient Manager	Tillering	10Feb	12kg of urea at 30DAT
Weeds check – no weeds	30-40 DAS/DAP	10-20Feb	Hand weed if any weeds
Fertilizer – Panicle initiation	40-50DAT	25Feb	15kg urea at 45 DAT
Drain water	10-14 days before harvest	26Apr-1May	Drain
Harvest	22-24% moisture	10May	Combine harvest at 22% MC
Drying	Post harvest	10May-12May	Flatbed dryer
Storage	Post harvest	12May-20Sep	Superbag storage
Milling	Post harvest	20Sep	Mill as brown rice
Marketing	Post harvest	20Sep	Higher value for brown rice
Sale	Post harvest	20Sep	Higher value because off-season and brown rice

3.5. Identifying and planning labour, machinery and equipment requirements

Scale of production plays a fundamental role in all current and future farm operations; it is a critical consideration in decision-making related to effective use of labor and in making sure the tools and equipment used can do the work that is needed.

3.5.1. Identifying and planning labour requirements

Identifying and planning labor requirements for crop production are crucial for optimizing efficiency, ensuring timely operations, and achieving successful harvests.

The followings are key points to identify and plan labor needs for crop production:

- **Crop Planning and Scheduling:**

  Starting with a detailed crop plan that includes information on planting dates, expected harvest dates, and crop varieties, this will serve as the foundation for labor planning.

- **Task Analysis:**

  Breaking down the entire crop production cycle into specific tasks, and identifying the activities involved in each stage, from soil preparation and planting to cultivation, irrigation, pest control, and harvest.

- **Labor Intensive Tasks:**

  Identifying tasks that are particularly labor-intensive, these may include activities such as planting, weeding, watering, harvesting, and post-harvest handling.

- **Labor Requirement Estimation:**

  Estimating the time required to complete each task and determining the number of labor hours needed by considering factors such as the size of the cultivated area, crop type, and the efficiency of your workforce.

- **Skill Requirements**

  Assessing the skills required for each task. Some activities may demand specialized skills or experience, such as operating machinery or conducting precision tasks like compost preparation.

- **Seasonal Variations:**

  Considering seasonal variations in labor requirements, certain stages of crop production may demand more labor during peak seasons, such as planting and harvest times.

- **Weather Considerations:**

Accounting for weather conditions that may impact labor availability and productivity. Extreme heat, rain, or adverse weather conditions can affect the pace of work.

- **Machinery and Technology:**

Evaluating the use of machinery and technology to streamline certain tasks, mechanization can reduce the need for manual labor in some operations, improving overall efficiency.

- **Labor Budget:**

Developing a labor budget that outlines the total labor hours required for each task throughout the crop production cycle, this budget should consider both regular tasks and seasonal peaks.

- **Flexibility and Contingency Planning:**

Planning for flexibility and contingencies, unexpected events, such as equipment breakdowns, weather disruptions, or sudden changes in crop conditions, may require additional labor or adjustments to the plan.

- **Training and Skill Development:**

Ensuring that the workforce is adequately trained for the tasks they are assigned, continuous training and skill development programs can enhance efficiency and effectiveness.

- **Labor Management Software:**

If possible using labor management software or tools that help in tracking labor hours, scheduling tasks, and optimizing workforce allocation.

- **Regular Monitoring and Adjustment:**

Monitoring the actual labor hours and performance regularly and compare the actual labor usage with the planned estimates and make adjustments as needed.

- **Feedback and Communication:**

Establishing open communication channels with workforce, encourage feedback on task difficulty, workflow, and potential improvements. This can contribute to a more efficient and motivated workforce.

- **Compliance with Labor Laws:**

Ensuring compliance with labor laws and regulations, understanding the legal requirements related to working hours, breaks, and wages to maintain a fair and lawful working environment.

- ✓ By systematically identifying and planning labor requirements, you can optimize your farming operations, reduce costs, and improve overall productivity throughout the crop production cycle.

3.5.2. Identifying and planning machinery and equipment requirements

There are several factors to consider when choosing appropriate agricultural equipment and tools:

- Does the tool or equipment support your whole-farm plan?
- Is the tool or equipment appropriate to your farm's location and growing condition?
- How does the tool or implement impact soil health, production, and marketing?
- Is it safe to use and appropriate to your skill and comfort level and to that of other farmworkers?
- Is it appropriate in scale now and for future growth?
- Is it easy to maintain and repair?
- How accessible are parts?

Common agricultural tools, equipment and machineries

Crop production involves a variety of tasks from soil preparation to harvesting and post-harvest handling. The tools and equipment needed for crop production depend on the type of crops, farming practices, and scale of operations.

Common tools and equipment used in different stages of crop production:

- **Soil Preparation:**
  - ✓ **Tractor:** Used for plowing, tilling, and cultivating large fields.
  - ✓ **Plow:** Breaks and turns over soil to prepare it for planting.
  - ✓ **Disc Harrow:** Breaks up clods and smoothens the soil surface after plowing.
  - ✓ **Rotavator/Rototiller:** Cultivates and mixes the soil, often used for smaller areas.
  - ✓ **Subsoiler:** Breaks up compacted soil layers below the surface.



Figure 3.1 Primary tillage implements

- **Planting and Seeding:**
  - ✓ **Seeder/Planter:** Mechanically sows seeds in rows with precise spacing.
  - ✓ **Seed Drill:** Places seeds at uniform depths and intervals.
  - ✓ **Transplanter:** Planting seedlings instead of seeds, common in vegetable farming.
  - ✓ **Dibble Stick:** Hand tool for manually making holes for planting seeds.

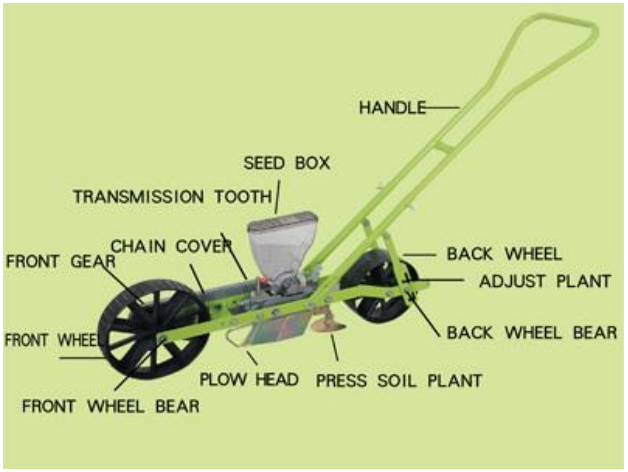


Figure 3.2 Hand driven seed planter

- **Cultivation and Weed Control:**
  - ✓ **Cultivator:** Breaks up soil and removes weeds between rows of crops.
  - ✓ **Hoe:** Manual tool for removing weeds and breaking up soil.

- ✓ **Weeder:** Mechanical tool for removing weeds without disturbing crops.
- ✓ **Mulching Equipment:** Used to apply mulch to suppress weeds and conserve moisture.

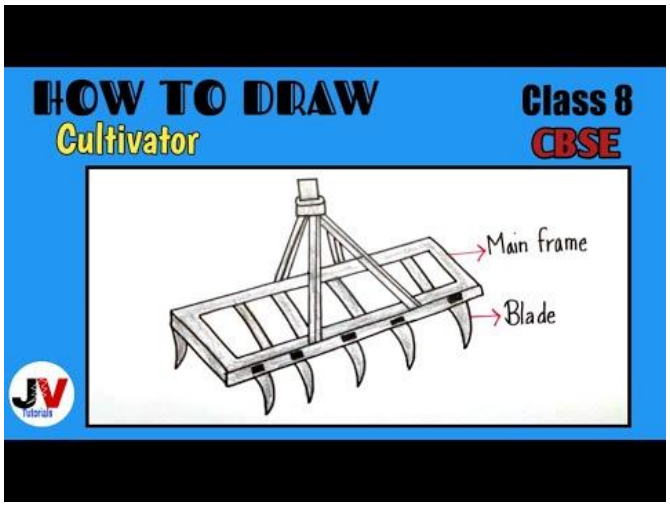


Figure 3.3 Simplified diagram of cultivator

- **Irrigation:**
  - ✓ **Drip Irrigation System:** Provides controlled water delivery to the base of plants.
  - ✓ **Sprinkler System:** Distributes water over the crops in an overhead pattern.
  - ✓ **Furrow Irrigation Equipment:** Channels water between rows.
- **Fertilization:**
  - ✓ **Fertilizer Spreader:** Distributes fertilizers evenly over the field.
  - ✓ **Manure Spreader:** Applies organic manure to improve soil fertility.

- **Pest and Disease Control:**
  - ✓ **Sprayers:** Used for applying pesticides or fungicides.
  - ✓ **Traps and Lures:** Control pests through monitoring and trapping.
  - ✓ **Biological Control Agents:** Introduce natural predators to control pests.
- **Harvesting:**
  - ✓ **Combine Harvester:** Harvests and threshes crops like wheat, rice, and corn.
  - ✓ **Reaper-Binder:** Cuts and ties crops like grains or small-stemmed crops.
  - ✓ **Forage Harvester:** Harvests and chops forage crops like hay or silage.

- ✓ **Hand Harvesting Tools:** Scythes, sickles, and knives for manual harvesting of fruits and vegetables.

- **Post-Harvest Handling:**
  - ✓ **Grain Dryer:** Removes moisture from harvested grains.
  - ✓ **Storage Bins:** Containers for storing harvested crops.
  - ✓ **Sorting and Grading Equipment:** Separates and grades produce based on size and quality.
  - ✓ **Packaging Equipment:** Packages crops for transportation and sale.

- **Miscellaneous Tools:**
  - ✓ **Wheelbarrow or Cart:** Transporting tools, seeds, or harvested crops.
  - ✓ **Trowel and Pruners:** Small hand tools for transplanting and pruning.
  - ✓ **Digital Soil Tester:** Measures soil characteristics such as pH and moisture.
  - ✓ **Weather Station:** Monitors weather conditions for better farm management.

- **Protective Gear:**
  - ✓ **Safety Glasses, Gloves, and Hats:** Personal protective equipment for farm workers.
  - ✓ **Ear Protection:** For use with loud machinery.
  - ✓ **Respirator/Mask:** For protection against dust, chemicals, or pesticides.

Before selecting tools and equipment, it's essential to assess the specific needs of your farm, the scale of operations, and the types of crops you are cultivating. Proper maintenance and calibration of equipment are also critical to ensure their effectiveness and longevity.

3.6. Determining resources and budget for cropping program

Determining resources for a cropping program involves assessing and planning for the various inputs and factors needed to ensure successful crop production.

3.6.1. Determining resources for cropping program

Some key resources to consider in cropping program include:

- **Land:**

Adequate and Suitable Acreage: Assess the availability and suitability of land for the chosen crops. Consider factors such as soil type, topography, drainage, and sunlight exposure.

- **Water:**

  Irrigation Sources: Evaluate water availability for irrigation. Determine whether the area relies on natural rainfall or if supplemental irrigation systems are necessary. Ensure a reliable and sustainable water source.

- **Seeds:**

  Quality and Quantity of Seeds: Select appropriate seed varieties based on climate, soil conditions, and intended market. Ensure the availability of sufficient high-quality seeds for planting.

- **Fertilizers and Soil Amendments:**

  Soil Testing: Conduct soil tests to determine nutrient levels and pH. Based on the results, plan for the appropriate use of fertilizers and soil amendments to optimize soil health and crop nutrition.

- **Equipment and Machinery:**

  Tractors, Plows, Harvesters, etc.: Assess the need for and availability of farming equipment. Ensure that all necessary machinery is in good working condition for plowing, planting, cultivating, and harvesting.

- **Labor:**

  Skilled and Seasonal Labor: Determine the labor requirements for various stages of the cropping program, including planting, maintenance, and harvesting. Ensure access to skilled and seasonal labor when needed.

- **Pesticides and Herbicides:**

  Integrated Pest Management (IPM): Develop a plan for pest and weed control. Incorporate integrated pest management strategies to minimize the use of chemical inputs while ensuring effective crop protection.

- **Storage Facilities:**

  Warehousing and Silos: Plan for storage facilities to store harvested crops. Adequate storage helps prevent spoilage and ensures the quality of the produce until it reaches the market.

- **Transportation:**

  Access to Markets: Consider transportation logistics for getting the harvested crops to markets. Assess the availability of roads, vehicles, and other infrastructure for transporting the produce.

- **Financial Resources:**

  Budgeting and Financing: Develop a budget for the cropping program, considering all expenses related to inputs, labor, equipment, and other costs. Secure necessary financing or funding for the program.

- **Knowledge and Expertise:**

  Training and Advisory Services: Ensure that the individuals involved in the cropping program have the necessary knowledge and skills. Consider providing training or accessing advisory services for best agricultural practices.

- **Weather and Climate Information:**

  Weather Monitoring: Stay informed about local weather patterns and climate conditions. This information is crucial for planning planting and harvesting schedules and adapting to changing weather patterns.

By carefully assessing and planning for these resources, farmers can optimize their cropping programs for success and sustainability.

3.6.2. Determining budget for cropping program

Determining enterprise budgets

Enterprise budgets represent estimates of receipts (income), costs, and profits associated with the production of agricultural products. The information contained in enterprise budgets is used by agricultural producers, extension specialists, financial institutions, governmental agencies, and other advisers making decisions in the food and fiber industry.

Budgets are used to:

- Itemize the receipts (income) received for an enterprise
- List the inputs and production practices required by an enterprise
- Evaluate the efficiency of farm enterprises
- Estimate benefits and costs for major changes in production practices

- Provide the basis for a total farm plan
- Support applications for credit

Table 3.4) Format of a typical crop enterprise budget (Summary of estimated costs and returns)

Item	Quantity	Unit	Price	Total	
Receipts					
Product 1					
Product 2					
Other					
Total receipts					
Variable Costs					
Custom lime application					
Harvest					
Fertilizer					
Nitrogen					
Phosphorus					
Potassium					
Other					
Herbicides					
Insecticides					
Fungicides					
Soil test					
Seed/plants					
Labor					
Tractor					
Self-propelled equipment					
Other					
Fuel					
Tractors					
Self-propelled equipment					
Other					

Repairs and maintenance						
Tractors						
Self-propelled equipment						
Implements						
Interest on operating capital						
Total variable costs						

Fixed Costs				
Tracrors				
Self-propelled equipment				
Implements				
Land charge				
Management				
Total fixed costs				
Total Costs				
Returns				
Gross margin (return over variable costs)				
Net returns				

Self-Check – 3	

Directions: Answer all the questions listed below.

Part I Write 'True' for correct statements and 'False' for incorrect statements

1. Biological property of soil encompasses soil microorganisms and other living organisms living in the soil
2. Identifying and planning labor requirements for crop production are crucial for optimizing efficiency.
3. Considering the climate of the region do nothing with deciding optimum time of sowing
4. Disc harrow breaks up clods and smoothens the soil surface after plowing
5. Agronomic practices refer only to the activities of soil preparation.

Part II Choose the best answer

1. Which one of the following is not a consideration in selecting crop variety?

A. High yielding B. Resistant to pests C. Profitability D. None

2. _____ is defined as a written schedule of the crop growing season from the land preparation, to crop establishment and maintenance (weeding, fertilizing) to harvest and storage.

A. Cropping calendar B. Weeding C. Fertilizing D. Storage

3. Which of the following is not primary tillage equipment?

A. Moldboard B. Leveler C. planter D. None.

4. One of the following is not a use of budget?

A. Itemize the receipts (income) received for an enterprise
B. List the inputs and production practices required by an enterprise
C. Evaluate the efficiency of farm enterprises
D. Over-estimate benefits and costs for major changes in production practices

5. Which of the following is not a factor to consider when choosing appropriate agricultural equipment and tools?

A. Does the tool or equipment support your whole-farm plan?
B. Is the tool or equipment appropriate to your farm's location and growing condition?
C. How does the tool or implement impact soil health, production, and marketing?
D. None of the above

Part III Give short answers

1. Define agronomic practices
2. What do we mean by chemical residue?
3. What are benefits of using a cropping calendar?
4. What are the key resources to consider in cropping program

Operation Sheet -3

Preparing Cropping Calendar Template

Objective: To Prepare cropping calendar for individual crop

Required materials

- Pen/pencil/ marker
- Note book/ sheets

Procedures

The following is the process or procedure of making a single crop calendar. For the best results, consider a tabular calendar that lists all activities and time. Besides, you can consider other methods of presentation like a cycle, or pictorial calendar.

Step 1 Make a table with three columns; time in days, activities and the selected technology to fulfill the tasks.

Step 2 List all the cropping activities before planting, after planting, agronomic practices, harvesting and marketing.

Step 3 Determine all the time required for each activity. Planting is given day zero. Activities before planting like land preparation are marked with minors (-).

Step 4 On the technology column, list the farm inputs you will use and methods you will use to fulfill the task e.g. use NPK fertilizer at rate of 120kg/ha.

Climate Types at Cropping Calendar (youtube.com) (Accessed date 17/01/2024)

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 **1** hour.

1. Crop calendar showing time, activities and technology for maize crop

LG #10 LO #4- Implement Production Plan

Instruction sheet

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

- Preparing logistical arrangement based on production plan
- Preparing agricultural inputs
- Implementing crop establishment and management based on cropping calendar
- Establishing physical and financial record keeping system
- Reviewing and amending production plan

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

- Prepare logistical arrangement based on production plan
- Prepare agricultural inputs
- Implement crop establishment and management based on cropping calendar
- Establish physical and financial record keeping system
- Review and amend production plan

Learning Instructions:

Read the specific objectives of this Learning Guide.

Follow the instructions described below.

Read the information written in the information Sheets

Accomplish the Self-checks

Information Sheet 4

4.1 Preparing logistical arrangement based on production plan

4.1.1 Understanding logistics in crop production point of view

In crop production, logistics refers to the management and coordination of various activities involved in the movement of agricultural inputs, equipment, and harvested crops throughout the supply chain. It encompasses the planning, implementation, and control of the efficient flow and storage of goods, services, and information from the point of origin (such as farms and input suppliers) to the point of consumption (such as processing facilities, markets, and consumers).

In simple terms, the **goal of logistics management** is to have the right amount of a resource or input at the right time, getting it to the appropriate location in proper condition, and delivering it to the correct internal or external customer.

It is crucial that the activities in this process are effectively managed to guarantee customers' demands are met on time and the maximum value of the cultivated products is achieved. Moreover, it is essential to minimize distribution expenses, improve the circulation of agricultural goods, reduce unnecessary losses, and strive for an environment-friendly and compliant logistics.

During the recent two decades, goods flow has been tremendously increased, even though the amount of goods remains at the steady state. Increased variety of goods, the just-in-time delivery system, low load rate, specialization and centralization of production systems, globalization of marketing and seasonal variations are among the main challenges of logistics system which may lead to the necessity of developing effective logistics in the sector. Effective logistics and technologies are a critical success factors for both manufacturers and retailers. Effective logistics requires delivering the right product, in the right quantity, in the right condition, to the right place, at the right time, for the right cost and it has a positive impact on the success of the partners in the supply chain.

Recently, the concept of Agricultural and Food Logistics has been under development as more effective and efficient management system is required for the food production planning, physical collection of primary produce from fields and homesteads, processing and storage at various

levels, handling, packaging, and distribution of final product. In the food supply chain many stakeholders such as farmers, vendors/agents, wholesalers, rural retailers and suppliers and transporters are involved. At all levels, information flow and management of produce is essential to maintain the food quality throughout the chain. The flow of input resources from farms to consumers needs to be described in detail and the constraints in each sub-process needs to be identified to develop appropriate solutions for logistics related problems.

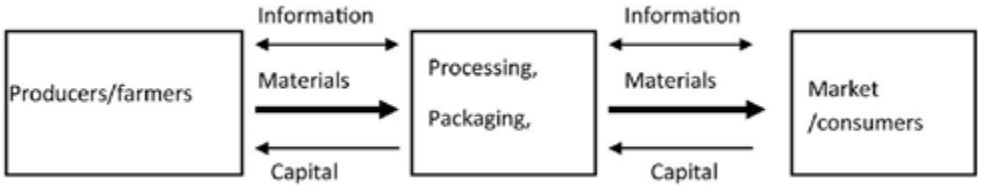


Figure 4.1 Material, capital and information flow between producers (farmers) and consumers

It is important to note that lack of packaging facilities may be one of the constraints in the logistics system of small-scale farmers during the transition from subsistence to commercial farming. Significant post-harvest losses occur when especially vulnerable crops and fruits are subjected to mechanical damage. Therefore management of packaging should be taken into consideration in the development of agricultural logistic systems.

4.1.2 Preparing logistical arrangement based production plan

Preparing logistical arrangements in crop production involves careful planning, coordination, and implementation of various activities throughout the agricultural supply chain.

Steps to prepare effective logistical arrangements in crop production:

- **Assessment and Planning:**
  - ✓ Conduct a thorough assessment of your crop production needs, considering factors such as the type of crops, scale of production, and resource requirements.
  - ✓ Develop a comprehensive plan that outlines the entire crop production process, from input procurement to distribution.
- **Input Logistics:**
  - ✓ Identify and establish relationships with reliable suppliers for seeds, fertilizers, pesticides, and machinery.

- ✓ Plan and schedule input deliveries to ensure timely availability during different stages of crop production.
- ✓ Implement inventory management systems to monitor and control input stocks.

- **Field Operations:**
  - ✓ Develop a planting and cultivation schedule, considering factors like climate, soil conditions, and crop requirements.
  - ✓ Ensure the availability and proper maintenance of farm machinery and equipment.
  - ✓ Plan for irrigation, pest control, and other field activities to optimize resource use.
- **Harvest and Post-Harvest Logistics:**
  - ✓ Develop a harvesting schedule, considering crop maturity and weather conditions.
  - ✓ Arrange for transportation and storage facilities for harvested crops.
  - ✓ Implement proper post-harvest handling practices to maintain crop quality.
- **Transportation:**
  - ✓ Identify transportation needs and select appropriate modes (e.g., trucks, tractors, or other vehicles) based on the distance and volume of products.
  - ✓ Optimize transportation routes to reduce costs and delivery times.
  - ✓ Ensure that vehicles are well-maintained and meet safety standards.
- **Processing and Packaging:**
  - ✓ Plan the processing activities based on the harvested crop volume and market demand.
  - ✓ Ensure the availability of processing equipment and facilities.
  - ✓ Implement effective packaging and labeling processes to enhance product presentation.
- **Distribution and Marketing:**
  - ✓ Establish distribution channels and partnerships with wholesalers, retailers, or markets.
  - ✓ Develop marketing strategies to promote your agricultural products.
  - ✓ Monitor market trends and adjust distribution plans accordingly.
- **Information Management:**
  - ✓ Implement information systems to track and monitor the movement of goods, inventory levels, and logistical processes.

- ✓ Utilize technology for real-time data collection and analysis to support decision-making.

- **Risk Management:**
  - ✓ Identify potential risks and develop contingency plans for unforeseen events such as adverse weather, transportation disruptions, or market fluctuations.
  - ✓ Consider insurance options to mitigate risks associated with crop production and logistics.
- **Compliance and Documentation:**
  - ✓ Ensure compliance with local and international regulations regarding crop production, transportation, and marketing.
  - ✓ Maintain accurate documentation for traceability, quality control, and regulatory purposes.

Regularly review and update your logistical arrangements to adapt to changing conditions and improve efficiency over time. Effective logistical planning and execution contribute to the overall success and sustainability of crop production operations.

4.2 Preparing agricultural inputs

Agricultural inputs refer to the various materials used in farming to increase crop yields, enhance product quality, and to improve efficiency.

Some of the common agricultural inputs include:

I. Seeds

Seeds are the most important input for farming, as they are the source of plants. Farmers need to choose the right type of seed based on their needs and the environmental conditions in their area. There are different types of seeds, including hybrid, open-pollinated, and genetically modified seeds.

Hybrid seeds are the result of crossing two different plant varieties, while open-pollinated seeds are produced through natural pollination. Genetically modified seeds have been altered in a laboratory to include desirable traits, such as resistance to pests or herbicides.

Seed purity, germination percentage and amount of seed to be sown should be known during seed preparation.

Calculating purity percentage, germination percentage and seed rate

$$\text{Purity percentage} = \frac{\text{pure seed}}{\text{weed seed} + \text{broken seed} + \text{other crop seed} + \text{inert material}}$$

$$\text{Germination percentage} = \frac{\text{Germinated seed}}{\text{Total seed sown}}$$

$$\text{Seed rate} = \frac{A}{\text{Spacing}} \text{ X } \frac{\text{Test weight of seed}}{1000} \text{ X } \frac{1}{GP} \text{X } \frac{1}{PP}$$

Where, A = Area

GP = Germination percentage

PP = Purity percentage

II. Fertilizers

Fertilizers are used to provide plants with the nutrients they need to grow. They can be organic or inorganic. Organic fertilizers, such as compost or manure, are made from natural sources and help improve soil quality while inorganic fertilizers, such as nitrogen, phosphorus, and potassium, are synthetic and provide plants with specific nutrients they may not get naturally.

III. Pesticides/ Insecticides/ Herbicides

Pesticides are used to control pests and diseases that can damage crops. The issue of pest infestation has been a thing of concern for farmers in Nigeria. This problem can be resolved today by dialling**.** Pesticides can be chemical or organic. Chemical pesticides are synthetic and can be harmful to the environment, while organic pesticides are made from natural sources and are considered safer.

These inputs are essential for crop production, as they help farmers to produce more food and to improve their income. Consequently, they have to be planned and prepared before starting crop production.

4.3 Implementing crop establishment and management based on cropping calendar

Crop establishment and management involve Selecting appropriate:

I. Time of sowing
II. Method of sowing
III. Type of fertilizers
IV. Method of fertilizer application
V. Pest management techniques

I. Time of sowing

Crop requirements for moisture, light and temperature are the major factors to consider determining the best planting date. Understanding these factors will help to decide the month or week of the year when planting should be done to obtain optimum yields. In tropical areas. Whole temperature and light are uniform, humidity will be the main factor to consider determining when to plant. In mild areas, temperature, rainfall, and day length need to be considered when determining the planting date. The best planting date for the area, based on the environmental factors and high production of the region, is reflected in the regional planting dates. Generally, planting crops out of their planting date will more likely result in lower yields, no matter how much fertilizer you use or how well you take care of the crop. Time of sowing of crop/date of planting should be based following subjects-

a. **Moisture**

When the cropping season approaches towards the rainy (humid/wet) period, seeds may be sown when the soil is dry before rain but when the sowing season approaches towards the rainless (dry) period, seeds should be sown on semi-dry (optimum moisture for seed germination of the crop concerned) or wet soil conditions. By increasing the seed water content prior to sowing and sowing seeds more shallowly, the time from sowing to field emergence can be reduced and this can curtail the period in which the sown seeds could be affected by an adverse change in the seedbed, from the favourable conditions in which they are sown. This can be brought about by

the equilibriation of the seeds with a humid atmosphere or by soaking seeds to allow the preliminary process of germination to proceed, but not enough to permit radicle emergence.

b. **Photosensitivity**

Certain crop varieties will not flower unless the critical day length is received for a minimum number of total days. Accordingly, planting date should be arranged so that the plant gets just sufficient time to complete its vegetative growth phase. For instance, Corchorus olitorius seeds if sown before mid-April, premature flowering would occur as the plant get the critical day length earlier before completing its vegetative growth properly.

c. **Thermo-sensitivity**

Planting date of thermosensitive crop varieties should be arranged so that the plants become able to escape the adverse temperature range.

II. Method of sowing

a. Broadcasting

In this process, the seeds are scattered on the seed beds either mechanically or manually. In the broadcasting method of sowing, the seeds are spread uniformly and are then covered with planking. When there are a large number of seeds, the work is done using mechanical broadcasters. The seed rate is very high in this system.

b. Dibbling

Holes are made in the seedbeds and the seeds are placed in it. The seedbeds are then covered. The holes are made at definite depths. It can be done manually or dibbler machine is used . It is a conical instrument that makes proper holes in the seedbed. This method is usually used to sow large grained field crops

c. Drilling

The seeds are dropped into furrow lines in a continuous flow and are then covered with soil. This is done either mechanically or manually. The proper amount of seeds are sown at proper depths and proper spaces. This method is good for small grained field crops such as wheat, barley, etc.

III. Type of fertilizers

Broadly fertilizers can be divided into two:

a) Organic fertilizers

Organic fertilizers are natural materials that have an origin tracing back to plants or animals. They include:

- Green manure

- Livestock manure
- Compost
- Household waste
- Crop residues
- Woodland litter etc.

b) Inorganic fertilizers

Inorganic fertilizers, also known as mineral fertilizers usually come from mining of mineral deposits. They need some processing and include:

- Phosphate
- Lime
- Rock
- Potash etc.

They can also be manufactured industrially through chemical processes and include:

- Urea
- DAP
- NPS

IV. Method of fertilizer application

The choice of method and time of fertilizer application depends on the form and amount of fertilizer, convenience of the farmer, the efficiency and safety of fertilizer application. Some methods of fertilizer application are listed below.

a) Solid Form

- **Broadcasting** – The manures and fertilizers are scattered uniformly over the field before planting the crop and are incorporated by tilling or cultivating.
- **Drilling and placement** – Fertilizers are placed in the soil furrows formed at the desired depth. Placement can be done by the following ways.
  - ✓ **Plough sole placement** – In this method fertilizers are applied or dropped in the plough sole, which will be covered by the plough during the opening of adjacent furrow.
  - ✓ **Deep placement** – Fertilizers or manures are placed at the bottom of the top soil at a depth of 10-12 cm, especially in the puddle rice soil.

- ✓ **Sub soil application** – Fertilizers are applied in the subsoil especially for tree crops and orchard crops at a depth above 15 cm.
- ✓ **Location or spot application** – Fertilizers are placed in the root zone or the spot near the roots from which roots can absorb easily.
- ✓ **Contact or drill placement** – Fertilizers or manures are placed at the time of drilling for placing the seeds. Fertilizers or manures will have good contact with the seeds or seedlings.
- ✓ **Band placement** – This is the placement of manures or fertilizers or both in bands on the side or both sides of the row at about 5 cm away from the seed or plant in any direction. Such band placement is of three types.
  - **Hill placement** – In widely spaced crops, like cotton, castor, cucurbits fertilizers or manures are applied on both sides of plants only but not continuously along the row.
  - **Row placement** – In widely spaced crops between rows (Example– Sugarcane, maize, tobacco, potato) manures or fertilizers are placed on one or both sides of the row in continuous bands.
  - **Circular placement** – Application of manures and fertilizers around the hill or the trunk of fruit tree crops in the active root zone.

- ✓ **Pocket placement** – Application of fertilizers deep in soil to increase its efficiency Especially for the sugarcane pocket placement is done. Fertilizers are put in 2 to 3 pockets opened around every hill by means of a sharp stick.
- ✓ **Side dressing** – It refers to hill and ring placement of manures or fertilizers. It consists of spreading the fertilizer between the rows or around the plants.
- ✓ **Pellet application** – Nitrogen fertilizers are pelleted like mud ball or urea super granules (USG) and placed deep (10 cm) into the saturated soils (reduced zone) of wet land rice to avoid nitrogen loss from applied fertilizers.

b) Liquid form

- **Foliar application:** It refers to spraying of fertilizer solution on the foliage of plants for quick recovery from the deficiency (either N or S).

- **Fertigation:** It is the application of fertilizer dissolved in irrigation water in either open or closed system i.e., lined or unlined open ditches and sprinkler or trickle systems respectively.
- **Starter solutions:** They are solutions of fertilizers prepared in low concentrations which are used for soaking seeds, dipping roots, spraying on seedlings etc., nutrient deficient areas for early establishment and growth.
- **Direct application to the soil:** Liquid fertilizers like anhydrous ammonia are applied directly to the soil with special injecting equipments. Liquid manures such as urine, sewage water and cattle shed washing are directly let into the field.

V. Pest management techniques

a. Cultural controls are practices that reduce pest establishment, reproduction, dispersal, and survival. For example, crop rotation - replacing a susceptible crop with a less susceptible crop; and changing irrigation practices - less watering can reduce root disease and weeds.

b. Mechanical and physical controls: kill a pest directly or make the environment unsuitable for it. For example, traps - for pest animals and insects; mulches - for weed management; steam sterilisation - for soil disease management; or barriers - such as screens or fences to keep animals and insects out.

c. Chemical control: - the use of chemical to control pests

Pesticides include:

- Herbicides - to kill weeds
- Insecticide – to kill insects
- Rodenticide – to kill rodents
- Fungicides - to kill fungal parasites
- Molluscicides - to kill mollusc pests
- Nematicides - to kill nematode pests

d. Biological control is reduction of pest populations by natural enemies and typically involves an active human role.



Figure 4.2 Biological pest control (the use of wasp to control caterpillar)

e. **Integrated Pest Management (IPM)** means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.



Figure 4.3 Integrated pest management diagram

4.4 Establishing physical and financial record keeping system

Establishing both physical and financial records is crucial for effective crop production management. Proper record-keeping helps farmers track expenses, monitor crop performance, and make informed decisions.

The followings are a guide on how to establish physical and financial records specifically for crop production:

I. Physical Records:

- **Field and Crop Records:**
  - ✓ Create a record for each field, including its size, location, and historical use.
  - ✓ Document crop rotation schedules, planting dates, and varieties planted.
- **Planting and Harvesting Logs:**
  - ✓ Maintain logs that detail when each crop was planted and when it was harvested.
  - ✓ Record yields and any observations about crop quality.
- **Input Application Records:**
  - ✓ Document the application of fertilizers, pesticides, herbicides, and other inputs.
  - ✓ Include details such as application rates, dates, and specific products used.
- **Irrigation Records:**
  - ✓ Keep records of irrigation practices, including schedules, water usage, and any issues with the irrigation system.
  - ✓ Note any changes made based on weather conditions or crop needs.
- **Weather and Environmental Records:**
  - ✓ Record weather conditions relevant to crop growth, such as temperature, rainfall, and sunlight.
  - ✓ Note any environmental factors that may affect crop development.
- **Soil Test Results:**
  - ✓ Maintain records of soil tests, including nutrient levels, pH, and soil structure.
  - ✓ Use this information to adjust fertilizer and nutrient management plans.
- **Field Maps:**
  - ✓ Create detailed maps of each field, indicating crop types, planting patterns, and any specific considerations.
  - ✓ Update maps regularly to reflect changes in crop rotation or field layout.

II. Financial Records:

- **Budgeting:**

- ✓ Develop a budget that outlines anticipated income and expenses for the crop production season.
- ✓ Categorize expenses, including seeds, fertilizers, pesticides, labor, equipment, and overhead costs.

- **Income and Sales Records:**
  - ✓ Document all income sources related to crop sales, government subsidies, or other revenue streams.
  - ✓ Keep sales receipts and invoices for each transaction.
- **Expense Tracking:**
  - ✓ Record all expenses related to crop production, including input costs, equipment maintenance, and labor.
  - ✓ Categorize expenses to facilitate financial analysis.
- **Equipment and Machinery Records:**
  - ✓ Maintain records for all farm equipment and machinery.
  - ✓ Document maintenance schedules, repairs, and associated costs.
- **Loan and Credit Records:**
  - ✓ Keep records of loans, credit lines, and financial agreements related to crop production.
  - ✓ Document interest rates, repayment schedules, and any collateral.
- **Insurance Records:**
  - ✓ Document insurance policies covering crops, equipment, and the farm.
  - ✓ Keep records of any claims filed and their resolutions.
- **Tax Records:**
  - ✓ Organize tax-related documents, including receipts, invoices, and financial statements.
  - ✓ Keep track of deductible expenses and comply with tax regulations.
- **Payroll Records:**
  - ✓ If employing labor, maintain payroll records, including wages, hours worked, and any benefits provided.
  - ✓ Comply with labor laws and regulations.
- **Financial Analysis:**

- ✓ Regularly analyze financial performance using key indicators.
- ✓ Use financial ratios and benchmarks to assess profitability and identify areas for improvement.

- **Record-Keeping Software:**
  - ✓ Consider using specialized farm management software or accounting software to streamline record-keeping processes.

Methods of Recordkeeping

Effective crop recordkeeping is essential for successful farm management. Keeping detailed and accurate records helps farmers track activities, make informed decisions, and comply with regulatory requirements. The followings are some of methods of crop record keeping systems:

- **Manual Recordkeeping:**
  - ✓ **Paper Logs and Notebooks:** Maintain handwritten records for each field, crop, or activity. Use notebooks or specific log sheets to document details such as planting dates, input applications, and harvest yields.
- **Digital Spreadsheets:**
  - ✓ **Excel or Google Sheets:** Create digital spreadsheets to organize and record crop-related information. Use different sheets for planting, harvesting, input applications, and financial transactions. This allows for easy sorting and analysis.
- **Farm Management Software:**
  - ✓ **Specialized Software:** Utilize farm management software designed for agriculture. These tools often include modules for crop planning, input management, financial tracking, and reporting. Examples include FarmLogs, AgSquared, and Granular.
- **Mobile Apps:**
  - ✓ **Field Note-Taking Apps:** Use mobile apps designed for farm recordkeeping. These apps often allow users to input data directly from the field, making real-time updates easy. Examples include AgriWebb, FieldView, and Farmbrite.
- **GIS and Mapping Tools:**

- ✓ **Geographic Information Systems (GIS):** Incorporate GIS tools to map fields and record spatial data. This method is particularly useful for tracking planting patterns, crop rotation, and soil characteristics.

- **Cloud-Based Storage:**
  - ✓ **Online Platforms:** Store records in the cloud using platforms like Dropbox, Google Drive, or Microsoft OneDrive. This ensures accessibility and data security, allowing multiple users to collaborate.
- **Automated Sensor Systems:**
  - ✓ **IoT Devices:** Implement Internet of Things (IoT) devices and sensors to collect real-time data on environmental conditions, soil moisture, and crop health. These devices can integrate with recordkeeping systems for automated data entry.
- **Integrated Farm Management Systems:**
  - ✓ **Comprehensive Platforms:** Adopt integrated systems that cover various aspects of farm management, including crop production, financials, and inventory. These systems streamline data entry and analysis.
- **Blockchain Technology:**
  - ✓ **Transparent and Secure Records:** Explore blockchain-based solutions to ensure transparent and secure recordkeeping. Blockchain can enhance traceability and provide an immutable ledger for transactions.
- **Collaborative Platforms:**
  - ✓ **Team Collaboration Tools:** Use collaborative platforms like Slack or Microsoft Teams to facilitate communication among farm personnel involved in recordkeeping. This ensures everyone is on the same page.
- **Regular Audits and Reviews:**
  - ✓ **Periodic Checks:** Conduct regular audits of records to identify discrepancies or areas for improvement. Regular reviews help maintain the accuracy and completeness of records.
- **Training and Documentation:**
  - ✓ **Education for Personnel:** Train farm personnel on recordkeeping practices. Provide documentation and guidelines to ensure consistency in data entry.
- **Regulatory Compliance Tools:**

- ✓ **Tools for Compliance:** Use tools that help track and ensure compliance with agricultural regulations and standards. This is crucial for maintaining legal and regulatory requirements.

The choice of recordkeeping method depends on the scale of the operation, available resources, and the specific needs of the farm. A combination of these methods may be employed to create a comprehensive and efficient recordkeeping system for crop

4.5 Reviewing and amending production plan

Reviewing and amending a crop production plan is a critical step in adaptive and responsive farm management. Agricultural plans should be dynamic, allowing for adjustments based on changing conditions and new information.

How to review and amend a crop production plan:

- **Periodic Review:**
  - ✓ **Regular Schedule:** Establish a routine for reviewing the crop production plan. This could be done weekly, monthly, or at key milestones throughout the growing season.
- **Data Collection:**
  - ✓ **Field Observations:** Conduct on-site inspections to assess the current state of the crops. Look for signs of pests, diseases, nutrient deficiencies, or any other issues.
  - ✓ **Weather Conditions:** Consider recent weather patterns and forecasts. Weather can significantly impact crop growth, irrigation needs, and disease pressure.
- **Review Goals and Objectives:**
  - ✓ **Compare Actual vs. Planned:** Evaluate how well the actual progress aligns with the goals and objectives set in the original plan.
  - ✓ **Yield Expectations:** Assess whether the expected yields are realistic based on current conditions.
- **Input Application and Soil Tests:**
  - ✓ **Review Input Plans:** Evaluate the effectiveness of input applications, including fertilizers, pesticides, and herbicides. Make adjustments based on observed outcomes and any unexpected issues.
  - ✓ **Reassess Soil Tests:** If soil tests were conducted earlier, revisit the results to ensure that soil nutrient levels align with crop requirements.

- **Pest and Disease Management:**
  - ✓ **Scout for Pests and Diseases:** Check for signs of pests and diseases. If detected, reassess the pest management strategy and consider adjustments to control measures.
  - ✓ **Integrated Pest Management (IPM):** Emphasize IPM practices and consider biological control methods where applicable.
- **Irrigation Management:**
  - ✓ **Evaluate Water Needs:** Consider current soil moisture levels and weather forecasts. Adjust irrigation schedules accordingly to meet the crop's water requirements.
- **Adjust Planting and Harvesting Schedules:**
  - ✓ **Assess Crop Development:** If crops are developing faster or slower than expected, adjust planting and harvesting schedules accordingly.
  - ✓ **Consider Market Demand:** Align harvest schedules with market demand to optimize sales opportunities.
- **Financial Review:**
  - ✓ **Expense Analysis:** Review actual expenses against the budget. Identify any cost overruns or unexpected expenses.
  - ✓ **Revenue Forecast:** Update revenue projections based on current market conditions and expected yields.
- **Equipment and Labor:**
  - ✓ **Assess Equipment Needs:** Ensure that equipment is meeting operational needs. Plan for maintenance or adjustments as necessary.
  - ✓ **Labor Requirements:** Reevaluate labor needs based on the current state of the crops and adjust workforce allocation if needed.
- **Recordkeeping:**
  - ✓ **Update Records:** Ensure that all changes and adjustments are documented. Maintain comprehensive records of amendments made to the crop production plan.
- **Consultation and Expert Input:**
  - ✓ **Seek Expert Advice:** If facing challenges or uncertainties, consult with agricultural extension services, agronomists, or other experts for guidance.
  - ✓ **Collaborate with Peers:** Share experiences and insights with other farmers or agricultural professionals.

- **Communication:**
  - ✓ **Team Briefings:** Communicate changes to the crop production plan with the farm team. Ensure that everyone is informed and aligned with the revised plan.
- **Regulatory Compliance:**
  - ✓ **Review Regulations:** Check for any changes in agricultural regulations that may impact the crop production plan. Ensure compliance with local laws and standards.
- **Continuous Monitoring:**
  - ✓ **Ongoing Surveillance:** Continue to monitor crops and environmental conditions throughout the growing season. Be prepared to make further adjustments as needed.
- **Learning and Improvement:**
  - ✓ **Post-Season Evaluation:** After the harvest, conduct a comprehensive review of the entire crop production process. Identify lessons learned and areas for improvement in future plans.

Adapting and amending the crop production plan based on real-time data and observations is key to optimizing yields and overcoming challenges. Flexibility, responsiveness, and a commitment to continuous improvement are essential elements of effective crop management.

Self-Check – 4	

Directions: Answer all the questions listed below.

Part I Write 'True' for correct statements and 'False' for incorrect statements.

1. In crop production, logistics refers only to the management and coordination of crop transportation.
2. Seeds are the most important input for farming, as they are the source of plants.
3. Green manure is one of important inorganic fertilizers
4. Establishing both physical and financial records is crucial for effective crop production
5. Periodic review is one of important technique to review and amend a crop production plan

Part II Choose the best answer

1. Which one of the following is not physical record?
   A. Crop yields
   B. Inputs (fertilizer, seed)
   C. Pesticide application
   D. Income and expense receipts
2. _____ involves reduction of pest populations by natural enemies

A. Cultural B. Biological C. Chemical D. IPM

3. One of the following methods is the placement of manures or fertilizers or both in one side or both sides of the row at about 5 cm away from the seed or plant in any direction.

A. Ring placement B. Foliar application C. Band placement D. Spot application

4. Which of the following is not a method of crop record keeping systems?
   A. Manual Recordkeeping
   B. Digital Spreadsheets
   C. Farm Management Software
   D. None

Part III Give short answers

1. Enumerate steps to prepare effective logistical arrangements in crop production

2. Define agricultural inputs
3. List and describe fertilizer application methods
4. List down some agricultural inputs
5. How do you review and amend production planning performance and risk outcomes?

LG #11	LO #5- Monitor, evaluate and learn crop production plan

Instruction sheet

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

- Determining monitoring and evaluation standards of production plan
- Selecting appropriate monitoring, evaluation and learning techniques
- Implementing monitoring and evaluation at every production stage as indicated in the production plan
- Preparing and submitting feedbacks and reports
- Implementing record keeping and documentation for future use

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

- Determine monitoring and evaluation standards of production plan
- Select appropriate monitoring, evaluation and learning techniques
- Implement monitoring and evaluation at every production stage as indicated in the production plan
- Prepare and submit feedbacks and reports
- Implement record keeping and documentation for future use

Learning Instructions:

Read the specific objectives of this Learning Guide.

Follow the instructions described below.

Read the information written in the information Sheets

Accomplish the Self-checks

Perform Operation Sheets

Do the “LAP test”

Information Sheet 5

5.1 Determining monitoring and evaluation standards

Monitoring and evaluation are the processes that allow assessing: how an intervention evolves over time (monitoring); how effectively a crop production program was implemented and whether there are gaps between the planned and achieved results (evaluation); and whether the changes in well-being are due to the program and to the program alone (impact evaluation).

5.1.1. Understanding monitoring and evaluation

Monitoring is a continuous process of collecting and analyzing information about a program, and comparing actual against planned results in order to judge how well the intervention is being implemented. It uses the data generated by the program itself. The existence of a reliable monitoring system is essential for evaluation.

Evaluation is a process that systematically and objectively assesses all the elements of a program (e.g. design, implementation and results achieved) to determine its overall worth or significance. The objective is to provide credible information for decision-makers to identify ways to achieve more of the desired results.

Broadly, there are two main types of evaluation:

I. Performance evaluations focus on the quality and the outcomes (results) achieved by a program. They typically cover short-term and medium-term outcomes. They are carried out on the basis of information regularly collected through the crop monitoring system. Performance evaluation is broader than monitoring. It attempts to determine whether the progress achieved is the result of the intervention, or whether another explanation is responsible for the observed changes.

II. Impact evaluations look for changes in outcomes that can be directly attributed to the program being evaluated. The determination of causality between the program and a specific outcome is the key feature that distinguishes impact evaluation from any other type of assessment.

Table 5.1) The link between monitoring and evaluation

Monitoring	*Evaluation*
Clarifies program objectives.	Analyses why intended results were achieved or were not achieved.
Links activities and their resources to objectives	Assesses the specific causal contribution of activities to results.
Translates objectives into performance indicators and set targets.	Examines the implementation process.
Routinely collects data on those indicators.	Explores unintended results.
Reports progress to the manager and alerts them of problems.	Provides lessons, highlights significant accomplishment or program potential, and recommends improvement.

Source: Kusek and Rist (2004)

5.1.2. Determining monitoring and evaluation standards

Determining monitoring and evaluation (M&E) standards is crucial for assessing the effectiveness and impact of programs, projects, or activities. M&E standards provide benchmarks and criteria against which performance and outcomes can be measured.

The followings are guides on how to determine monitoring and evaluation standards:

- **Defining Objectives and Outcomes:**
  - ✓ Clearly articulate the objectives and expected outcomes of the program or project. These should be specific, measurable, achievable, relevant, and time-bound (SMART).
- **Developing Key Performance Indicators (KPIs):**
  - ✓ Identify KPIs that align with the objectives and outcomes. KPIs are specific metrics that indicate progress and success. They could include quantitative measures, such as the number of beneficiaries reached or the percentage of targets achieved.
- **Setting Targets and Benchmarks:**

- ✓ Establish realistic and attainable targets for each key performance indicator. Targets provide a basis for comparison and help assess whether the program is meeting its goals.

- **Incorporating Stakeholder Input:**
  - ✓ Involve stakeholders, including beneficiaries, donors, and implementing partners, in the process of defining standards. Their perspectives can provide valuable insights and ensure a more comprehensive evaluation.
- **Utilizing Existing Standards and Guidelines:**
  - ✓ Refer to existing industry standards, guidelines, and best practices. This is particularly relevant in sectors where established norms and benchmarks exist. Adapt these standards to fit the specific context of the program.
- **Legal and Regulatory Compliance:**
  - ✓ Ensure that the monitoring and evaluation standards comply with relevant laws, regulations, and policies governing the program or project. This includes ethical considerations and data privacy regulations.
- **Considering Context and Environment:**
  - ✓ Take into account the specific context and environmental factors that may influence the program's success. Consider geographic, cultural, and socio-economic factors that could impact the relevance of the standards.
- **Creating a Monitoring and Evaluation Framework:**
  - ✓ Develop a comprehensive M&E framework that outlines the overall structure of the evaluation process. This includes the identification of indicators, data sources, responsible parties, and frequency of data collection.
- **Ensuring Data Quality:**
  - ✓ Define standards for data quality, including accuracy, reliability, and completeness. Establish protocols for data collection, validation, and verification to maintain high data quality standards.

5.2 Selecting appropriate monitoring, evaluation and learning techniques

Crop monitoring and evaluation are crucial aspects of modern agriculture that involve the systematic assessment of crop growth, health, and overall performance. These processes help farmers make informed decisions, optimize resource utilization, and maximize yield.

Monitoring and Evaluation Techniques

Remote Sensing and Satellite Imagery:

Utilize satellite imagery and remote sensing technologies to monitor large agricultural areas.

Identify crop health, detect diseases, assess nutrient levels, and evaluate overall crop vigor.

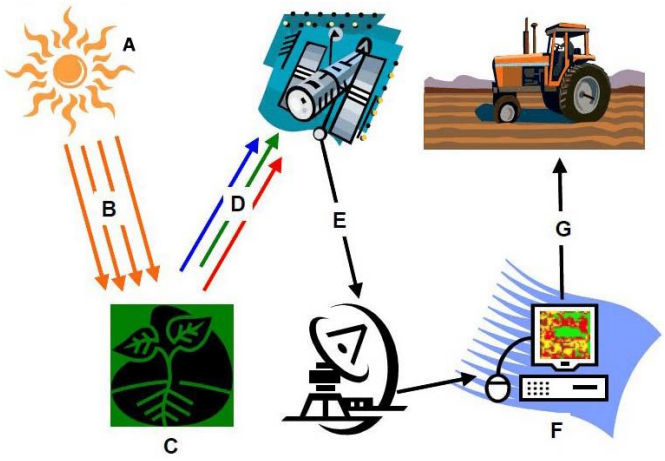


Figure 5.1 Satellite remote sensing in agriculture

Drones and UAVs (Unmanned Aerial Vehicles):

Employ drones equipped with cameras or sensors to capture high-resolution images of crops.

Monitor specific areas for pest infestations, nutrient deficiencies, and other issues.

Sensor Technologies:

Deploy ground-based sensors to collect real-time data on soil moisture, temperature, and nutrient levels.

Use weather stations to monitor climatic conditions and predict potential challenges.

Data Analytics and Modeling:

Implement data analytics tools to process and analyze the vast amount of data collected.

Use predictive models to forecast crop growth, yield, and potential risks.

Satellite-Based Navigation Systems:

Utilize GPS and other navigation systems for precision farming, enabling accurate placement of seeds, fertilizers, and pesticides.

Automated Machinery and Robotics:

Integrate automated machinery and robotics for tasks such as planting, harvesting, and weeding.

Enhance efficiency and reduce labor requirements through mechanized processes.

Mobile Apps and Software Solutions:

Develop and use mobile applications for farmers to access real-time data, monitor crop conditions, and receive alerts.

Implement farm management software for comprehensive analysis and decision-making.

Crop Health and Disease Detection:

Utilize image recognition and artificial intelligence to identify signs of diseases, pests, or nutrient deficiencies in crops.

Implement early warning systems to mitigate potential crop losses.

Yield Monitoring:

Use sensors and equipment to measure and monitor crop yield during harvesting.

Analyze yield data to understand the effectiveness of different farming practices.

Economic and Environmental Impact Assessment:

Evaluate the economic viability of different crops and farming techniques.

Assess the environmental impact, including water usage, soil health, and pesticide usage.

Government and Industry Collaboration:

Encourage collaboration between government agencies, research institutions, and agricultural industries to share data and develop best practices.

Crop monitoring and evaluation contribute to sustainable and efficient agriculture by optimizing resource use, reducing environmental impact, and ensuring food security. Continuous advancements in technology will likely play a significant role in further enhancing these processes.

5.3 Implementing monitoring and evaluation at every production stage as indicated in the production plan

Crop yield is determined long before the crop sets seed. It is the culmination of how the crop performed during each stage of growth-establishment, seedling growth, tillering/ branching, flowering and grain fill. Monitoring the agronomic factors that are responsible for achieving profitable and sustainable yields is essential.

By identifying limitations to crop growth, action can then be taken to address such issues before significant losses occur, for increasing crop production and profitability. Crop monitoring allows farmers to be pro-active rather than reactive to factors affecting crop performance. Most farmers carry out some form of assessment of their farming systems. For example, simple measurements such as the volume and frequency of irrigation and/or rainfall allows farmers to determine likely crop yields. Assessing weed types and densities may help in deciding the type and concentration of herbicide to be applied, or the number of tillage operations that are to be performed. Final crop yield is a reflection of the effectiveness of the decision-making process and an overall indicator of crop performance

Crop monitoring calendar

Calendar of activities and factors monitored for cereals, pulses, and oilseeds

Pre-season

(Time: harvest to sowing)

- Plan activities for the year
- Field selection, crop rotation planning and review
- Soil fertility testing
- Seed quality testing
- Set yield and quality targets

Crop establishment

(Time: 3 to 4 weeks after sowing)

- Sowing depth
- Plant stand
- Weed types and densities
- Insect pests and diseases

Vegetative growth

(Time: 6 to 10 weeks after sowing)

- Nitrogen level in soil and plants
- Number of tillers (in cereals)
- Root diseases (in cereals)
- Nodulation (in pulses)
- Root and foliar diseases (in pulses)

Flowering and grain fill

(Time: 12 to 22 weeks after sowing)

- Weed types and densities
- Insect pests and diseases
- Head numbers (in cereals)
- Flowering (in pulses)
- Pod numbers (in pulses)
- End of flowering (in oilseeds)

Harvest

(Time: After harvest)

- Assessment of yield and grain loss
- Assessment of seed quality
- Windrowing assessment (in oilseeds)

5.4 Preparing and submitting feedbacks and reports

Definition of crop reporting

Crop reporting is the description of the crop in the growing stage, mentioning the present condition involving yield status and pest management with comments for improvement.

Objectives of crop reporting

A crop report is made by an investigator to know about the general situation of the existing crop in the field. The followings are objectives of crop reporting

- To evaluate crop production.
- To achieve crop forecasting.
- To compile information with different statistical data.
- To alleviate the loss from the attack of pests and disease.
- To determine total production.
- To facilitate decision making for cropping pattern.
- Future suggestion for improvement of crops.

When preparing and submitting feedback and reports on crop production, it's important to provide comprehensive information to facilitate informed decision-making.

The followings are a guide on how to structure and present feedback and reports for crop production:

- **Introduction:**

  Clearly state the purpose of the report (e.g., monthly production update, seasonal analysis, or specific project evaluation).

- **Crop Overview:**

  Provide a brief overview of the crops under consideration, including types, varieties, and planting details.

- **Cultivation Practices:**

Detail the cultivation methods employed, including planting dates, soil preparation, irrigation practices, and any relevant agronomic practices.

- **Weather Conditions:**

  Include information on weather conditions and how they have affected crop growth. Highlight any unusual weather events, such as droughts, floods, or extreme temperatures.

- **Pest and Disease Management:**

  Report on the presence of pests and diseases, the strategies used for management, and the effectiveness of these measures.

- **Crop Monitoring and Progress:**

  Provide updates on the growth stages of the crops, highlighting any delays or advancements. Include information on crop health and overall progress.

- **Yield Estimates:**

  Offer estimates or actual yields for the crops based on current conditions. Compare these figures to previous periods or targets.

- **Quality Assessment:**

  Assess the quality of the harvested produce, considering factors such as size, color, flavor, and any issues related to market standards.

- **Challenges and Solutions:**

  Identify challenges faced during the production cycle and propose solutions or strategies for improvement. This demonstrates a proactive approach to problem-solving.

- **Resource Utilization:**

  Discuss the use of resources like fertilizers, pesticides, water, and labor. Evaluate their efficiency and suggest any adjustments for optimization.

- **Budget and Financial Analysis:**

  Include a financial analysis that covers production costs, revenue estimates, and profitability. This is particularly important for farmers and stakeholders.

- **Recommendations:**

  Provide recommendations for future actions based on the findings of the report. This could include changes in cultivation practices, adjustments to

5.5. Modifying or amending production plan, when necessary, based on the monitoring and evaluation feedbacks and reports

Through monitoring and evaluation of production activities, modification or amendments could be made to production plan to be successful in crop production process.

Modifications to a production plan are made for various reasons, and they typically occur in response to changes in internal or external factors that affect the production process.

Some common reasons and situations that may prompt modifications to a production plan:

- **Market Demand Fluctuations:**

  Changes in customer demand or market trends may necessitate adjustments to production volume and schedules.

- **Supply Chain Disruptions:**

  Unforeseen events such as supplier issues, transportation problems, or raw material shortages can impact the supply chain, requiring modifications to the production plan.

- **Equipment Failures or Maintenance:**

  Breakdowns of production machinery or the need for scheduled maintenance may disrupt the original production schedule, leading to adjustments.

- **Quality Issues:**

  If there are concerns or defects in the quality of the produced goods, modifications to the production plan may be required to address and rectify the issues.

- **Resource Constraints:**

  Limitations in manpower, technology, or other resources may necessitate changes to the production plan to optimize resource utilization.

- **Regulatory Changes:**

  Modifications may be needed to comply with new regulations or standards imposed by government authorities or industry bodies.

- **Competitive Pressures:**

  Changes in the competitive landscape, such as the introduction of new products or pricing strategies by competitors, may prompt adjustments to stay competitive.

- **Cost Considerations:**

If there are changes in production costs, such as fluctuations in raw material prices or unexpected expenses, the production plan may need to be revised to maintain profitability.

- **Technology Advancements:**

  Integration of new technologies or changes in production methods may lead to modifications in the production plan to enhance efficiency or product quality.

- **Weather or Environmental Factors:**

  External factors like weather conditions or environmental issues can impact transportation, logistics, and overall production, requiring adjustments to the plan.

- **Emergencies and Force Majeure:**

  Unexpected events such as natural disasters, pandemics, or other emergencies may necessitate rapid modifications to the production plan to ensure business continuity.

- **Feedback from Monitoring and Evaluation:**

  Regular monitoring and evaluation processes may reveal performance gaps or areas for improvement, prompting modifications to enhance overall effectiveness.

Modifications to a production plan are essential for maintaining adaptability and responsiveness in a dynamic business environment. Being proactive in identifying and addressing potential challenges allows organizations to optimize their production processes and meet evolving market demands.

5.6 Implementing record keeping and documentation for future use

Record keeping in agriculture is the systematic process of documenting data, observations and other information related to agricultural operations. It's used to gain insights into the current farm performance and to make smarter decisions in the future.

Benefits of record keeping

Keeping detailed records in crop production offers numerous benefits for farmers and agricultural businesses. Here are some key advantages:

- **Decision-Making:**

Informed decisions: Access to historical data helps farmers make informed decisions about crop selection, planting schedules, and resource allocation.

- **Performance Evaluation:**

  Evaluation of crop performance: Record keeping allows farmers to analyze the success and failures of different crops over time, enabling adjustments for better yields.

- **Cost Management:**

  Expense tracking: Keeping records of inputs (seeds, fertilizers, pesticides) and other costs allows farmers to manage expenses more efficiently, identify cost-saving opportunities, and improve profitability.

- **Resource Optimization:**

  Efficient resource allocation: Detailed records aid in planning and optimizing the use of resources such as water, labor, and machinery, leading to increased efficiency.

- **Crop Rotation Planning:**

  Crop rotation insights: Historical records help in planning crop rotations to maintain soil fertility, prevent disease, and manage pest issues.

- **Compliance and Certification:**

  Regulatory compliance: Accurate record keeping ensures compliance with agricultural regulations, certifications, and standards, which may be necessary for selling produce in certain markets.

- **Quality Control:**

  Quality assurance: Monitoring and recording factors such as crop health, yield, and harvest timing contribute to maintaining high-quality produce.

- **Risk Management:**

  Risk assessment: Keeping records helps farmers identify and mitigate risks associated with weather conditions, pests, diseases, and market fluctuations.

- **Financial Planning:**

  Financial analysis: Records support financial planning and budgeting, facilitating better management of cash flow, loans, and investments.

- **Performance Benchmarking:**

Benchmarking against benchmarks: Comparative analysis of current and past performance provides benchmarks for improvement and helps set realistic goals for future growth.

- **Traceability:**

  Product traceability: Record keeping enables traceability of products back to their source, which is valuable in case of quality issues or recalls.

- **Research and Development:**

  Support for research: Detailed records can be valuable for research and development purposes, contributing to advancements in agricultural practices and technology.

- **Succession Planning:**

  Farm succession planning: Records can be crucial in succession planning, helping the next generation of farmers understand the history and intricacies of the farm operation.

- **Insurance Claims:**

  Insurance documentation: In the event of crop damage due to natural disasters or other unforeseen events, detailed records support insurance claims and facilitate a smoother claims process.

- **Market Positioning:**

  Marketing advantage: Farmers with comprehensive records may have a marketing advantage, as they can provide transparent information about their farming practices and product quality.

Examples of crop production records template

Table 5.2) Crop data

Year	Crop	Hybrid/ Variety	Yield Goal	Actual Yield	Planting Date	Pop. Planted	Actual Pop.	Planter Settings	Tillage Practices and Dates	Crop Residue *	Harvest Date

Table 5.3) Nutrient Applications

Year	Date	Material*		**Analysis**		**Rate/ha**		Kg/ha		Lime	Other**
			N	P_2O_2	K_2O		N	P_2O_2	K_2O		

Self-Check – 5	

Directions: Answer all the questions listed below.

Part I Write 'True' for correct statements and 'False' for incorrect statements.

1. Determining monitoring and evaluation standards is crucial for assessing the effectiveness and impact of programs.
2. Remote Sensing and Satellite Imagery are among important techniques of monitoring and evaluation.
3. Production plan is considered as rigid and doesn't need any modification.
4. Crop type and variety should be neglected during presentation of feedback and reports for crop production.
5. Farmers with comprehensive records always face a marketing problem.

Part II Choose the best answer

1. Which of the following is not objective of crop report?
   A. To evaluate crop production
   B. To achieve crop forecasting
   C. To compile information with different statistical data
   D. None
2. _____ focuses on the quality and the outcomes (results) achieved by a program.

A. Performance evaluation
B. Impact evaluation
C. Monitoring
D. None

3. One of the following is important guide to determine monitoring and evaluation standards
   A. Defining Objectives and Outcomes
   B. Developing Key Performance Indicators
   C. Setting Targets and Benchmarks
   D. All of the above
4. Which of the following may not prompt modifications to a production plan?

E. Market Demand Fluctuations
B. Supply Chain Disruptions
C. Equipment Failures or Maintenance
D. Risk free production process

5. From the following, which one is considered as a guide to determine monitoring and evaluation standards:
   A. Defining Objectives and Outcomes
   B. Developing Key Performance Indicators
   C. Setting Targets and Benchmak
   D. All

Part III Give brief and precise answers

1. Compare and contrast monitoring and evaluation
2. What are the benefits of record keeping?
3. What are the objectives of crop reporting?
4. Write down at least four monitoring and evaluation tools and equipment in crop production
5. Define crop reporting

Operation Sheet -5

5.1. Preparing reports of established crop (on field)

Objective: To prepare reports of crop conditions on field

Tools and equipment

- Pen/ pencil/marker
- Note books
- Smartphone/camera
- GPS Machine (if available)

Procedure

Step 1 Record the name of crops with the varieties



Figure 5.2 Recording crop name and variety

Step 2 Record total area of the cropping land by using GPS machine or smart phone application



Figure 5.3 Recording total area of the cropping land by using smart phone application

Step 3 Record the age and development of crops

Step 4 Record crop condition such as vigour, growth and infection by pests or disease



Figure 5.4 Observing and recording crop conditions at field

Step 5 Finally report crop conditions to the appropriate personnel

https://www.youtube.com/watch?v=sEtTe6pw1tI (Accessed date January 17, 2024)

5.2. Implementing record keeping and documentation

Objective: To implement generalized record keeping and documentation for crop production

Tools and equipments

- Field record sheets
- Pen/pencil or markers
- Documentation forms (templates)
- PC, Tablet or smart phones

Procedures

Step 1 **Choose the right tools**: Select a record-keeping method that suits your needs, such as paper, electronic spreadsheets, or specialized farm management software

Step 2 **Establish a comprehensive system**: Create a system or use available templates for recording expenses, labor, chemical usage, harvest and yield data, planting information, and compliance records

Step 3 **Utilize digital solutions**: Consider using digital record-keeping tools like spreadsheets, orchard management software, or farm management apps to manage extensive data collection

Step 4 **Follow best practices**: Keep well-maintained, accurate records to enhance farm planning, forecasting, and risk management. This includes tracking income and expenditures, and maintaining detailed pesticide and spray records for safety and regulatory compliance

Step 5 **Monitor and update records**: Regularly update your records to reflect changes in crop production, and use the information to make informed decisions about pricing, crop management, and resource allocation

Step 6 **Create and document proper procedures**: Develop a thorough procedure for your new records management plan to ensure that the proper steps are taken moving forward

LAP TEST-5	

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **1** hour.

1. Prepare crop report for established maize farm.
2. Develop generalized record keeping and documentation form for wheat farm

Reference

Books

Gebresenbet, G. (2012). Logistics and supply chains in agriculture and food. Chapters.Gillet, V., & Biancalani, R. (2022). Guidelines for the calculation of the agriculture water use efficiency for global reporting.

Khanal, U., Stott, K. J., Armstrong, R., Nuttall, J. G., Henry, F., Christy, B. P., ... & O'Leary, G. J. (2021). Intercropping—evaluating the advantages to broadacre systems. Agriculture, 11(5), 453.

Maitra, S., Hossain, A., Brestic, M., Skalicky, M., Ondrisik, P., Gitari, H., ... & Sairam, M. (2021). Intercropping—A low input agricultural strategy for food and environmental security. Agronomy, 11(2), 343.

Maliwal, P. L., Maliwal, P. L., & Mundra, S. L. (2007). Agronomy at a glance (Vol. 2). Agrotech Publishing Academy.

Panda, S. C. (2005). Agronomy. Agrobios.

Shrestha, A. (2004). Cropping systems: trends and advances.

Steiner, K. G. (1982). Intercropping in tropical smallholder agriculture with special reference to West Africa.

Villalobos, F. J., & Fereres, E. (Eds.). (2016). Principles of agronomy for sustainable agriculture (p. 443457). New York, NY, USA:: Springer.

Wajszczuk, K. (2016). The role and importance of logistics in agri-food supply chains: An overview of empirical findings. Logistics and Transport, 30(2), 47-56.

Web Addresses

(357) Climate Resilient Agriculture Technology / Climate Smart Agriculture Technology - YouTube (Accessed date January 20, 2024)

Benchmark your farm to improve your profitability and financial position | UMN Extension (Accessed date: January 21, 2024)

Benchmarking potential yield of barley in higher rainfall zones - YouTube (Accessed date January 17, 2024)

Climate Types at Cropping Calendar (youtube.com) (Accessed date January 17, 2024)

Estimating Yield Goal for Crops | Cooperative Extension | University of Delaware (udel.edu) (Accessed date January 20, 2024)

How do I give you a realistic yield target, so that my fertilizer recommendations are practical and affordable? - CROPNUTS Helpdesk (helpscoutdocs.com) (Accessed date: January 21, 2024)

https://www.youtube.com/watch?v=SRx1pq2ky6A (Accessed date, January 16, 2024)

https://www.youtube.com/watch?v=sEtTe6pw1tI (Accessed date January 17, 2024)

Land equivalent ratio - Wikipedia (Accessed date: January 21, 2024)

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