Draft Study Material

Pulses Cultivator

(QUALIFICATION PACK: Ref. Id. AGR/Q0104)

SECTOR: AGRICULTURE

Grade 12

विद्यया ऽमृतमश्नुते

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NCERT

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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives. The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material. Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material. This material is copyrighted and should not be printed without the permission of the NCERT-PSSCIVE.

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Module 1
Irrigation Management in Pulse Crops

Module Overview

"Irrigation is the artificial application of water to the soil in order to maintain proper soil moisture regime for plant growth."

The main aim of irrigation management is to apply and use water in the most profitable way at sustainable production levels. In the context of production agriculture, this generally means that one has to adopt artificial means for supplementing precipitation with water.

An efficient water conservation, its management, and use of irrigation water are key for successful pulse crops production, especially when field are under moisture deficit condition. Pulse crops required irrigation at its critical stages for its better growth and development. Irrigation requirement may vary from crop to crop. If water is a limiting factor, then a proper management and conservation practices can be fruitful to cultivate crops round the year.

Learning Outcomes

After completing this module, you will be able to:

- Explain the importance of irrigation in pulse crop and identify various irrigation methods

Module Structure

- Session 1: Importance and Methods of Irrigation

Sources of water for plants

Two main sources of water for plants are through rainfall and irrigation respectively.

Rainfall is a natural source of water and its quality is good. However, it is a limited and unpredictable natural source of water. Irrigation is a practice of planning and applying water artificially to maintain soil moisture. It can be made as an assured source.

Function of water in pulse crop's plant

- Water is an essential element for plant life.
- It helps plants to absorb and transport minerals from soils.

- It is essential to regulate biochemical reactions in plant.
- It is an integral part of photosynthesis process in plant.
- It helps plants to manage high & low temperature stresses.
- It is essential for seed germination and seedling establishment in the field.

Irrigation requirement of crop plants depends on:

- **Type of pulse crop**: Shallow rooted crops need light but frequent irrigation than deep-rooted pulse crops.
- **Growing season**: In summer season, pulse crops require irrigation more frequently in comparison to winter season crops and occasionally in rainy season crops.
- **Climate:** Under cold climatic conditions, irrigation frequency is less. In tropical or hot climatic conditions, irrigation frequency is more.
- **Soil type**: Sandy soils require frequent but light irrigation whereas clay soils require less frequent but deep irrigation.
- **Type of irrigation System**: Regular irrigation is needed in Drip System and less frequently in case of Surface, Sub-surface and Sprinkler Irrigation System.

Session 1: Importance and Scope of Pulse Crops Cultivation

Importance of irrigation

- Pulse crops generally grew under rain-fed condition, but in case of water shortage conditions, the yield and quality of pulses suffers badly. Hence, irrigation is very essential for higher yields and good quality of pulses during rabi and kharif season pulses.
- Sufficient amount of water in root zone is pre-requisite for better yield and quality produce.
- Irrigation reduces dependency on rainfall because it can be done as and when required.
- If irrigation is properly schedule, it can save water and minimize the weed problem.
- Irrigation helps to grow more number of crops with varying water demand in a year in the same field.

Sources of irrigation water

1. **Surface water sources**: These sources are either natural or created through rainwater harvesting into water harvesting structures. Water quality is quite good and fit for irrigation.

   Examples: Rivers, canal, small tank, ponds, lakes, dams, etc.

2. **Ground water sources**: It is underground water, lifted through dug wells, tube wells, and bore wells. Water quality varies from poor to good.

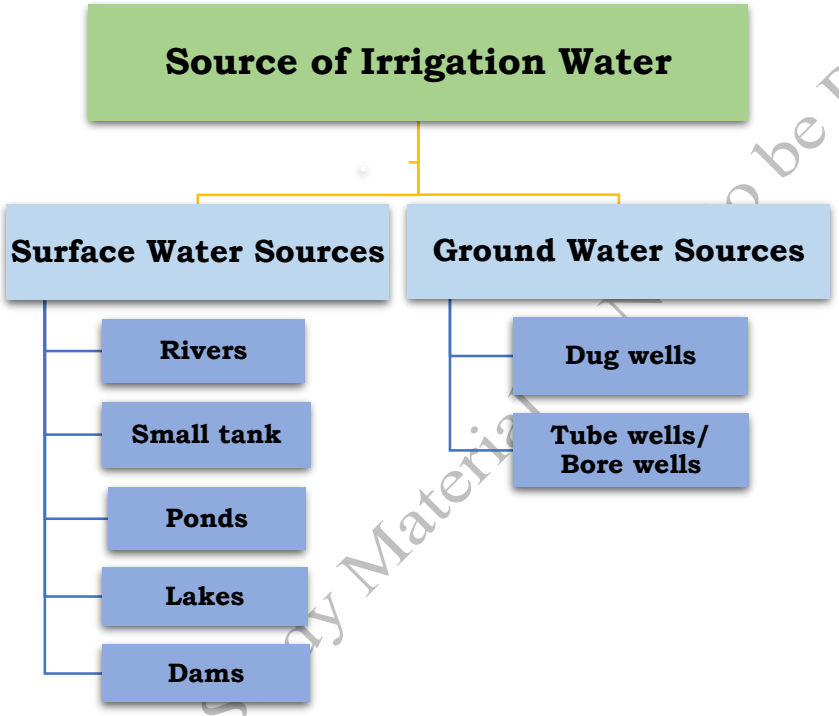

***Fig.* 1.1: Sources of Irrigation Water**

Do you know?

- Water resources are too short in India and groundwater level is also depleting at alarming rate. So, it is essential we need to conserve the rainwater.

- In some areas, poor quality water, full of toxic, heavy metals and microbes, is in use in cultivation of vegetables. It is necessary that only after proper treatment it can be used in cultivation process.

The quality and quantity of water is very important for successful vegetable cultivation. Earlier in India, water quality concerns were less due to the availability of good quality water but presently this situation is changing in many

areas. Poor quality water from industrial areas and saline ground water requires proper treatment before their use in irrigation purpose.

Quality of water

- Good quality of water is a crucial factor for soils to remain productive for long-term.
- Good quality water allows growing any kind of vegetable crop.
- Good quality water favours high yield and better quality of vegetable crops.
- Various regions in the country have poor quality water to irrigate the crops.
- Untreated water from urban industrial areas is of poor quality.
- In some areas, ground water is very deep and is poor in quality.

Need of water quality test

- Quality test tells us suitability of water for its immediate use in irrigation or its immediate need for treatment.

Don't use poor quality water for irrigation, otherwise

- It will deteriorate soil health.
- Deposit excess salts in root zone
- Reduces uptake of minerals and affect crop yield.
- Reduce soil permeability and increase water runoff.
- Toxicity of metals also appears in some plants.

Criteria of water suitability for irrigation

- **pH** of irrigation water ranges in between 6.5 to 8.5.
- **Water salinity**: It is an indicator of total dissolved salts present in water. It is of prime concern for both soil structure and crop yield. One can measure Salt concentration by Electrical Conductivity (EC) in milli Siemens per meter (mSm^{-1}) or micromhos per cm ($\mu mhoscm^{-1}$). Water having EC below 1500 micromhos/cm is good for irrigation.
- **Sodium adsorption ratio (SAR):** It is a measure of relative proportion of sodium (Na^{+}) to calcium (Ca^{+2}) and magnesium (Mg^{+2}) in water. High sodium causes breaking of soil aggregates and sealing the soil pores. Sodium weakens binding capacity of soil. A small SAR value indicates low sodium content in water. It should be below 10 for irrigation water.

- **Residual sodium carbonate and bicarbonate concentration**: High carbonate and bicarbonate content in water increases the pH. This will cause an alkalizing effect and high SAR index. Residual sodium carbonate below 1.5 meq/litre is safe of irrigation water. For the management of such water quality, following measures can be adopted **-**

  i. Addition of gypsum in low calcium soil + Leaching

  ii. Addition of sulphur + Lime + Leaching

  iii. More frequent irrigation

  iv. Avoid sprinkler method of irrigation

  v. Avoid use of chloride and boron containing fertilizers

  vi. Select tolerant crops

- **Boron** (ppm): Boron is the most common element found in toxic concentrations in water. Boron cannot be easily removed from water. The only remedy is to dilute high boron water with low boron water. Below 1.0 ppm is acceptable level of boron content in irrigation water.

Water quality testing instruments:

It is important to test the suitability of water quality for its intended purpose. Water testing will help to know whether the quality of water is fit for irrigation or not, and if not then what is the specific reason for its poor quality. In general, the pH and electrical conductivity (EC) are two most important parameters for water quality analysis. Fig 1.2 shows change in pH colour strip when dip into the alkaline/acidic water.

***Fig.* 1.2. pH colour strip**

pH meter: It is an equipment by which we can measure the pH of any solution. It consist of a display unit and electrode. When the electrode is insert in to solution, the display unit shows the pH value. Ideally, the pH of the soil and water has to be 6–6.5 and that of nutrient solution should be 5.6–6.5. The pH

meter, like all other equipment, should be calibrate beforehand for accurate data collection. It is more accurate than pH colour strip.

***Fig.*1.3: Digital pH meter**

Electrical conductivity (EC) meter: Electrical Conductivity is a measure of total dissolved salts in irrigation water and is measured through conductivity meter or EC meter. It gives information on degree of salinity in water in terms of Millimhos Per Centimetre (mmhos/cm), Decisiemens Per metre (dS/m), Microsiemens Per Centimetre (µS/cm) or Millisiemens Per Centimetre (mS/cm) which. Microsiemens Per Centimeter is the standard unit to represent EC value of freshwater measurements. They are all indeed similar on numerical count, i.e., numerical value remains same per unit area, only the reference varies. Electrical Conductivity of irrigation water is more when it contains more soluble salts and vice versa. Temperature of water affects conductivity and it is usually reported at 25 °C. The EC measurement is the simplest and fastest method for determining the salinity of water, but it is non-specific because it measures only the total effect of all ions present and cannot distinguish between different types of ions.

***Fig.*1.4: Digital Electrical Conductivity (EC) meter**

Water requirement

Water Requirement (WR) of a crop is the total quantity of water needed, either supplied through rainfall or irrigation or both, for crop growth and yield. Water Requirement varies crop to crop and soil profile. It is different from Irrigation Requirement (IR) which is the total quantity of water applied to a cropped field to supplement rainfall and soil profile contribution.

When irrigation supplies the entire water requirement, the Water Requirement (WR) and Irrigation Requirement (IR) are the same. One can express the Water Requirement as the unit of absorbed water required for the production of one unit of dry matter.

Water Requirement (mm) = Evapo-transpiration + Application losses + Special

Were,

Evapotranspiration (ET) =	Total losses of water by transpiration from crop and evaporation from soil
Application losses =	Water losses during the application of irrigation water
Special needs =	Water required for land preparation, transplanting, leaching *etc.*

How much to irrigate?

If the water requirement of a particular crop is 2 mm per day, it means every day we have to give 2 mm of water to the crop. Practically speaking, it is not achievable in the field; therefore, it can be delivered as 10 mm every 5 days or 20 mm every 10 days. Frequency of irrigation varies with growing season, types of crop, and types of soil and its condition.

When to irrigate?

Water shortage in early crop stages delay crop maturity and reduce the yield. Moisture stress in later stages of the crop reduce quality of produce. Hence, adequate moisture is essential for high yield and good quality produce. Frequency of irrigation and amount of water to be applied depends on the number of factors, such as, depth of root system, water use efficiency, stages of growth, soil type, prevailing weather conditions and actual consumptive use of

the vegetable crops. Vegetables need frequent and timely irrigation for higher yield and good quality produce.

The basis of the decision on 'when to irrigate' depends on visual plant indices, soil appearance and climatic parameters. Visual symptoms, such as dropping and rolling of plants in mid-day, are used to determine time of irrigation. One can plan irrigation when soil sample from root zone do not form 'soil ball' properly.

Irrigation scheduling is the frequency of water application in which water is to be applied based on needs of the crop and nature of the soil.

Criteria for scheduling irrigation or approaches for scheduling irrigation

An ideal irrigation schedule must indicate when to apply irrigation water and in how much quantity. There are several approaches used by scientist and farmers for scheduling irrigation. These are as follows:

1) soil moisture depletion approach:

The available soil moisture in the root is a good criterion for scheduling irrigation. Irrigation replenishes soil moisture in a specified root zone depth (which varies for different crop) to a particular level.

For practical purpose, start the irrigation when the available moisture in the soil root zone reduced to 50 percent. The available water is the soil moisture, which lies between field capacity and wilting point. The relative availability of soil moisture is not same from field capacity to wilting point stage. Finding the ideal point within the range of soil moisture to time the irrigation, to sustain crop yield at a high level, is crucial since the crop begins to suffer before the soil moisture reaches the wilting point. Soil Moisture Deficit represents the difference in the moisture content at field capacity and that before irrigation. One can measure Soil Moisture Deficit by taking into consideration the percentage, availability, tension, resistance etc.

2) Plant basis or plant indices:

Plants, being the user of water, can act as a guide for scheduling irrigation. Water deficit plants reflect and indicates itself for irrigation scheduling through dropping, curling or rolling of leaves and change in foliage colour. However, these symptoms indicate only the need for water. They do not permit quantitative estimation of moisture deficit.

One must use go through growth indicators such as cell elongation rates, plant water content and leaf water potential, plant temperature, leaf diffusion

resistance etc., for deciding when to irrigate. Some indicator plants are also a basis for scheduling irrigation. For example, in Hawaii, the sunflower plant, which is used to estimate the soil's PWP, serves as an indicator plant for irrigation of sugar cane.

3) Climatological approach:

Evapotranspiration (ET) mainly depends up on climate. In this approach, climatological data aids in estimation of the amount of water lost by evapotranspiration and when ET reaches a particular level, irrigation is scheduled. The amount of irrigation given is either equal to ET or fraction of ET. Different methods in climatological approach are IW/CPE ratio method and pan Evaporimeter method.

In IW/CPE ratio method, a known amount of Irrigation Water is applied when Cumulative Pan Evaporation (CPE) reaches a predetermined level. The amount of water given at each irrigation ranges from 4 to 6 cm. The most common being 5 cm irrigation. Scheduling irrigation at an IW/CPE ratio of 1.0 with 5 cm. Generally, one can schedule irrigation at 0.75 to 0.8 ratios with 5 cm of irrigation water.

Problem: Calculate the Cumulative Pan Evaporation required for irrigation at 0.5, 0.6, 0.75, and 0.8 with 5 cm of Irrigation Water.

Solution:

Cumulative pan evaporation at IW/CPE ratio of 0.5, IW/CPE=0.5

$$= \frac{5}{CPE} = 0.5,\ CPE * 0.5 = 5,\ CPE = \frac{5}{0.5} = \frac{50}{5} = 10cm$$

Irrigation of 5 cm is given when CPE is 10 cm

CPE at 0.6 ratio = 5/0.6 = 8.33cm
CPE at 0.75 ratio = 5/0.75 = 6.66cm
CPE at 0.8 ratio = 5/0.8 = 6.25cm

In IW/CPE ratio approach, irrigation can also be scheduled at fixed level of CPE by varying amount of irrigation water.

Problem: Calculate the amount of water for each irrigation for scheduling irrigation at 0.5 and 0.8 IW/CPE with 10cm of CPE.

Solution:

Amount of water to be given at

$$\text{IW/CPE ratio of 0.5} = \frac{\text{IW}}{10} = 0.5 \text{ IW} = 0.5 \times 10 = 5\text{cm}$$

Amount of water to be given at

$$\text{IW/CPE ratio of 0.8} = \frac{\text{IW}}{10} = 0.8, \text{ IW} = 10 \times 0.8 = 8\text{cm}$$

Estimating evapo-transpiration from evaporation data:

It is been observed that a close relationship exists between the rate of CU (consumptive use of crop) by crops and the rate of evaporation from a well-located evaporation pan. The standard United States Weather Bureaus Class A Pan Evaporimeter or the Sunken Screen Pan Evaporimeter may be used for measurement of consumption use.

4) Critical growth approach:

Moisture stress causes irreversible yield loss in each crop at certain growth stages. These stages are known as critical periods or moisture sensitive periods. If Irrigation Water is available in sufficient quantities, then one can schedule irrigation whenever soil moisture depletes to critical moisture level. For example, 25 or 50 percent of available soil moisture. Under limited water supply conditions, one can schedule irrigation at moisture sensitive stages and skip the irrigation at non-sensitive stages. In cereals, panicle initiation, flowering, and pod development are the most important moisture sensitive stages.

Pulse crop	Critical stage	Water management
Pigeon Pea	Pre flowering & Pod filling	Being a deep-rooted crop, it can tolerate drought If one sow the crop in month of June, then it can have one or two pre-monsoon irrigations as per requirements. After the start of monsoon, there is no need to irrigate but in case of prolonged drought during the reproductive period of growth, it needs one or two irrigations. A pre-requisite for the success of Arhar (Pigeon Pea) is proper drainage. Ridge planting is effective in areas where sub-surface drainage is poor. This provides enough aeration for the roots during the

		period of excess rainfall. During rainy season, water should not stand anywhere in the field
Green Gram	Pre flowering, Flowering & Pod filling	In kharif season, Green Gram does not require any irrigation if the monsoon rainfall is well distributed. However, for good crop growth, it is recommend having one irrigation under drought situation for longer period at flowering stage particularly in sandy loam soil. In summer season, the number of irrigations and their time of application vary according to seasonal conditions. At least three irrigations, the first at pre-flowering stage (20-25 days), the second at flowering (25-40 days) and the third at grain-filling stage, are necessary. Pre-sowing irrigation is necessary to ensure adequate soil moisture for germination. The availability of water is generally scares in the canals during the summer months but there is a great scope of growing summer Mung bean around tube wells
Black gram	Pre flowering, Flowering & Pod filling	Good drainage, not irrigation, is essential for rainy season crop. Irrigation facilities should be available for raising the crop during summer season. Number and frequency of irrigation depend upon the soil type and weather, prevailing during the growth period. Generally, in summer season, the crop should get irrigation at an interval of 10-15 days. From flowering to pod development stages, there is need of sufficient moisture in the field.

Chickpea	Pre flowering & Pod development	Chickpea, generally known as grown in India, invariably suffers from moisture stress as 'terminal drought', at their most critical pod development stage due to high atmospheric and soil temperature coupled with high wind velocity. To minimize transpiration loss and conserving residual soil moisture for longer time, a foliar spray of 2% KCl (Potassium Chloride) is giving promising results. However, under assured irrigation, one irrigation each at maximum branching and pod development resulted in 25-70% increase in yield in absence of winter rain. Never apply irrigation, in any case, earlier than four weeks after sowing and during active flowering. This is because in former situation, it is harmful for maximum 'N' fixation as the Rhizobial bacteria work only in aerobic conditions and in later situation, excess irrigation may reverse the crop again to vegetative phase with severe depression in yield due to ultimately shorter reproductive phase.
Lentil	Flower initiation & Pod formation	Generally, lentil grow as un-irrigated crop in the residual soil moisture but irrigation at pod development stage helps in getting more yield. Most critical stage for moisture stress is pod formation followed by flower initiation. In Central India, where there is absence of winter rains and soil moisture contribution is negligible, two light irrigations may be required for significant yield improvements.

Field Pea	45 DAS (Days After Sowing) & Pod filling	Field peas are crop that can withstand some drought conditions since they grow on residual soil moisture and are rainfed or unirrigated. Pre-sowing irrigation is necessary for good germination. There is sufficient amount of moisture in paddy fields. Hence, one can sow field pea, after cultivating paddy, in these fields without irrigation. After sowing, it requires one or two irrigations at 45 DAS. If required, the best-recommended irrigation schedule will be at pod filling stage. Heavy irrigation leads to the yellowing of plants and thus reducing the yield.
Lathyrus	60-70 DAS (Days After Sowing)	Lathyrus grow as rainfed crop on residual moisture. However, under high moisture stresses, one irrigation at 60-70 DAS may be remunerative in terms of production.
Raj mash	25 DAS (Days After Sowing) & 75 DAS (Days After Sowing)	Raj mash has shallow root system and it is the most irrigation responsive pulse crop due to its shallow root system and high nutrient requirements. It requires 2 to 3 irrigations in north-eastern plain zone and 3 to 4 irrigations in central zone for achieving highest productivity. Irrigation at 25 DAS is most critical followed by irrigation at 75 days after sowing.
Cowpea	Vegetative, Flowering & Pod filling	Cowpea grow as kharif crop. Early sown rainy season crop may require one or two irrigations in pre monsoon/delayed onset of monsoon. In rainy season, crop drainage is more essential than irrigation. This crop can tolerate flooding up to 2 days at flowering and pod setting thereafter, a marked decrease in yield

		and its attribute. For summer crop, irrigation is most critical among all inputs followed by weeding and fertilizer. Generally, this crop requires 5-6 irrigation depending on soil, prevailing weather condition etc., at an interval of 10-15 days. Increasing moisture regime from dry to medium wet, results in significant yield improvement. The response to irrigation is in order of flowering > pod filling > vegetative.

5) Plant water status itself:

This is the latest approach for scheduling of irrigation. Plant is a good indicator of a soil moisture and climatic factors. The water content in the plant itself is considered for scheduling irrigation. It is, however, not yet common use for want of standard and low-cost technique to measure the plant water status or potential.

Methods of irrigation: The way of application of Irrigation Water into the crop field refer as Method of Irrigation. Selection of suitable irrigation method mainly depends on the Soil Characteristics, Cropping System, Land Topography, Quantity and Quality of Irrigation Water, and the Nature and Availability of Inputs like labour and energy. There are four principle systems of irrigation viz. Surface, Sub Surface, Aerial or Overhead or Sprinkler Irrigation and Drip Irrigation.

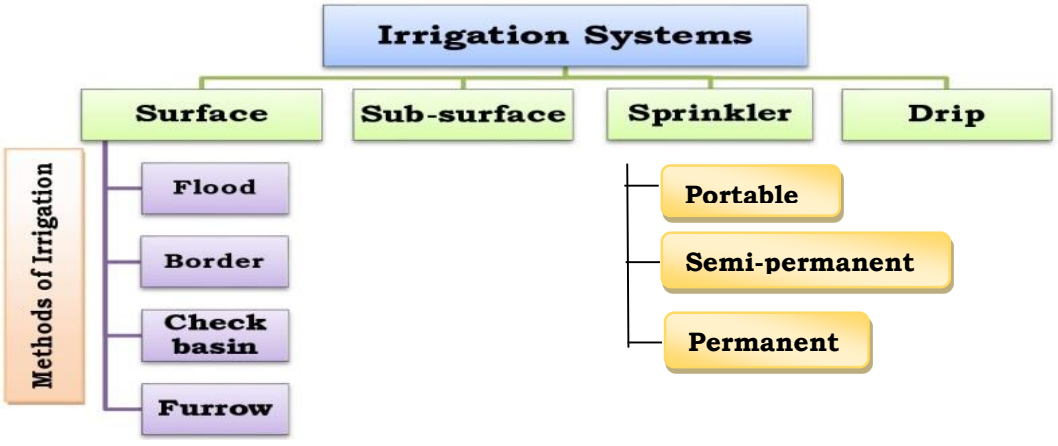

***Fig.*1.5: Irrigation systems and methods**

Irrigation Systems and Methods

Efficient method aims at proper use of irrigation water in conjunction with other inputs to enhance yield. Land topography, soil and crop types, water quality and quantity, availability of labour and energy are factors to decide irrigation method. Fig 1.5 shows the system of irrigation and their methods.

A. Surface irrigation system:

Surface Irrigation System, also known as gravity irrigation method, is the most common and cheapest method of irrigation. In this method, one applies water to the field by introducing a stream of water through channels, pipes or ditches at the head of a field and allowing gravity and hydrostatic pressure to spread the flow over the surface of throughout the field. Land levelling and smoothing are essential operations. Important surface irrigation methods are

1. Flooding

2. Bed or border method

3. Basin (ring and basin) method and

4. Furrow (ridge and furrow, broad ridge or raised bed) method

1. **Flood irrigation method:** Being an ancient practice of irrigation, it consists of opening water channel in a field and allowing it to flow freely in all directions to cover the land surface as a sheet. This practice is suitable for areas where water is abundant and have levelled topography, as shown in Fig. 1.6.

***Fig.*1.6: Flood Irrigation Method**

Advantages

1. It is applicable to properly levelled soils.
2. Low cost of operation due to use of gravity and hydrostatic pressure.

3. Skilled human resource is not required.
4. No specialized equipment is required.

Disadvantages

1. It is unscientific and inefficient method of irrigation
2. Maximum losses of irrigation water occur in this method
3. It requires more water per unit area than all other methods of irrigation.
4. Unsuitable for spacious crops and crops that are sensitive to waterlogging as it can spread soil borne diseases. It results wetting of all field surface, hence increases weed population in the field.
5. Variability in infiltration rate of soil in field cause non-uniformity of water distribution in the root zone.
6. Loss of nutrients is more.

2. Border irrigation method: In this method, land is levelled and divided into different strips of appropriate size by making the borders of 30 cm height in between each strip. Strips of 3-10 m width and 30-90 m length with up to 0.5% slope are formed. This is suitable for a variety of close and row growing vegetable crops (Fig. 1.7).

Advantages

1. It is easy to prepare, operate and maintain borders and strips.
2. It is suitable to irrigate crops on steep slopes by making small strips.

Disadvantages

1. It requires flat and smooth topography.
2. Larger water flow is required for irrigating border stripe.
3. Not suitable for sandy soil.
4. To avoid water logging proper drainage system is required.

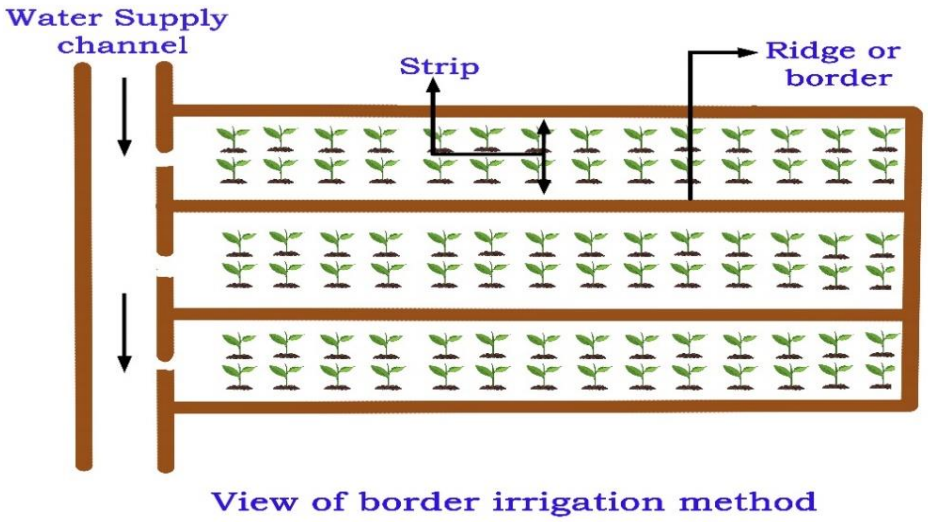

***Fig.*1.7: Border irrigation method**

3. Check basin method: In check basin method, field is divided into square or rectangular checks or plots surrounded by ridges for irrigation as shown in Fig. 1.8. The plots are generally levelled or have a very mild slope. It is used successfully for both field and row crops. A modification in basin method is ring-and-basin method in which there is a circular basin, of about 45-60 cm wide, around the plant for irrigation of the crop. In this method, the water is impounded to irrigate a single tree or vine pulses (Fig. 1.8 & 1.9).

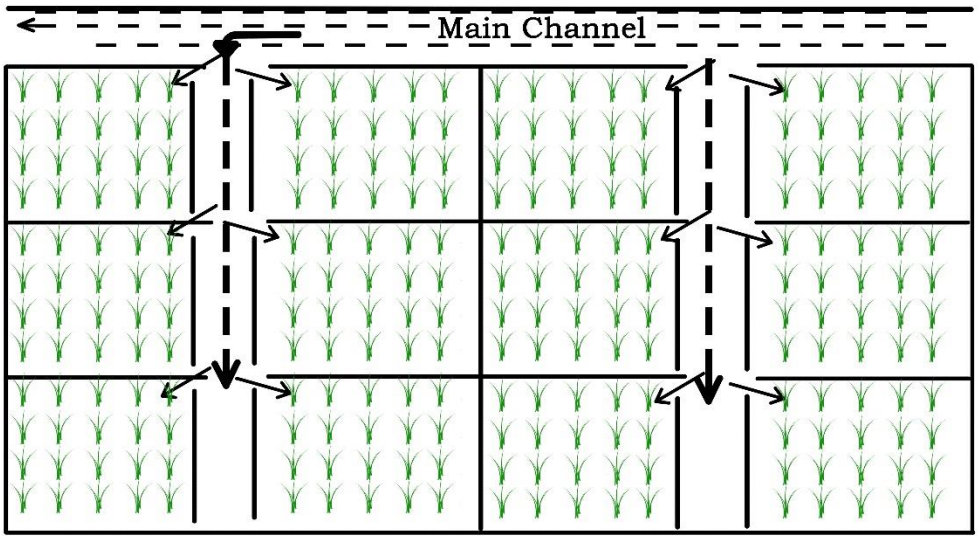

***Fig.*1.8: Line diagram of Check Basin Method**

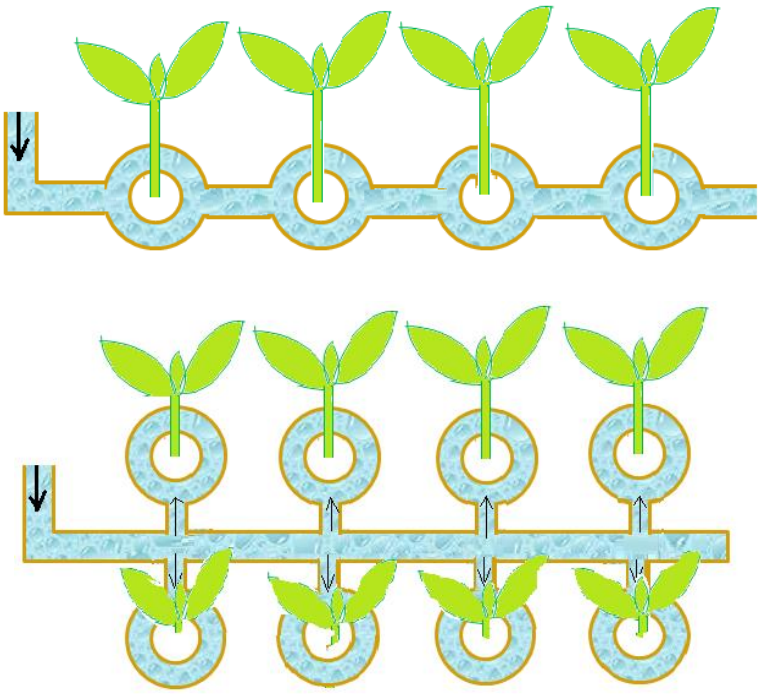

***Fig.* 1.9: Line diagram of Ring and Basin Irrigation Method**

Advantages

1. This method is useful in irrigating the fields having irregular shapes.
2. Water application and distribution efficiencies are generally high.

Disadvantages

1. It requires proper land levelling.
2. Comparatively more labour intensive.
3. Borders interfere with the use of farm machines.
4. It is not suitable for the crops sensitive to water logging.

4. Furrow irrigation method: In this method, water moves into the field through furrows between two ridges. These furrows are lined among rows of the crop according to slope of land as shown in Fig.1.10. Furrows are channels with continuous and nearly uniform slope in the direction of irrigation. Furrows run 3-6 m in length in such a way that water reaches to every nook and corner of the field. Planting is done on the side of ridges or raised beds (about 15-22 cm high) and water is given in 15-20 cm deep furrows of 30-50 cm width.

Advantages

1. Water efficiency is high due to less wastage because irrigation is done in furrows only.

2. Since water does not cover the entire land thus weed problem is quite minimized.
3. It is more suitable for pulse crops grown on rows or beds.
4. Relatively easy to operate and require less labour, hence not much expensive.
5. Evaporation losses are less because it exposes a smaller area of open water.
6. Adapted to most soils.

***Fig.* 1.10: Furrow Irrigation Method**

Disadvantages

1. Labour requirement is more for making ridges and furrows and streaming irrigation water.
2. Furrows interfere with farm machinery for weeding, spraying and crop harvesting.
3. Not suitable for sandy soils because of poor stability of furrows, land levelling problem and high infiltration rate.
4. Not applicable on uneven lands because levelled field is required for proper flow of water.

B. Sub-surface irrigation:

Sub-surface irrigation consists of applying water below the ground surface and the water movement by capillaries. When an impervious layer exists naturally below the root zone, it allows water into series of ditches dug up to the impervious layer, which then moves laterally to wet the root zone. In artificial sub-surface irrigation, perforated or porous pipes are laid out underground below the root zone and water is led into the pipes by suitable means.

Advantages

1. Reduces water loss due to less evaporation.
2. Do not create any interference with the farm operations.
3. Easy to maintain water level at optimum depths as per crop requirements.

Disadvantages

1. It requires high cost for installation.
2. Difficult to locate leaks in the system.
3. Repairing requires large expenses.
4. This method not suitable, where irrigation often needed to germinate crops.

C. Sprinkler or Overhead Irrigation:

In the sprinkler systems of irrigation, water, in the circular manner of rainfall, is sprinkled over the crop as well as on the soil. With pressure, water is forced through pipes fitted on stand with revolving sprinkler nozzles. The nozzles revolve due to pressure of water and spread water in the form of thin spray. In this system, one can uniformly distribute and control the rate of application of water. This is a much more efficient system as compare to the other method. It is an ideal system for hilly and undulating regions. Major components of sprinkler system are pump, main line, lateral pipe and sprinkler.

Advantages

1. It is useful in irrigating undulated lands.
2. There are no obstacles during the use of farm implements.
3. Water saving is up to 30-35%.
4. Fertilizers and pesticides can also be applied by this method.
5. Amount of water can be controlled as per crop requirement.
6. More area of land can be covered for irrigation by this method.
7. This system is useful for controlling frost during freezing temperature.

Disadvantages

1. The installation and maintenance cost are very high.
2. High wind velocity influenced the distribution pattern of water.
3. It is not suitable if water contain appreciable amount of dissolved salts.
4. Skilled labours are required for operation and maintenance of this system.

5. It is not useful in case of tall growing crops with more spacing.

Fig.1.11a: View of sprinkler or overhead irrigation system

Fig.1.11b: View of sprinkler or overhead irrigation system

Fig.1.11c: View of sprinkler or overhead irrigation system

Fig.1.11d: View of sprinkler or overhead irrigation system

***Fig.*1.11: View of sprinkler or overhead irrigation system**

D. Drip irrigation system:

It is also known as trickle irrigation or micro irrigation which supplies water in the form of discrete, continuous drops at slow rate through emitters, either onto the soil surface or directly on to the root zone. There is direct and continuous wetting of the root region. One can also apply fertilizers and chemicals amendments through this method. It is highly water use efficient system having very less irrigation water requirement thus suitable in water scarce areas. It saves 40-60 % of water over the other conventional method.

Components of drip irrigation system

Head control unit: Based on the system requirement, it consists of the following equipment:

1. **Pump**: It provided pressure to lift water from source and distribute it through the nozzles.

2. **Fertilizer tank**: It is used when fertilizers are applied along with irrigation.
3. **Filter**: It cleans the water by removing its suspended impurities.
4. **Main line and Sub line:** These are flexible black Polyvinyl Chloride (PVC) pipes for distribution of water to laterals from the water source.
5. **Lateral lines**: These are 1 to 1.25 cm diameter black flexible PVC tubes taking off from the mains or sub mains. Laterals normally lie parallel to each other.
6. **Emitter or drippers**: It is the most important component in the drip system and regulates the discharge rate of water. These are fixed at regular intervals in the laterals.

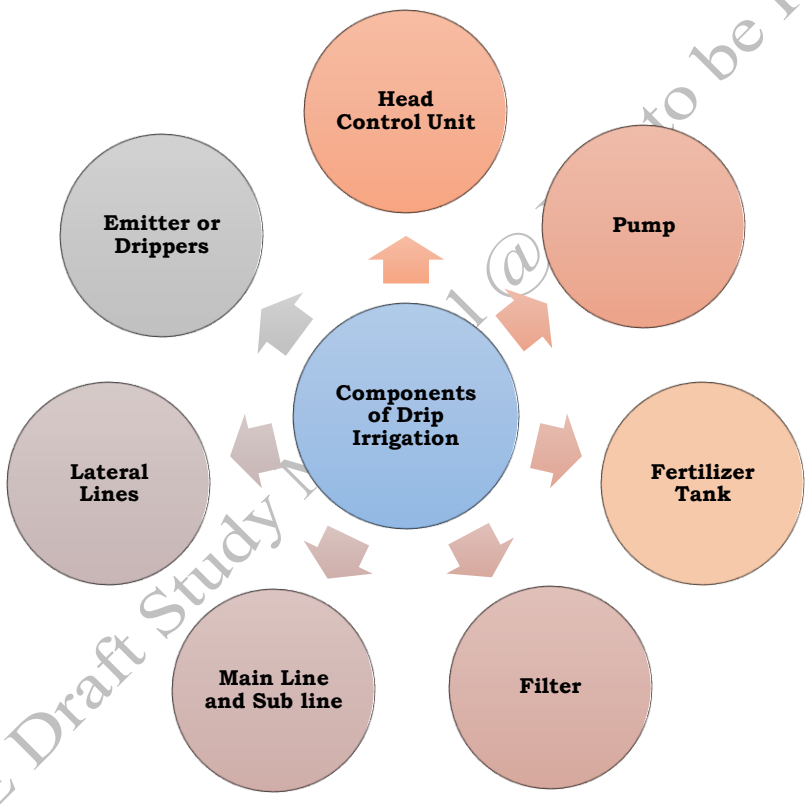

***Fig.*1.12: Components of Drip Irrigation System**

Advantages

1. It is highly efficient system with 80 to 90 % water use efficiency.
2. It saves water up to 40 to 60%.
3. This system also facilitates the supply of liquid fertilizers directly to the root zone.
4. It increases the plant yield up to 10-25%.

5. It minimizes the problem of weeds and cost of labour.
6. It is ideal for undulated land or slopes, and especially on hills.

Disadvantages

1. The installation cost is very high.
2. It needs regular care and maintenance.
3. Technical skill is essential to maintain and operate it.
4. It is not suitable where water or subsoil contains appreciable amount of salt.

Fertigation: It is the process of direct application of water-soluble solid fertilizer or liquid fertilizers with irrigation water.

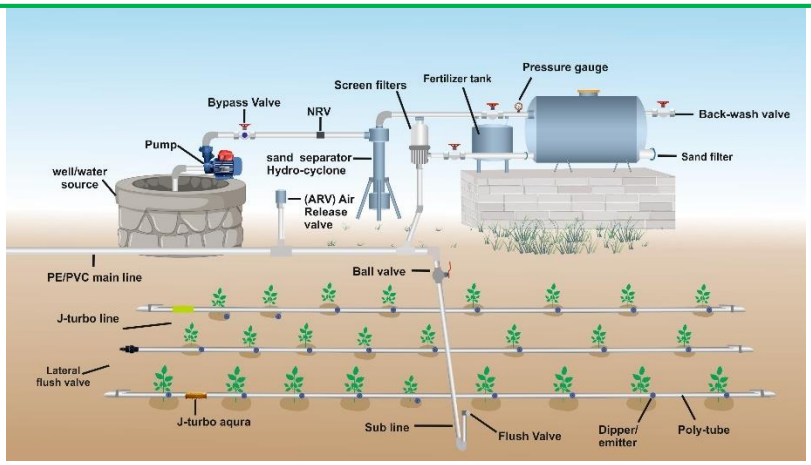

***Fig.* 1.13: Component and layout of drip irrigation system**

Recommended irrigation practices are:

1. Under conditions of adequate irrigation facilities, four irrigations, one each at sowing, branching, flowering and pod development are adequate for optimum yield during winter and summer seasons

2. If irrigation water is limiting, a pre sowing irrigation followed by another irrigation at flowering can result in near optimum yield of winter and summer crops

3. Scheduling irrigation at 50 per cent DASM during flowering and pod formation and at 75 per cent DASM during other stages could be as effective as the above, at times of deficit water supplies

4. There may not be any necessity for irrigating these crops during rainy season unless prolonged dry spells occur during the critical stages for soil moisture stress.

5. Other pulse crops like cowpea, kidney bean and lentil are of little importance as irrigated crops. The principle of irrigating these crops is same as that for green gram and black gram.

Activities

Material required-Pen, pencil, notebook etc.

Procedure:

Discuss the following with the farmer -

1. Observe and note down different components of drip irrigation system.
2. Discuss with the farmers about care and maintenance of drip system.
3. Discuss with the farmers about fertigation through drip system.
4. Note down your observations and present them before class.

Check Your Progress

Fill in the Blanks

1. The artificial application of water to the soil in order to maintain proper soil moisture regime for plant growth is known as.....
2. pH of irrigation water ranges in between.....
3. ..... is a measure of relative proportion of sodium (Na+) to calcium (Ca+2) and magnesium (Mg+2) in water.
4. .....is the most common element found in toxic concentrations in water.
5. Water with pressure is forced through revolving nozzles is ..... system of irrigation.

Multiple Choice Questions

1. Drip irrigation system is known as _____.

   (a) Trickle irrigation

   (b) Micro irrigation

   (c) Both (a) and (b)

   (d) None of the above

2. Surface Irrigation Systems are _____.

(a) Flood Irrigation method

(b) Check basin method

(c) Furrow irrigation method

(d) All of the above

3. Which of the following statement/s is/are true about the sprinkler system of irrigation?

(a) It saves water up to 30–35 per cent.

(b) It is useful in irrigating undulated lands.

(c) Both (a) and (b)

(d) None of the above

4. Which method of irrigation supplies water in the form of discrete, continuous drops at slow rate through emitters, either onto the soil surface or directly on to the root zone?

(a) Drip irrigation method

(b) Sprinkler irrigation method

(c) Furrow irrigation method

(d) Check basin method

Match the Columns

A	**B**
1) Surface irrigation method	a) Indicator of total dissolved salts in water
2) Sub-surface irrigation	b) Saves water up to 40 to 60%
3) Water salinity	c) Upward movement capillaries
4) Climatological approach d)	d) Gravity irrigation method
5) Sprinkler irrigation	e) Overhead irrigation
6) Drip irrigation	f) IW/CPE ratio method

Subjective Questions

1. Why is irrigation important for plant life?
2. What are the different methods of irrigation? Describe drip irrigation system.
3. Give the merits and demerits of sprinkler irrigation system.
4. Describe furrow irrigation method.

Module 2
Weed Management in Pulse Crops

Module Overview

To ensure food security to the ever-growing population, that is going to be more than 9 billion by 2050, it is now necessary to increase the global food production by 70 percent. In view of multiple challenges faced by the agriculture majorly due to climate change, the efforts are to be made to minimize the economic losses that occur due to biotic and abiotic factors. Among various biotic stresses, weeds are considered as most notorious causing huge yield losses to agricultural crops. Weeds are known to cause direct yield losses by suppressing crops' growth and development, and competing with crops for space, sunlight, water and nutrients. Weeds harbour insect, pests and diseases causing pathogens which leads to huge economic losses. They also destroy native habitats of weedy and wild relatives of the crops posing serious threat to losses of biodiversity. A number of factors like rainfall pattern, weed emergence time, weed density, types of weeds and architecture of crop plants affects yield in all the crops.

Learning Outcomes

After completing this module, you will be able to:

- Identify common weeds affecting pulse crops and understand their impact on crop growth and productivity.
- Demonstrate the integrated weed management strategies in pulse crops

Module Structure

- Session 1: Identify Common Weeds of Pulse Crops
- Session 2: Integrated Weed Management in Pulse Crops

Importance of Weed Management

The yield losses, due to weeds, vary from five to 100 percent with an average of 34 percent depending upon season and crops. India is the largest producer and

consumer of pulses. Weeds can cause yield losses ranging from 30% in gram, lentil, pea, pigeon pea, and so on, to more than 50% in Mung bean, urd bean, cowpea, etc. If the weeds are not removed or managed properly, they can cause 100 percent yield losses in rainy season crops like Mung bean, urd bean, cowpea, pigeon pea, maize, sorghum, sesame, etc.

Countries like India, where farm size is small or medium, farmers remove weeds manually, which is labour intensive. The practice of removal of weeds manually has become unaffordable for small farmers due to the increasing wages and unavailability of farm labour due to migration from rural to urban.

The farmers are aware of the crop weeds since time immemorial. All unwanted plants, other than the targeted crops plants, are categorized as weed. The weeds and its wild relatives are useful resources for crop improvement programs. Most of the todays cultivated species back traces their evolution from their weedy and wild relatives.

Weedy and its wild relatives of crops are rich reservoir of useful genes. The researchers are utilizing these wild and weedy relatives of the crops in developing new varieties. There are more than 30,000 weed species and out of these about 18,000 species damage crops.

Researchers considered that many weeds principally originated from two important and major arbitrarily defined groups. The term “weed” was coined and used in 1931 by Jethro Tull for the first time in his book “Horse Hoeing Husbandry”. For his thoughts, Jethro Tull has been recognized as “Father of Weed Science”.

Session: 1 Identify Common Weeds of Pulse Crops

Weeds

Weeds are undesirable and unwanted plants growing with any crop in the same place and at the same time. Jethro Tull defined weed as “a plant growing where it is not desired”. These are naturally growing plants with the crops known to cause yield losses. Researchers had recognized the importance of weed species

very well. It is also a fact that all weed species are unwanted but all unwanted plant species may not be necessarily weeds.

Characteristics of weeds: Weed plant species have peculiar characteristics those helped them to survive for years. Some of these characteristics are as follows:

i. **Seed production in abundance:** The weed plants are known to produce a large number of seeds. For example, Chenopodium sp. can produce 72,000 seeds per plant.

ii. **Morphological similarities:** Many weed species have similarity with crop plants hence they grow with main crops and maintain their life cycle. For example, plants of *Phalaris minor* are very similar to wheat plants and plants of *Echinochloa* species resembles with rice plants. *Phalaris minor* and *Echinochloa* are also known as mimicry weeds of wheat and rice crop, respectively.

iii. **Deep root system:** Weed plants have deep to very deep root system to extract soil moisture from deeper strata of the soil. For example, *Convolvulus* sp. has deep roots (20 feet approx.), and *Cyperus rotundus* has deep root (5-7 feet).

iv. **Vegetative propagation:** Many weed species propagate through rhizome, bulbs, tubers, stolen, suckers etc., hence these survive for many years.

v. **Seed dormancy**: Seeds of weed species have dormancy due to which, under adverse condition, they will remain viable for longer period. For example, seeds of Chenopodium species and *Phalaris minor* can remain dormant up to 20-25 years and 4-5 years respectively.

vi. **Competitiveness and aggressiveness**: Weed plants grow very fast in comparison to crop plants. Weed plants compete well for moisture, nutrients and sunlight with crops and attain higher canopy area leading to suppressed growth and development of crop plants.

vii. **Invasiveness:** Weed species have capacity to grow well in the area where they were not native. This peculiar characteristic is known as invasiveness. The invasive weed species adapt very fast in new areas and affect native biodiversity, causing huge economic losses. For example, *Lantana camera* is an invasive weed species that pose threat to many other native species.

viii. **Early seed setting and early maturity:** Besides various disadvantages weed also have some importance for various purposes and these are as follows:

Importance	**Species**
Maintain soil fertility	• *Convolvulus arvens* • *Typha spp.* (adds 1 to 35 per cent nitrogen)
Controls soil erosion	• *Cynodon dactylon*
Fodder use	• *Cichorium intybus*
Medicinal value	• *Argemone maxicana* is used in skin disease • *Striga spp.* is used in diabetes • *Phyllanthus niruri* is used in Jaundice • *Leucas aspera* is used in snake bite
Economic importance	• Roots of *Cichorium intybus* is used in adding flavour to coffee • *Cyperus rotundus* is used in making Agarbatti • *Saccharum spontaneum* is used in roof making
Ornamental plants	• *Lantana camara* • *Eichhornia crassipes*
Maintains pH	• *Rumex acetocella* is used for making acidic soil to alkaline • *Argemone maxicana* is used for making

	alkaline soil to acidic
Used in cleaningwater	• *Eichhornia crassipes*
Adds organic matterto soil	• *Amaranthus viridis* • *Convolvulus arvensis*
Used as vegetables	• *Chenopodium album* • *Amaranthus viridis*
Religious purpose	• *Cynodon dactylon*
Useful for cottage industries	• *Saccharum spontaneum* • *Typha spp.*
Donating genes to crop plants (cropbreeding)	• *Saccharum spontaneum* (used in sugarcane)
Used as nematicides	• *Crotolaria* • *Parthenium*

Fig.2.1: *Parthenium hysterophorus*

Fig.2.2: *Celosia sp.*

Fig.2.3: *Gomphrina celosides*

Fig.2.4: *Argemone mexicana*

Fig.2.5: *Chenopodium sp.*

Fig.2.6: *Anagellis arvensis*

Fig.2.7: Cyperus rotundus

Fig.2.8: *Cynodon dactylon*

Classification of weeds

Researchers divide weeds into various types based on:

A. Life cycle
B. Parasitic nature
C. Morphology
D. Another basis

A. On the basis of life cycle

The weeds classified under this group are on the basis of their lifespan and can be further be divided into following:

a. Annual Weeds: Weeds that complete their life cycle in one season, i.e. in kharif or rabi season, are known as annual weeds.

- **Kharif Weeds**: *Eleusine*, *Echinochloa* sp.
- **Rabi Weeds**: *Argemone Mexicana*, *Phalaris minor*

b. Biennial Weeds: Weeds that complete their life cycle within 2 years are known as biennial weeds. For example, Dacus carota, Cirsium vulgare etc.

c. Perennial Weeds: Weeds that complete their life cycle in more than 2 years are known as perennial weeds. For example, *Cyperus rotundus*, *convolvulus arvensis* etc.

B. On the basis of parasitic nature

Parasitic weeds are the weeds that are very dependent on their host plant for the completion of their lifecycle. They are of following types:

a. Semi root parasite: These types of weeds have chlorophyll and can synthesize their own organic food but they fulfil their mineral and water requirements from their host plants by attacking on their roots. For example, *Striga sp.* in sorghum and sugarcane.

b. Semi stem parasite: These types of weeds have chlorophyll and can synthesize their organic food themselves but they fulfil their mineral and water requirements from their host plants by attacking on their stem. For example, *Loranthus sp.* in mango.

c. **Total root parasite:** These types of weeds are very dependent on the roots of the host plant. For example, *Orobanchae sp.*

d. **Total stem parasite:** These types of weeds are very dependent on the stem of the host plant. For example, *Cuscuta sp.* in lucerne.

C. On the basis of morphology

Based on their morphological parameters, weeds are divided into following groups:

a. **Grasses:** These types of weeds are monocot. Grassy weeds belong to family Poaceae that have narrow leaves with ligules and auricles with cylindrical stems.

b. **Sedges:** These types of weeds are also monocot. Sedges belong to family Cyperaceae that have narrow leaves with no ligules and auricles with triangular stem.

c. **Broad-leaved weeds:** These types of weeds are dicot. Broad-leaved weeds belong to family Asteraceae that have broad leaves with no ligulesand auricles with circular stem.

D. On another basis

Based on the other factors, the following weeds come under this group:

Relative weed	Occurrence of other crop in the main crop (rice plants in wheat crop)
Absolute weeds	Proper weed species found with crops
Rogue weeds	Plants of other variety of the same crop in the field
Facultative weed	Weeds found in crop field as well as in uncultivated or wild land
Obligate weeds	Weeds found only in the cropped land
Aquatic weed	The weeds found in the water e.g. *Eichhornia crassipes*
Noxious weed	Problematic weed which destroys whole crop e.g. *Parthenium hysterophus*
Exotic weed	The weeds which were introduced from foreign countries e.g. *Lantana camera*

Activities

Collection and identification of weeds in pulse crops and preparing a herbarium.

Material required- Pen, pencil, notebook, tape, scissor, blotting paper, herbarium file.

Procedure

- Visit a nearby field where pulse crop is growing.
- Identify weeds in the crop and collect specimen.
- Write the name of the crop field from where weed species was collected.
- Dry and press the specimen in blotting paper.
- Paste the dried and pressed weed on the herbarium sheet.
- Write common name, botanical name and family in the herbarium file.

Check Your Progress

Fill in the blanks

1. ……. is a plant grown where not desired.
2. The Chenopodium sp. can produce ……. seeds/plant.
3. The example of aquatic weed is……
4. Weeds which destroy whole crop are known as……
5. The weeds have……. ….. root system.

Multiple choice questions

1. The seeds of *Phalaris minor* can be dormant up to……. .
   (a) 1 year
   (b) 2 years
   (c) 3 years
   (d) 4-5 years
2. ……weeds are used for controlling soil erosion.
   (a) *Cynodon dactylon*
   (b) *Phalaris minor*

(c) *Cyperus rotundus*

(d) *Convolvulus arvensis*

3. Total root parasitic weed is……

(a) *Striga sp.*

(b) *Loranthus sp.*

(c) *Orobanchae sp.*

(d) *Cuscuta sp.*

4. The weeds found in water is called… weeds.

(a) Aquatic

(b) Annual

(c) Parasitic

(d) Broad leaved weeds

5. ……weed is used as ornamental plants.

(a) *Saccharum spontaneum*

(b) *Lantana camara*

(c) *Eichhornia crassipes*

(d) Both b and c

Match the following

	A		**B**
1)	Total stem parasitic weed	a)	Cynodon dactylon
2)	Facultative weed	b)	*Cuscuta sp.*
3)	Exotic weed c)	c)	*Lantana camera*
4)	Religious purpose d)	d)	In cropped and wild lands

Subjective questions

1. What are weeds and their characteristics?
2. Write importance of weeds
3. Describe classification of weeds.

Session 2: Integrated Weed Management in Pulse Crops

Integrated Weed Management

Weeds compete with the crop for natural resources thereby reducing their Agri-inputs that leads to poor crops yield. Thus, the use of herbicides is considering as good strategy to control weeds as manual weed removal is becoming more and more expansive. However, the indiscriminate use of herbicides/weedicides, to control seasonal crop weeds, leads to soil deterioration and herbicidal resistance (i.e., no effect on weeds after herbicide spray). There is a growing concern about soil and water pollution due to high dose of the herbicides and also at the same time, there is fear that super weed may evolve in case low doses of the herbicides are applied to control weed menace. Hence, considering the economic returns and judicious use of various weed control techniques, researchers developed Integrated Weed Management (IWM) strategies for different crops. Integrated Weed Management (IWM) is an approach to manage weeds in the sustainable manner by integrating cultural practices, mechanical, physical, chemical and biological methods that lead to control of weed population, without deteriorating the health of crop, soil, water bodies and environment.

Concepts of Integrated Weed Management

1. **Weed prevention**: It means practicing techniques that restricts the entry of weeds into the cropped lands from infested area.
2. **Weed eradication**: It means complete removal of weeds from an area.
3. **Weed control**: It is an old concept that focuses on practicing methods of reducing weed population so that crops can be grown profitability with short-term goals.
4. **Weed management**: It means to maintain weed population below the level they can harm the crop and is eco-friendly.

5. **Integrated weed management**: It is the use of combination of weed control methods in a holistic manner.

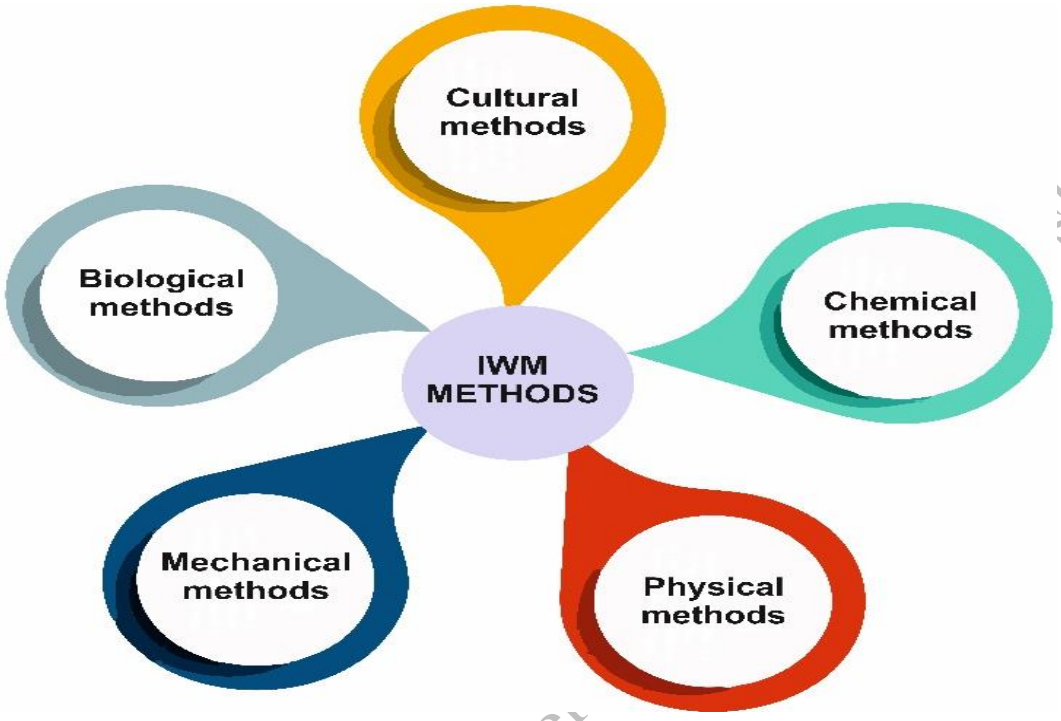

Fig.2.9: Methods of Integrated Weed Management (IWM)

Methods of Integrated Weed Management (IWM)

1. **Cultural methods**: The cultural methods of weed control include proper tillage operations, planting methods, fertilizer application, irrigation techniques, crop rotations, intercropping systems etc., which ensure good growth of the crop so that the crop can fight against the weeds by themselves.
2. **Mechanical methods**: The mechanical method of weed control include the use of machines, like power weeder, kono weeder etc., for removal of weeds from the crops.
3. **Physical methods**: The physical methods of weed control include removal of weeds by the labours from the crops at an appropriate stage.
4. **Chemical methods**: The chemical methods of weed control use chemicals like herbicides/weedicides to kill weeds. For the purpose of

managing weed losses and the control of weeds in diverse crops, a sizable number of herbicides have been developed and recommended. Some of the most popular herbicides are Glyphosate, Pendimethalin, Imazethapyr, Metribuzin etc.

5. **Biological methods**: The biological methods of weed control include insects that feed on leaves of weeds thereby helping in controlling their growth. For example, *Zygogramma bicolorata* provide control of *Parthenium hysterophorus.*

Principles of Integrated Weed Management (IWM)

1. The components of integrated weed management should be eco-friendly.
2. Cultural practices, like crop rotation, should be used for the control of biennial and perennial weeds.
3. The management practices should be feasible, economical and sustainable.
4. The control methods should be directed to reduce the survival mechanism of weeds.
5. IWM practices should lead to competitive advantage of crops over weeds.

Advantages of Integrated Weed Management (IWM)

1. It is suitable for preventing annual, biennial and perennial weeds.
2. It is environmentally friendly.
3. It prevents development of herbicidal resistance (no effect on weeds after herbicide spray) and evolution of super weed.
4. It gives more profit over use of single method of weed control.
5. It leads to sustainable crop production without deteriorating soil and environmental health.

Necessary precautions during the application of weedicides

1. The quality of herbicides should be checked before purchase.
2. Weedicides should be sprayed under proper technical guidance.
3. Right time, right quantity and right herbicide should be used for weedicides application.

4. Dissolve appropriate quantity of weedicides in water to get the proper concentration.
5. Weedicides should be sprayed in the morning and evening hours to avoid evaporation and can be absorbed easily.
6. It should be kept away from eatables and animals.
7. Wash the sprayer with soap and detergent after spraying.
8. The instructions written on the herbicide packet should be followed.
9. One should not taste, touch and smell the chemical.
10. The weedicides should be kept away from children.
11. Use gloves and mask during application of herbicide

Activities

Demonstrate the Integrated Weed Management of pulse crops.

Material required- Pen, pencil, notebook etc.

Procedure:

1. Visit the nearby field of pulse crops.
2. Observe and note down the following observations given below.
   a. Name of the crop
   b. Sowing time
   c. Weeding schedule
   d. Growing of inter crops, if any
   e. Tools and equipment's used for weed management
   f. Name of the chemicals used for weed control
   g. Any other information such as cultural, mechanical and biological methods of weed control adopted/used.

Check Your Progress

Fill in the Blanks

1. .....is an approach to manage weeds in the sustainable way.
2. ..... means complete removal of weeds from an area.
3. Machines like..... are used for removal of weeds in the crops.

4. The insects which feed on leaves of weeds are used for……. control.

5. Right ……., right……..and right……..should be used for weedicides application.

Multiple Choice Questions

1. The Integrated weed management approach uses……. methods.

   (a) Cultural, Chemical

   (b) Mechanical

   (c) Biological

   (d) All

2. Cultural methods are

   (a) Fertilizer use

   (b) Glyphosate use

   (c) *Zygogramma sp.* use

   (d) Power weeder use

3. The management practices should be

   (a) Feasible

   (b) Not eco-friendly

   (c) Not economical

   (d) Disturbs soil

4. Dissolve appropriate quantity of weedicides in to get the proper concentration.

   (a) Oil

   (b) Water

   (c) Any liquid

   (d) None

5. means practicing techniques which leads to stopping of entry of weeds into the cropped lands from infested area.

   (a) Weed control

   (b) Weed eradication

   (c) Weed prevention

(d) Weed management

Match the Following

	A		B
1)	Weed control of weeds	a)	Before entry destroying
2)	Weed management	b)	Complete removal
3)	Weed eradication	c)	To make crop profitable
4)	Weed prevention	d)	To keep weed population below destroying level

Subjective Questions

1. What is Integrated Weed Management? Describe in detail.

2. Define Integrated Weed Management and their components.

3. What are weedicides? What are the precautions one must consider while using them?

Module 3
Integrated Insect-Pest and Disease Management in Pulse Crops

Module Overview

Pulse crops are more susceptible to different types of insect-pests and diseases. The yield loss of pulses crop incurs due to various insect-pests and diseases. Insect-pests and diseases are interlinked and complement each other. Individually, each one of these is responsible for a considerable loss by itself but if one remains neglected, it gives rise to the infestation of the other. Some insects secrete a sugary substance that act as a medium for fungi development.

Pesticides are synthetic compounds that kill insects-pests in crops. They are hazardous for the environment and for non-target insects too. Indiscriminate use and improper application of pesticides create ecological imbalances due to the destruction of beneficial insects and the emergence of pesticide resistant pulses and strains. In the past, a single approach to control pests and diseases was in practice, which was neither economical nor safe. Therefore, a systematic approach of Integrated Pest or Disease Management (IPM or IDM) was adopted.

Learning Outcomes

After completing this module, you will be able to:

- Identify major insect pests of pulse crops and understand the management strategies for controlling these pests.
- Identify diseases symptoms of pulse crops

Module Structure

- Session 1: Identify Major Insect-Pest of Pulse Crops and Their Management Strategies
- Session 2: Identify Diseases of Pulse Crops and Their Control Measures

Session 1: Identify Major Insect-Pest of Pulse Crops and their Management Strategies

The grain legumes, being rich source of protein, are damaged by several insect species throughout the crop growth period in field as well as during the storage. The pests, which were earlier recognised as minor pests with lesser economic significance, are attaining a status of major pests in many pulses. An because of this, pulse productivity has been severely threatened by increasing difficulties in managing these emerging pests. More than 200 species of insects live and feed on pigeon pea, though relatively few causes heavy yield losses. The few serious pests however, can be devastating. Most of the pests have a sporadic or restricted distribution, or are seldom present at high densities to cause the economic loss. Pests that feed on reproductive structures, flower and pods causes the greatest harm. Foliar damage rarely reduces seed yield. Let us now look some of the major insects and their management.

Major Insect-Pest of Pulse Crops

1. Pod Borer (*Helicoverpa armigera*):

Fig. 3.1: **Larvae of Pod borer**

Pod borer is one of the major polyphagous pests distributed throughout the country and causes devastating yield loss. The adult moths have yellowish to orange forewings in females and greenish grey in males, with a lightly darker transverse band in the distal third. Females lay several hundred eggs on all parts of plant, but prefer young shoots and florets. On hatching, the larvae feed for a short time on the tender leaflets by scrapping green tissue and then shift to flower buds and tender shoots. Larval and pupal periods last for 17-23 and 9-11 days, respectively in normal conditions. The colour of the larvae varies from yellow to green, pink, orange, brown or black but all have characteristic light and dark stripes along each side.

The larva slowly enters and feeds on the seeds inside the pods. The half portion of larvae remains inside pod while feeding on the developing seeds. They can cut hole on one to another locule and feed 20-25 pods in its lifetime.

Management strategies:

- Summer ploughing to expose the hidden stages of the pest to natural predation.

- Installations of different type of traps (light, sticky, pheromone) 3-4 traps/acre and release of parasitoids. For example, *Bracon Hebetor*.
- Manual shaking of pigeon pea plants to dislodge larvae and destruction.
- Fixing of bird perches with branched tree twigs to attract predatory birds for insect predation. Application of 5% Neem fruit/seed extract at flower initiation.
- Application of HaNPV @ 500 LE ha^{-1} at peak oviposition phase and repetition of the same after 15-20 days in case of fresh oviposition.
- Spraying of insecticides like Thiodicarb 75 WP 0.6 g or Profenophas 50 EC 2 ml or Methomyl 40 SP 0.6 gL^{-1} of water Indoxacarb 14.5 SC % @ 300 ml/ha or Emamectin Benzoate 5% SG @ 11 a.i g/ha or Spinosad 45 SC @ 56-73 a.i g/ha is effective against pod borer complex.

2. Spotted Pod Borer (*Maruca vitrata*): This is a major pest of pigeon pea and other grain legumes in many areas of central and south India. The larvae cause extensive damage to floral buds and flowers. The immature larvae are dull to yellow-white in colour and a length of 18 mm. Each segment has dark spots that form a distinct series along the length of the body. This pattern is visible on the upper surface. The larval head is dark brown to black in colour. The adult moth has three white spotted brown forewings and greyish white hind wing with distal brown markings. The female lay eggs singly in the sepals or petals of the flower or buds or on the pods. The caterpillar, upon hatching, feeds on the tender leaves, flower buds and developing seeds in the pods for about 3 weeks. Thereafter, it emerges from the pod during night, crawls to descend to the soil, and pupates beneath leaf debris.

Fig. 3.2: **Larva and adult moth of Spotted pod borer**

They damage flowers causing discoloration and shedding. Damaged pods have small-darkened entry holes on the surface and borers inside. Many a time, leaves and pods are stuck together by webbing with signs of surface feeding.

Management strategies:

- Mixing of fumigant insecticide such as DDVP @ 0.5 ml/l is required to make the larvae come out from the web.

- Application of Neem seed powder and Neem kernel extract 5 % and Spinosad 45% SC @ 73 g a.i/ha or Indoxacarb 14.5 EC @ 0.4 ml/lt.

3. Pigeon Pea Pod Fly (*Melanogromyza obtusa*): Pigeon pea Pod Fly is a common pest in India that has a substantial negative economic impact, particularly in the northern regions, especially on long-lasting cultivars.

Fig. 3.3: **Symptom of Pigeon pea Pod Fly**

The small black fly lays eggs through the wall of the developing pod and the white legless larva, of 3 mm long in size, feeds on the inside of the green seed. Generally, only one maggot develops in one seed. The brown puparium is formed inside the pod but outside the seed. One generation takes about 3 weeks under optimum conditions. Partially matured pods are preferred for egg laying than the tender or fully matured pods. A single fly lays 80-100 eggs that incubate for 3 days and hatching maggot bores into the pod and feeds on developing seed.

Management strategies:

- When two adult fly appears then spray Deltamethrin 1 EC + Triazophos35 EC @ 252 g a.i./ha, or Thiaclopride 21.7 SC @ 151 g a.i./ha and Profenophos 50 EC @ 350 g a.i. /ha or Spraying of Quinalphos 25% EC is effective against pod fly and pod borer.

4. Pod Sucking Bugs: The most common pod-sucking bugs include Coreid bug (*Anoplocnemis* species), Spiny brown bug (*Clavigralla species*), Riptortus bug (*Riptortus* species) and green stink bug (*Nezara viridula*). These bugs suck the sap from developing seeds through the pod wall, making them shrivelled with dark patches that are often associated with saprophytic fungi. Attacked seeds do not germinate and are not acceptable as food.

a. Coreid Bug (*Anoplocnemis curvipes*): Adult is about 2.5 cm long and causing damage similar to that of *Clavigralla species*. Males have a single large spine on each hind leg, which is lacking in females. Newly hatched nymphs are bright red in colour, which gradually turn to black.

b. **Spiny Brown Bug (*Clavigralla gibbosas* pinola)**: Spiny brown bug are widely distributed. They attack a wide range of leguminous plants. The external symptoms of the damage are tiny depressions on the pod walls and seed coat. Affected seeds lose viability, shrivel and rot. Adults are stout, about 10 mm long, furry and brown, having a pair of elongated

spines projecting interiorly on pro-thorax. A single female may lay about 250 eggs. Nymphs are sluggish and form colonies on pods and peduncles.

c. **Riptortus Bug (*Riptortus dentipes* F):** Damage is similar to pod bugs. Adult bugs are slender and about 20 mm long. They are light brown with white or yellow lines on the lateral sides of the body. Adults lay eggs in small groups on leaves and tender pods of pigeon pea.

d. **Green Stink Bug (*Nezara viridula*)**: The green stink bug has piercing-sucking mouthparts consisting of a long beaklike structure called the rostrum. Green stink bug affects all parts of plant; however, they mostly prefer growing shoots and developing pods. The shoots, with which they are attached, usually wither or in extreme cases may die. The damage from the punctures is dark brownish or black spots. Pod growth is retarded, leading to withering and dropping from the plant.

Management strategies of sucking bugs:

- Application of insecticides i.e., as Acephate @ 1.0 g/l or dimethoate 1.7 ml/l or Monocrotophos 1.0 ml/l are most effective in controlling the bug.
- Grow resistant and tolerant varieties

5. Defoliators: A number of polyphagous defoliators are reported on pigeon pea crop. Larvae of insects like *Amsacta spp. Spilosoma obliqua, Chrysodeixis orichalcea* and *Euproctis spp.* feed on the leaves, flowers and enter pods and cause defoliation and shedding of pods. The damage caused is obvious on pigeon pea, where the larvae feed upon leaves and inflorescence. The *Amsacta spp*. and *S. obliqua* are commonly known as 'hairy caterpillars' for they are densely covered with long hair. The hair of these and other caterpillars cause skin rashes and irritation, so one must take care while handling them.

Management strategies:

- Population of these larvae on pigeon pea is seldom large enough to use pesticide. However, there are occasional reports of severe defoliation, particularly by *Amsacta spp*.
- Application of Spinosad 45% SC @ 73 g a.i/ha or Indoxacarb 14.5 EC @ 0.4 ml/lt.
- Alternate application of neem based eco-friendly botanicals for effective management

Beetles

Blister Beetles: *Mylabris pustulata* Thunberg and *M. Phalerata* Pall

Fig. 3.4: **Blister beetles**

These beetles are found to occur throughout the year in pigeon pea, cowpea, green gram and black gram. Peak incidence is generally observed during September, causing a maximum (95 per cent) flower damage.

Adults blister beetles feed on the flowers, tender pods and young leaves resulting in fewer pods. In locations where pigeon pea is grown in small plots and are in the flowering stage during the period of peak adult activity (August-October in southern India), most of the flowers may be eaten by the beetles and crop losses may be substantial. The adults are medium to large (2.5 cm in length), usually black with large yellow spots and a red band across the abdomen, which sometimes changes into yellow spots. The immature stages (larvae) do not feed on plants. They live in the soil and eat grasshopper eggs, and are therefore beneficial.

Management strategies:

- One can manually pick them or collect them with an insect net and crush them since they are slow moving but care should be taken to protect the skin.
- Most insecticides are not very effective against these beetles, but synthetic pyrethroids such as Cypermethrin 10 EC @ 1.0 ml/l or Lambda cyhalothrin 5 EC @ 1.0 ml/l work reasonably well.

Other minor pests

- **Leaf webbers**: *Grapholita critica* Meyr.
- **Eriyophid mite:** *Aceria cajani* Channabasavanna,
- **Aphids:** *Aphis craccivora* Koch, *Myzus persicae* Sulzer
- **Scale insect:** *Ceroplastodes cajani* Maskell,
- **Ash weevil:** *Myllocerus undecimpustulatus* Faust,
- **Thrips:** *Megalurothrips usitatus* (Bagnall)
- **Termites**: *Odontotermes spp.* And *Microtermes spp.*

- **Ash weevil:** *Myllocerus undecimpustulatus* Faust, *Nematocerus spp, Phyllobius* spp and *Systates* spp

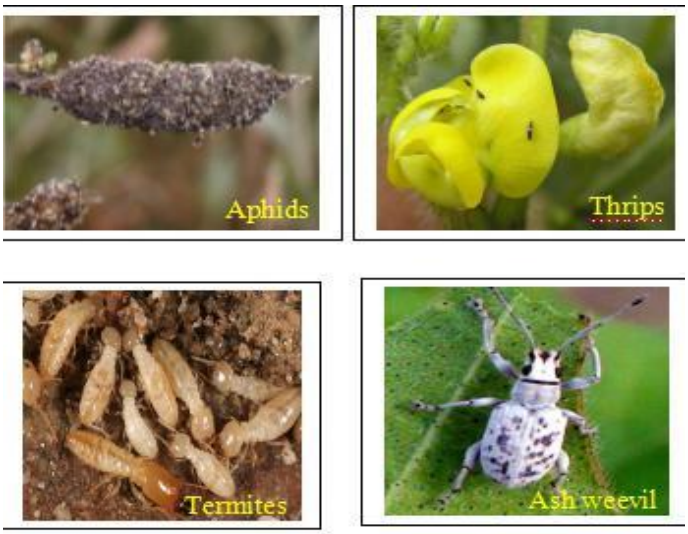

Fig. 3.5: **Minor pests**

Management strategies of minor pests:

- Although leaf webber make young pigeon pea crop look untidy, they apparently cause no yield loss. The plants produce side shoots to compensate for the loss of terminal buds. If insecticides are not used, the build-up of many parasites and predators brings this pest under control. The larvae inside the webs are well protected from coming in contact with the insecticides. However, systemic insecticides, such as Monocrotophos 36 SL @ 1.0 ml/l + Dichlorvos 76 EC for fumigant action @ 0.5 ml/l, can be applied.
- To prevent mite, Dimethoate 30 EC @ 1.7 ml/l, and Acaricides such as Dicofol 18.5 EC @ 2.5 ml/l, help control these mites effectively.
- Aphid colonies on pigeon pea seldom thrive for long, probably because of the natural enemy activity. Systemic insecticides, including Dimethoate 30 EC @ 1.7 ml/l adequately control aphids.
- Thrips on pigeon pea is generally not large enough to cause substantial yield however a spray of Monocrotophos 36 SL @ 1.0 ml/l or Dimethoate 30 EC @ 1.7 ml/l used to control pests effectively.
- Blue Butterflies are common and lay many eggs on the pigeon pea plants, relatively few larvae are found on the crop, probably because natural enemies reduce their numbers. Specific control for these insects is rarely required other pesticides that control major pests can be used.

- Termites form large mounds that hinder cultivation. Thus, their nests can be poisoned by drenching them with solutions of Chloropyriphos 25 EC. In general, however, with adequate cultivation and rapid growth of healthy plants, termite damage seldom results in crop loss.

Activities

Identify the major insect pest of pulses crop.

Material required: Insect net, collection box, Pen, pencil and notebook etc.

Procedure:

Visit a nearby farmers field and note down the following information.

a. Crop grown in the field

b. Stage and age of crops

c. Identify the insect pest.

d. Write the control measures of the collected insect pest.

Check Your Progress

Fill in the Blanks

1. Pod borer is one of the major …….. distributed throughout the country and causes devastating yield loss.
2. Spotted pod borer, larval head is …….. in colour.
3. Application of Neem seed powder and Neem kernel extract …… percent.
4. Green stink bug has piercing-sucking mouthparts consisting of a long beaklike structure called the……

Multiple Choice Questions

1. Causative agent of pod borer is.

   (a) *Clavigralla species*

   (b) *Helicoverpa armigera*

   (c) *Maruca vitrata*

   (d) *Anoplocnemis curvipes*

2. The most common pod-sucking bugs are.

   (a) Spiny brown

   (b) Riptortus

(c) Green stink

(d) All of the above

3. A number of polyphagous defoliators are reported on crop.

(a) Pigeon pea

(b) Moong bean

(c) Pea

(d) Lentil

4. Termites form large mounds that hinder cultivation; nests can be poisoned by drenching them with solutions.

(a) Chloropyriphos 25 EC

(b) Monocrotophos 36 SL

(c) Dimethoate 30 EC

(d) None of the above

Subjective Questions

1. Write about the following insect pest and their management strategies.
   - Blister beetles
   - Pod Borer
   - Pod sucking Bugs
   - Pigeon pea Pod Fly
2. Write about the management strategies of minor pests.

Session 2: Identify Diseases of Pulse Crops and their Control measures

Pulses are the principal sources of dietary protein among the vegetarian populations, and are an integral part of daily diet in several forms worldwide. These crops grow mainly under rainfed conditions and the productivity levels are quite low because of severe losses due to several diseases at various stages of crops. Farmers and extension workers generally use chemical pesticides for managing diseases and getting higher yields. However, it is well known that injudicious use of agricultural chemicals is regarded as ecologically unacceptable as they can cause environmental pollution and pose serious health hazards to man, plants, domestic animals and wild life. Therefore, a need for renewed knowledge is require to assess the current severity of these problems

and in line to this Integrated Disease Management (IDM) modules are developed to protect crops in a cost-effective and eco-friendly manner. IDM is a multidisciplinary approach that manage diseases effectively by integration of host plant resistance; cultural, physical, and biological control; safer chemical and molecular approaches. These approaches can play a major role in reducing the losses due to the diseases under subsistence farming conditions. Since IDM comprises of many approaches, it will definitely prove to be an effective strategy for enhancing pulses production in India. In this session, we will go through the major diseases which affect chickpea, lentil, field pea, pigeon pea, Mung bean/green gram and their management through integrated ways.

Table 1: List of major diseases affect the legumes/pulse crops in India

Name of Crop	**Name of Diseases**	**Causative agents**	**Distribution**
Pigeon pea/Arhar/Tur	Phytophthora stem blight	*Phytophthora drechsleri f. sp. cajani.*	All the pigeon pea growing areas
	Wilt	*Fusarium udum* (Butler)	All the pigeon pea growing areas
	Leaf spot	*Cercospora spp.* *Alternaria spp*	All the pigeon pea growing areas
	Powdery mildew	*Erysiphe polygoni* DC	All the pigeon pea growing areas
	Sterility mosaic	Virus	Eastern and Southern part of the country
	Dry root rot	*Rhizoctonia bataticola*	All the pigeon pea growing areas
	Collar rot	*Sclerotium rolfsii*	All the pigeon pea growing areas
	Stem/white rot	*Sclerotinia sclerotiorum*	All the pigeon pea growing areas

Chickpea/ Gram	Wilt	*Fusarium oxysporum f. sp. ciceri*	All the pigeon pea growing areas
	Dry Root Rot	*Rhizoctonia bataticola*	Central and south India
	Ascochyta blight	*Ascochyta rabiei*	West Asia, northern Africa, Mediterranean region
	Stem Rot	*Sclerotinia sclerotiorum*	All the pigeon pea growing areas
	Rust	*Uromyces ciceris-arietinii (Grogn.)* Jacz. & Boy.	All the pigeon pea growing areas
	Wet Root Rot	*Rhizoctinia solani*	All the pigeon pea growing areas
	Botrytis graymold	*Botrytis cinerea*	All the pigeon pea growing areas
Lentil	Wilt	*Fusarium oxysporum f. sp. lentis*	All over the country
	Root rot	*Macrophomina phaseolina*	All over the country
	Rust	*Uromyces fabae*	All over the country
	Ascochyta blight	*Ascochyta fabae f. sp. lentis*	All the lentil growing areas
Field pea	Rust	*Uromyces fabae*	All the field pea growing areas
	Powdery mildew	*Erysiphe polygoni* DC	All over the country

	Root rot	*Rhizoctonia solani*	All over the country
	Downey mildew	*Peronospora pisi*	All over the country
	Wilt	*Fusarium pisi*	All over the country
	Pea enation mosaic	Virus	All over the country
Mung bean/Urd bean	Root rot	*Macrophomina phaseolina*	All over the country
	Leaf Spot	*Cercospora spp.*	All over the country
	Yellow mosaic disease	Yellow mosaic virus	All over the country

Major Disease of Pulse Crops

Fusarium wilt: This disease is caused by soil and seed borne fungus *Fusarium udum* Butler in pigeon pea, *Fusarium oxysporum f. sp. ciceris* in chickpea, *Fusarium oxysporum f. sp. pisi* in field pea and *Fusarium oxysporum f. sp. lentis* in lentil crops. The fungus can survive on infected plant debris in the soil. Wilt symptoms usually appear when plants are at flowering and podding stage, but sometimes occur earlier when plants are 1-2 months old. The disease results in withering and mortality of the plants.

Fig. 3.6: Symptom of Fusarium wilt

Management

Cultural:

- Field sanitation and deep summer ploughing can be followed to reduce inoculum load of Fusarium under field conditions
- Selection of resistant/tolerant varieties of:

  Pigeon pea: BDN-1, BDN-2, NPW-15, BSMR-726, BSMR-736, BSMR-853, C-11, Maruti, Asha, IPA-203, PT-012, NA-1, Amar, Azad, Malviya Arhar, IPA-206, IPA 15-02 etc.

Chickpea - Desi: JSC-55, JSC 56, GNG 2144, CSJ 515, GJG 0809, GNG 2171, Pant Gram-5, GNG 2207, Purva GNG 2299, IPC 2006-77, RVS 205, Pusa chickpea 10216, Super Annigeri 1, Phule Vikram, Jawahar Gram 24, PDKV-Kanak, Pusa chickpea 20211 & Lochan chana, RVG 210, IPC 2011-112, RKG 13-515, IPC 2004-01 etc.

Kabuli: HK-4, Vallabh kabuli chana-1, Kota kabuli chana-2, RLBGK-1, JGK-6, Pant Kabli gram-3, RVKG 121, Pant Kabuli gram-4, RKGK 13-271 etc.

Lentil: Kota Masoor 4, VL Masoor-148, LL 1373, Kota Masoor 3, L- 4729, IPL 220, L 4727, L 4717, IPL 316, Pant L 8, IPL 329, IPL 225, IPL 534 & Chhattisgarh Masoor -1 etc.

- Lighter soils were more favourable to wilt development than heavier soils.
- Intercropping or mixed cropping of chickpea with linseed/ pigeon pea with sorghum.
- Intercropping or mixed cropping of chickpea with linseed has been found to reduce the incidence of chickpea wilt considerably.
- Soil amended with decomposed *Sesbenia aculata*, mustard cake and farmyard manure.

Chemical:

- Seed treatment with fungicides (Carbendazim @ 2.5g/kg seeds) is feasible, protects the seedlings from infection, and ensures better plant stand.
- Treatment of seeds with bio-agents (*Trichoderma viride* and T. harzianum@ 10 g/kg) and fungicide (vitavax 1.0g/kg).

Biological:

- Use of different bio-control agents like Trichoderma spp. and PGPRs provide eco-friendly control of the disease management of pigeon pea wilt through antagonistic fungi.
- Seed treatment with *Gliocladium virens, Trichoderma viride/T. harzianum/T. asperellum/T. afroharzianum/Pseudomonas fluorescens* @ 6 g/kg seed + soil application @ 2.5kg/ha.
- Seed treatment with *Trichoderma asperellum and T. afroharzianum* @ 10gm/kg of seed at the time of sowing of crops.
- Soil application of *T. asperellum* @ 2.0 kg/acre and seed treatment @ 10gm/kg seed is highly effective for managing this soil borne disease.

Stem rot/white rot: The causal organisms of stem rot/white rot is *Sclerotinia sclerotiorum* (Lib.) de Bary. It has been reported in major pulses crops pigeon pea, chickpea and field pea growing state of the country. This fungus is a soil-borne that occurs at any stage of the crop. The pathogen infect stem near the soil line or approximately 6 inches above the ground, the disease is characterized by the appearance of stem discoloration and necrosis or drying branches or whole plants due to girdling of the stem above ground. The disease is scattered in the field. A fluffy, web of white mycelium is evident on the surrounding soil surface or lower stem or branches when plants are infected at the soil line and such plants frequently have small black irregular shaped sclerotia associated with external tissues or surrounding soil.

Fig. 3.7: Symptom of stem rot/white rot

Management

Cultural:

- Deep ploughing, low land with continuous stagnation of water reduces the sclerotial population.
- Remove weeds from the fields.
- Maintaining plant-to-plant and row-to-row spacing that allows better air circulation between plants, thus providing space for drying of plant canopy.
- Do not over-irrigate which will create favourable conditions for fungus and avoid application of excessive nitrogenous fertilizer that leads to dense, lush plant growth that is favorable for Sclerotinia.
- Avoid cultivating chickpea on infected field.
- Practice crop rotation by growing non-susceptible crops (onions, grasses, cereals) for 8 to 9 years, before planting susceptible crops (alfalfa, clover, bean, lettuce, potato, crucifers, celery, etc.).
- Seed cleaning is essential to remove the sclerotial mixer during threshing and processing period.

Chemical methods:

- One or two applications of thiophante methyl or carbendazim @ 0.1%

Collar rot: The disease usually occurs at seedling stage of pigeon pea and chickpea particularly in light wet sandy soil. The causal organism of collar rot is *Sclerotium rolfsii*. The disease can cause considerable loss to plant stand when soil moisture is high and temperature is warmer (30°C). The presence of undecomposed organic matter and excessive moisture during sowing time favours sclerotial germination and disease development.

A seedling disease that usually appears within a month of sowing when patches of dead seedlings at the primary leaf stage are seen scattered over the field. The seedlings may turn slightly chlorotic before they die. The confirmatory symptom is rotting in the collar region with a covering of white mycelial growth. This differentiates collar rot from other seedling diseases caused by species of Fusarium, Rhizoctonia, or Pythium. One can easily uproot seedlings affected by collar rot but the lower part of their root usually remains in the soil. Sometimes white or brown sclerotial bodies of the fungus can be found attached to the collar region of a dead seedling or in the soil around it.

Management:

Cultural:

- Deep summer ploughing, select well-drained fields.
- Collect cereal stubble from the field and destroy it before sowing pigeon pea.

Biological:

- Seed treatment with *Gliocladium virens, Trichoderma viride/T. harzianum* /Pseudomonas @ 2.5kg/ha.
- Soil application of *T. asperellum* @ 2.0 kg/acre and seed treatment @ 10gm/kg seed is highly effective for managing this disease.
- Amendment of soil with mustard cake.

Chemical:

- Seed dressing with Tolclofosmethyl (Rhizolex®), Captan, Orthiram @ 3 g kg^{-1} seed.
- Application of Carboxymethyl cellulose (CMC) @ 1gm with G. virens in combination with vitavax found better against chickpea collar rot (*S. rolfsii*) and root rot (*R. solani*).

Alternaria leaf Blight/spot: Alternaria leaf spot or Alternaria leaf blight are a group of fungal diseases which are common in pigeon pea and chickpea pulse crops. The causal organism for this disease is Alternaria tenuissima (Kunze ex Persoon) Wiltsh or Alternaria alternata (Fries) Keissler. It is an emerging disease under climate change scenario.

The symptoms are small, circular, necrotic spots on leaves that develop quickly forming typically concentric rings. The lesions appear on all aerial plant parts including flowers, flower buds and pods. They cause blighting of leaves and severe defoliation and drying of infected branches. The fungus sporulates well under warm, humid conditions.

Management:

Cultural:

- Planting resistant cultivars, and adopting effective management and compact varieties can avoid the spread of disease.
- Avoiding excessive irrigation.
- Adopting wider spacing to decrease plant density in chickpea.
- Intercropping of chickpea with linseed.
- Avoid fields close to perennial pigeon pea.

Chemical:

- As preventive, alternately spray of Mancozeb (Dithane M- 45®) @ 2.5 g L^{-1} water at 15 days intervals.
- Seed treatment with thiram 3g kg^{-1} or vinclozolin or Dithane M-45.

Cercospora leaf spot: This disease caused by *Cercospora cajani* Hennings. The disease is a problem for plants growing in humid regions. Losses are severe when defoliation occurs before flowering and podding in pigeon pea and Mung bean. They appear as small circular to irregular necrotic spots or lesions usually on older leaves. These lesions coalesce causing leaf blight and defoliation. During epidemics, lesions appear on young branches and cause their tips to dry and die. The pathogens produce a fluffy mycelial growth on their lesions.

Management:

- Field sanitation, crop rotation, destruction of infected crop debris and avoiding collateral hosts near the crop may help in reducing the disease incidence.

- Delayed sowing of Mung bean in Kharif season reduces the disease severity and allows the crop to escape from heavy rains.
- Use of disease-free seed help in reducing the seed borne inoculums of the pathogen.
- Alternate spray Mancozeb (Indofil M 45®) @ 2.5 g L-1 water if infection is epidemic
- Treat the seed with the fungicides captan or thiram (@2.5 g/kg) before sowing.
- When symptoms start appearing on the leaves, spray carbendazim (0.05%) @ 0.5 g/l or mencozeb (0.25%) @ 2.5 g/l on crop. The spray may be repeated 2-3 times after 10-15 days, if required.

Stem Canker: Stem canker is common disease in pigeon pea crops that is caused by *Xanthomonas campestris pv. cajani*. The disease usually appears in the rainy season especially during July and August. The symptoms, as seen on the lower leaves of plants that are about 1 month old, are small necrotic spots surrounded by bright yellow halos and later on, the rough and raised cankerous lesions appear on the stem. Leaf spots do not usually cause defoliation. Cankers can cause stems to break, but the broken part usually remains attached to the plant. Stems often break at the point where the primary leaves are attached. Often, the affected plants do not break and the stem cankers increase in size until they are 15-25 cm long. In cases of severe infection, the affected branches dry.

Management:

Powdery Mildew: Powdery mildew is fungal disease caused by *Oidiopsis taurica* (Lev.) Salmon in pigeon pea, *Erysiphe pisi* in field pea and *Erysiphe polygoni* in Moog bean and urd bean.

Infected plants have white powdery fungal growths on all their aerial parts, especially the leaves, flowers, and pods. Severe infections result in heavy defoliation. The disease causes stunting of young plants, followed

Fig. 3.8: Symptom of powdery mildew

by the visible symptoms of white powdery growth that appear gradually before the flowering stage. The initial symptoms develop as small chlorotic spots on the upper surface of individual leaves and subsequently the

corresponding lower surfaces develop white powdery patches. When the fungus sporulates, this white powdery growth covers the entire lower leaf surface.

Management:

Cultural:

- Late planting should be avoided the disease severity
- Collect and burn the plant debris/stubbles that left on the field after crop harvest
- Avoid excess irrigation in the field during flowering stage of the crop.
- Use of diseases resistant/tolerant cultivars of field pea; IPFD 10-12, IPFD 11-5, IPFD 12-2, IPFD 9-2, IPFD 6-3, IPFD 13-2, IPFD 12-8, IPF 16-13, IPFD 2014-2, Pant Pea 250, HFP 1428, Pant Pea- 347, HFP 715.
- Select well-drained fields. Upon high infection sprays with antibiotics like Streptocycline® @ 100 µg L^{-1} at 10-day intervals may be done.
- Use of diseases resistant/tolerant cultivars of Mung bean; LBG 17, LBG 402, TARM 1 and Pusa 9072 for South Zone, especially for rabi season.

Biological:

- Biocontrol agents like *Acremonium alternatum, Irpex lacteus, Paecilomyces fumosoroseus, Verticillum lecanii, sporothrix regulosa, Trichoderma harzianum, Stephanoascus spp* and *Tilletiopsis spp.* have been used for management of powdery mildew.
- Seed treatment with *Trichoderma asperellum, T. afroharzianum* @ 10gm/kg of seed at the time of sowing of crops.

Chemical:

- The diseases can be managed by alternate spray of any of the wettable sulphur (0.3%), karathane (0.05%) or carbendazim (0.05%). Give the first spray after the appearance of the diseases in the crop. Second spray should be given 15 days after the first spray and the third spray only if there is a need.
- Spray wettable sulphur @ 1 g L^{-1} or triadimefon (Bayletan® 25% EC) @ 0.03% for better management.

Ascochyta Blight: Ascochyta Blight, caused by *Ascochyta rabiei* (Pass.) Labr, happens majorly in chickpea pulse crop. This disease is seed borne in nature. Infected plants debris, left over in the fields, serve as a source of primary

inoculum for this disease. One can notice symptoms of this disease in the plant parts above the ground. Affected seedlings may collapse and die. Initially, the disease appears in the form of several small water-soaked necrotic spots on the younger leaves of almost all branches. Under favourable conditions, these spots enlarge rapidly and coalesce causing blighting the leaves and buds. One can observe small black spots (Pycnidia) on the blighted parts. In cases of severe foliar infection, the entire plant dries up suddenly. If conditions are unfavourable, plants will not die and shows discrete lesions on all plant parts. The symptoms on the leaflets are round spots with brown margins and a grey centre, that contains Pycnidia, arranged in concentric rings. Size of the lesion may be around 3-4 cm on stem and often cause girdling. Symptoms on the seeds appear as a brown discoloration and often develop into deep, round or irregular cankers, sometimes bearing Pycnidia which can be visible to the naked eye.

Management

Cultural:

- Remove all infested crop residues and volunteer plants.
- Seed treatment can improve establishment of seedling. Hence, before planting, treat the seeds with fungicides like Thiram or Carbendazim (Bavistin) @ of 2.5 g/kg of seed.
- Chickpea should not be grown more frequently than every 3-4 years.
- Use of tolerant varieties like G-543, Pusa-256, Gaurav, GNG-146, PBG-1.

Chemical:

- Spraying of Chlorothalonil fungicide @ 2gm/litre of water during flowering and early podding stage to reduce the disease severity.

Botrytis Grey Mold: Botrytis Grey Mold is a fungal disease caused by *Botrytis cinerea* in in chickpea. The symptoms are water soaking and softening of affected parts which include leaf, stems, flower, and tender shoots. Later, on these plant parts, gray or dark brown lesions are produced which are radially coverd with dense growth of fungus. Lesions on stem are 10 - 30 mm long and they girdle the stem completely. Affected flowers becomes rotten. If the disease moves to pods, the seed may not form or they may be shrivelled or become discolored.

Management

- Chickpea crop should be sown in last fortnight of November in irrigated tracts.
- Follow wider row and plant spacing.

- Seed treatment with a mixture of 25% carbendazim and 50% thiram at 2.5 g kg^{-1} seed.

Black root rot: Black root rot is fungal disease, common in chickpea caused by *Fusarium solani*. The disease can occur at any stage of the crop. Black root rotting is main characteristic symptoms of this disease. Affected chickpeas will turn yellow, wilt, and prematurely dry. Most of the finer roots are shed, while taproot remain intact but, turns black.

Management:

- Avoid high soil moisture in the field.
- Seed treatment with Thiram or Carbendazim (Bavistin) at the rate of 2.5 g/kg of seed.

Rust: The causal organism of rust is *Uromyces spp.*. It is another one of the major diseases in chickpea, field pea, lentil etc. The disease appears late in the season when the crop is maturing. Moderate warm weather conditions favour rust development.

Fig. 3.9: Symptom of rust

Initially, first rust symptoms appear on leaves as small, round or ellipsoidal, cinnamon-brown, powdery pustules. These pustules tend to coalesce and sometimes a ring of small pustules can be seen around larger pustules. Pustules appear on both leaf surfaces but more frequently on the lower side of the leaf surface. During severe infection, pustules is occasionally visible on stems, petioles, twigs and pods that result in premature defoliation and possible death of the entire plant.

Management

Cultural methods:

- Cultural practices to control rust have shown that early sowing could be a method to control rust as early sown crops escaped from infection.
- Burn the affected plant debris and trash after harvesting.
- Cultivation of tolerant/resistant varieties of field pea like Aman, IPF 4-9, Pant Pea- 347, HFP 1428, IPF 16-13, Pant Pea 243, Pant Pea 250, IPFD 12-2, HFP 529 etc.

- Cultivation of tolerant/resistant varieties of chickpea like Gaurav.
- Integrated management of rust includes control of volunteer plants over the summer and removal of infected plant debris. It is advisable to use clean seeds without rust contaminations, and to treat the seed with a suitable fungicide such as diclobutrazol @ 1gm/kg of seed

Chemical methods:

- Spraying 0.2% of Mancozeb 75 WP two times at 10 days intervals when first symptom appears.
- Foliar spray of propiconazole and hexaconazole @ 0.1% at the time of first appearance of the disease symptoms.

Downy Mildew: Downy mildew caused by *Perenospora pisi.* It appears early on young plants, in the form of downy growth on the under surface of leaves. As the disease advances, the affected tissues turn brownish grey, dry up and the leaves drop off prematurely. If the young growing stems are systematically infected, they become distorted and is checked growth, with subsequent stunting of the entire plant. On pods, the disease is first noticed when they are green and flat. The patches are as pale green, more or less elliptical in shape, blotches on the sides, or more irregular, elongated lesions along the pods. The lesions gradually become bright brown in colour.

Management

Cultural:

- Sanitation and crop rotation
- Deep summer ploughing during the month of May-June

Chemical:

- Spraying of Ridomil @1.0ml/Litre and Mancozeb @ 2.5gm/Litre of water at 15 days intervals

Macrophomina Blight: The disease is caused by the fungus *Macrophomina phaseolina* causing root rot, collar rot, seedling blight, stem rot, leaf blight, pod and seed infection in Mung bean and urd bean. The disease develops rapidly and cause severe infestation under high temperature and water stress conditions. The fungus attacks the stem at ground level, forming localized dark brown patches that collapse and encircle the stem. Black dot like sclerotia forms on the surface and below the epidermis on the outer tissue of the stem and root.

Management

- Uproot and destroy the disease plant so that sclerotia do not form or survive.
- Treat seed with Trichoderma @ 5-10g/kg of seed or captan 75 WP @ 2.5g/1 and thiram 80% WP @ 2 g/1 before sowing.
- Spray of carbendazim 50 WP @ 1.0g/1 at 15 days interval on appearance of the symptoms.

Phytopthora stem blight: Phytophthora stem blight occur in pigeon pea due to the fungus *Phytophthora drechsleri Tucker f. sp. Cajani*. This disease is soil borne that causes seedlings to die suddenly. Infected plants have water-soaked lesions on their leaves, with their colour ranges from brown to black, and slightly sunken lesions on their stems and petioles. Infected leaves lose their turgidity and become desiccated. Lesions girdle the affected main stems or branches that break at this point, causing the foliage above the lesion to dry up.

Management:

Cultural:

- Early or normal sowing.
- Practice ridge planting methods. Summer solarisation and summer ploughing should be done. It is important to select fields with no previous record of blight.
- Avoid sowing pigeon pea in fields with low-lying patches that are prone to water logging. Prepare raised seedbeds and provide good drainage. Use wide inter-row spacing

Chemical:

- Seed dressing with Ridomil MZ® @ 3 gm kg-1 seed before sowing is more effective for managing the disease.
- One or two foliar sprays of Ridomil MZ® at 15-day intervals starting from 15 days just after appearance of the disease.

Biological:

- Seed treatment with *Trichoderma harzianum*/*T. asperellum* @10 gm/kg seed before sowing.
- Soil application of *T. asperellum* @ 2.0 kg/acre and seed treatment @ 10 gm/kg seed is highly effective for managing this soil borne disease.

Sterility Mosaic: Sterility mosaic virus, which transmit through vector Eriophyid mite (*Aceria cajani*), is common in pigeon pea. It is also known as the 'green plague' given the reason that the infected plants remain in the vegetative state without producing any flower. Stunted and bushy plants, leaves of reduced size with chlorotic rings or mosaic symptoms, and partial or complete cessation of flower production (i.e., sterility) characterize sterility mosaic disease.

Management

- Wipe out the sources of sterility mosaic inoculums from field.
- Uproot infected plants at an early stage of disease development and destroy them, as they are potential sources of inoculate.

Pea mosaic: There are two causative agents responsible for pea mosaic virus, pea common mosaic virus and bean yellow mosaic virus (bean virus 2). Molting of the foliage is the characteristic symptoms of this disease. Veins of the tissue become yellow leaving the green patches scattered irregularly over the surface of leaves and stipules. Young plants infected with this virus become stunted and may have pods fewer in number as compared to the healthy plants. Severity of the symptoms depends upon the virus and pea varieties involved.

Management:

- Use resistant cultivars and monitor aphids closely.
- Apply insecticide of Metasystox @ 0.1% when aphid populations reach two per plants for effective management.

Pea streak: Pea streak is caused by Wisconsin pea streak virus, western peak streak virus, alfalfa mosaic virus and bean yellow mosaic virus. The characteristic symptoms of the disease are stem streaks. The streak begins as light brown to purple oblong lesion along the length of the stem and petiole. On terminal, foliage vein necrosis and leaf yellowing are common. Pods develop brown to purple dead areas which are sunken and are of different size.

Management:

- Monitor aphids closely. Control when aphid populations reach two per plant.

Leaf curl/necrosis disease: Leaf curl is a viral disease found across all Mung bean growing areas of India. It is, however, more severe in southern states, especially in rice fallows. It is spread through many species of thrips. The affected plant becomes economically useless, as necrosis in the affected plant parts is common. This disease has the potential of causing heavy damage to the crop. The earliest symptoms appear on the leaflets as chlorotic spots around

some lateral veins and its branches near the margin. Such leaflets show downward curling of the margins. Twisting of leaves may also be seen. The plants infected at early stage remain stunted and are often killed.

Management:

- Seed treatment with insecticide imidacloprid @ 5 gm / kg seed
- Spraying the crop with imidacloprid @ 0.5 ml/l after 15 days of sowing.

Yellow Mosaic Disease:

Yellow mosaic disease (YMD) is the most destructive and widely distributed disease of Mung bean. Mung bean yellow mosaic virus is the cause of this disease and it is transmit through whitefly in the Mung bean crops. The symptoms appear are irregular yellow spots on the infected leaves that merge to form larger spots. Ultimately, entire leaves turn yellow and dries. The infected plant matures late and the number of flowers and pods is severely infected plants are reduced drastically. One can observe yellow spots on pods and seeds on severely infected plants.

Fig. 3.10: Symptom of yellow mosaic disease

Management

- Sowing and cultivation of resistant varieties is the most economical and practical method of YVMV disease management.
- Spraying of Imidacloprid @ 2-4ml/10 litre of water or dimethoate @0.3% (30 ml/10 litre of water) after 15 days of sowing. Repeat after 45 days of sowing, if required.
- Uproot and destroy diseased plants at early stage of the crop.

Activities

Identify the disease samples of pulse crops.

Material required: Diseased samples of different pulse crops, Pen, pencil and notebook etc.

Procedure: Collect the disease sample of different pulses crop and note the following information.

1. Name of the crop

2. Name of disease
3. Causal organism
4. Control measures

Check Your Progress

Fill in the Blanks

1. Integrated disease management modules to protect crops in a ……and ……manner.
2. Fusarium wilt disease is caused by ……and ……fungus.
3. Phule Vikram is resistant/tolerant varieties……
4. The causal organisms of stem rot are……
5. Treat the seed with the fungicides captan or thiram ……before sowing.

Multiple Choice Questions

1. *Fusarium udum* is the causal organism of……
   (a) Wilt
   (b) Leaf spot
   (c) Powdery mildew
   (d) Collar rot

2. Treatment of seeds with bio agents……..
   (a) Carbendazim
   (b) *Trichoderma viride*
   (c) Vitavax
   (d) Captan

3. Yellow mosaic virus and is transmitted by……..
   (a) Fruit fly
   (b) House fly
   (c) Whitefly
   (d) Leaf hopper

4. Botrytis grey mold is a ……disease caused by Botrytis cinereain in chickpea.

(a) Fungal

(b) Bacterial

(c) Viral

(d) Mycoplasma

Match the Columns

	A		**B**
1)	Chickpea	a)	*Uromyces spp.*
2)	Seed treatment	b)	*Sclerotium rolfsii*
3)	Collar rot	c)	Gaurav
4)	Rust	d)	Vitavax

Subjective Question

1. Write about the following diseases and their management.

a) Powdery mildew

b) Yellow mosaic

c) Alternaria leaf Blight/spot

d) Fusarium wilt

Module 4
Harvest and Post-Harvest Management of Pulse Crops

Module Overview

Pulses are edible seeds from legume plants. They are the chief source of protein to vast vegetarian population. They are rich in minerals, vitamins, complex carbohydrates and dietary fibres. In India, Chickpea, Pigeon pea, Green gram, Back gram, Lentil, Field pea, Rajmash (Bean), Moth bean, Horse gram and Lathyrus are the commonly grown pulses. Chickpea, Lentil, Peas, Lathyrus, Rajmash (bean) etc. are major Rabi pulses, whereas Pigeon pea, Green gram, Black gram, Cowpea, Horse gram, Moth bean etc. are grown in Kharif season.

Pulses proteins are of high biological value ranging between 18 to 32% for different pulses. Pulses proteins contain nutritionally important amino acids such as lysine, which is deficient in cereals and other edible plant sources. Proteins present in pulses are complementary to cereals proteins, which are rich in methionine, another essential amino acid, and their combination makes a balanced diet. Traditional Indian diets, viz., dal-roti, dal-chawal, idali- sambhar etc., are the perfect combination of protein present in cereals and pulses.

Pulses play a major role in providing nutritional security to the nation. Green revolution in 1960s made country self-sufficient food grain production and provided food security to the nation. However, despite being highest producer and consumer, India is net importer of pulses to meet the domestic demand. Huge quantity of pulses produced are lost during various postharvest operations. Adoption of appropriate postharvest management practices can reduce the postharvest losses of pulses.

Learning Outcomes

After completing this module, you will be able to:

- Demonstrate harvesting and threshing crops to ensure optimal quality and efficiency.
- Explain the importance of post-harvest management
- Identify effective methods for storing pulses and managing storage pests to maintain quality and reduce losses.

Module Structure

- Session 1: Harvest and Threshing
- Session 2: Importance of Post-Harvest Management
- Session 3: Pulse Storage and Storage Pests

Session 1: Harvest and Threshing

When the grains inside pods attain an appropriate degree of maturity, the crop is then harvested and collected from the field. In general, harvesting takes place about 10-15 days after grain reaches the physiological maturity. Crop maturity indices include crop moisture and physical grain characteristics. Crop is harvested at higher moisture content to minimize shattering losses. The time to harvest the crop is usually determined by the length of crop cycle that varies according to crop and variety. Pod ripening, hardening of grains, drying of stem, yellowing and falling of leaves are major indices for crop maturity.

Table 1: Maturity indices for different pulse crops

Grains	**Physical characteristics**
Pigeon pea	Pods become ripe and black, falling of lower leaves
Chickpea	Drying of stem and leaves, hardness of grains
Urd bean	Dried shells, pod ripens and become black
Mung bean	Dried shells, pod ripens and become black
Rajmash	Dried shells, yellowing of leaves
Lentil	Drying of upper leaves, pods become pale and yellow
Field pea	Drying of upper leaves, pods become pale and yellow

Harvesting is done when the pods are ripe but still not open. In case of pulses, most harvesting is done manually with the help of sickles. Early morning dampness of plants prevents shattering of the pods. Combine-harvesters are used for mechanized harvesting of pulses as these harvesters have adaptation for pulses along with wheat crops. For instance, lengthy and sturdy plants of pigeon pea are harvested manually using chopper and bundled for further drying. Mechanized harvesting of pulses is not common but it reduces the operational time and cost. After harvesting, threshing and winnowing are the

next essential operation to separate grains from the crops. The crop harvested at high moisture contains too much green matter and grains may not have uniform maturity. Therefore, this makes the pre-drying of the harvested crop very essential. In the pre-drying stage, harvested crops are piled on drying floor. Prolong sun drying for few days makes crop ready for threshing. During pre-drying stage, it is necessary to protect harvested crop from sudden rains. In threshing stage, dried bundles of pulse crops are spread over the threshing floor and are beaten by the wooden sticks to open their pods. After threshing, grains are collected by the process called winnowing which removes chaff away with the blowing air. Large quantities of crops are threshed by treading the animals or vehicles. The bundles are turned upside down between two passages of treading. Tractor operated multi-crop threshers have become common for threshing of pulse crops. Provisions for adjustments in machine parameters like cylinder - concave clearance, gap in concave bars, number of pegs and peg configuration etc., makes threshers adaptable for different pulses.

Activities

Visit a nearby farmer field and observe the harvesting and threshing process of pulse crops.

Material required: pen, pencil, notebook, etc.

Procedure:

- Visit a nearby farmer field
- Note down the names of the pulse crops grown in the field
- Observe the maturity indices for different pulse crops
- Discuss with farmer about harvesting and threshing process of pulse crops
- Note down the types of tools and equipment used during the harvesting and threshing processes.

Check Your Progress

Fill in the Blanks

1. Chickpea, Lentil, Peas, Lathyrus and Rajmash are the main……. season pulses.

2. Pigeon pea, Green gram, Black gram, Cowpea, Horse gram, And Moth bean are the main……..season pulses.

3. Crop maturity indices include …… and ……

4. Pod ripening, hardening of grains, drying of stem, yellowing and falling of leaves are major indices for …….

5. ……..are essential operation to separate grains from the crops.

Multiple Choice Questions

1) Lentil and field pea are grown in:

a) Rabi Season

b) Kharif Season

c) Zaid Season

d) All the seasons

2) Pulses are rich in important amino acid:

a) Methionine

b) Lysine

c) Isoleucine

d) All the three

3) Maturity indices indicating crop is ready to harvest:

a) Pod ripening

b) Grain hardening

c) Leaf yellowing

d) All the above

4) Crop is harvested at higher moisture content to minimize loss due to:

a) Pod ripening

b) Infestation

c) Shattering

d) All the above

5) Threshing of pulses can be done by:

a) Animal treading

b) Vehicle treading

c) Thresher

d) All the above

Match the Columns

	A		B
1)	Methionine	a)	Pulses
2)	Lysine	b)	Shattering losses
3)	High crop moisture	c)	Cereals
4)	Harvesting	d)	Cylinder - concave clearance
5)	Multi-crop Thresher	e)	Physiological maturity

Subjective Questions

1. Explain the maturity indices indicating crop is ready to harvest.
2. Describe the modes of pulse threshing. What major adjustments are required to be made in threshers to thresh different pulse crops?

Session 2: Importance of Post-Harvest Management

Post-harvest activities start immediately after harvesting of the crops. It includes drying of crops, threshing, cleaning, grading, storing, handling and processing. The post-harvest chain completes when food reaches to the consumers table. At each stage of handling, some losses take place. Minimizing losses at different post-harvest stages is defines as post-harvest management. Production of agricultural commodities are season specific but are consumed throughout the year. Post-harvest management helps in making the grains available beyond growing seasons. Biological commodities start deteriorating with the time. Post-harvest management, especially storage and processing, is important to prevent qualitative or quantitative deteriorations, maintain availability and regulate market prices. Thus, post-harvest management may be defining as "Systematic handling and processing of agricultural commodities involving series of operations after harvest in complete value chain from field to plates of consumers".

Post-Harvest Losses in pulses:

Post-harvest losses mean quantitative and qualitative loss that takes place from production until consumption during the various stages of the post-harvest system. These losses lead to economic or monetary loss. Further, some losses are result from poor management of post-harvest systems. Qualitative deterioration makes grains unfit for human consumption.

Supply of pulses has always been less than demand. Moreover, to match both supply and demand, one has to increase production either through improving in

crop varieties and applying new crop production technologies or by expanding the area. Pulses, being rich source of protein, attract insects from the field. These insects, carried-over with the crops to the storage godowns, cause severe damage during hot and humid seasons, which promotes infestations. In case of pulses, losses are reported over 25% at different post-harvest stages though it can be as high as 50% if there are poorly managed conditions. Reducing post-harvest losses can make more pulses available for human consumption. Among all the post-harvest losses, storage and milling contributes maximum. The post-harvest losses at different stages are as tabulated below:

Stages	Losses (%)
Harvesting	1-3
Handling	1-7
Threshing	0.5-5
Drying	1.0-5
Transport	0.5
Primary Processing	1.0
Storage	5-10
Milling	15-20
Total	26-51.5

Storage losses:

Storage losses can be as high as 10%. The loss primarily depends upon initial field-level infestation that goes to the godowns through infested pods or seeds. However, field-level infestation is usually not more than 1%, but due to specific climatic conditions, it hastened up the insect activities that may cause 30% grain damage within span of 2-3 months. Storage losses have been reported between 3.4 to 32.6%. Roughly speaking, storage losses can be taken around 10%. In India, pulses are stored in stacks of gunny bags in godowns. These gunny bags are pervious to ambient environmental conditions. Jute bags and grains are hygroscopic in nature. They absorb or desorb moisture from atmosphere when relative humidity is high or low respectively, until it reaches equilibrium

moisture content (EMC). Insect activities increase during favourable hot and humid climatic conditions. If not managed properly they can cause maximum post-harvest loss. Damage during storage caused by various agents, viz., rodents, birds, insects and moisture are 3.78, 1.31, 3.86 and 1.05% respectively. Among these agents, damage caused by insects is maximum followed by rodents. To reduce storage losses, it is important to reduce and control the activities of these agents.

Milling losses:

Milling of pulses is an essential operation required to remove husk or seed coat over the cotyledons and subsequently split in two halves before consumed as dal. Pulse milling especially involve dehiscing and splitting. Milling process reduces fibre content of pulses and improve culinary properties such as texture, cooking quality, palatability and digestibility.

The major operations involve in pulse milling are:

i) loosening of seed coat and

ii) husk removal and splitting.

Process of loosening of seed coat is referred as pre-milling treatment or pre-treatment. Presence of gummy substances between seed coat and cotyledons play crucial role in dehiscing process. Depending upon quality and quantity of gums, pulses are categorized into easy or difficult-to-mill kind of pulses. Chickpea, Lentil and Field pea have lesser gums content, hence considered as easy-to-mill kind of pulses, whereas Pigeon pea, Black gram and Green gram comes into category of difficult-to-mill pulses. Process of dehusking and splitting of pulses is an age-old practice adopted at domestic or cottage scale, before turning to large-scale organized industry. At cottage scale, after pre-treatment, dehusking and splitting is done with the help of stone chakkies. In commercial large-scale mills, this process is performed with the help of abrasive rollers, made of emery or carborundum. Theoretically, milling should recover all the cotyledons with loss of husk and germ. However, in practice, dal recovery is less than theoretical dal yield as some part of cotyledons is lost in from of broken and powder and is mixed with husk. The germ, which is 2-5% part the grain, is also lost. The milling by-product obtained in pulse milling is consumed as low value cattle feed. In commercial mills, milling operation is performed with the abrasive roller surfaces in two to three passes, the scouring losses are higher in comparison to stone chakki. The gap between theoretical and actual dal yield is considered as milling loss, which is reported to be between 15-20%.

Management of post-harvest losses:

Grain saves is considered as grain produced. Hence, every effort should be made to minimize grain loss at every stage of pre- and post-harvest stages of handling, transportation, storage and processing of pulses. During crop production phase, insects must be controlled after pod filling and grain maturity stages. The management of postharvest losses starts from the field when the crop is mature and ready to harvest. Losses can be managed at different stages by adopting simple techniques as listed below:

i) Harvesting:

- Harvesting at appropriate grain maturity
- High grain and crop moisture
- Harvesting in early morning hours

ii) Handling:

- Do not leave harvested crops in field
- Use bulk mode of transport like tractor trollies
- Sun drying of the crop on 'pukka' floor

iii) Threshing:

- Treading of crops may be avoided
- Change concave sieve according to grain size
- Adjust cylinder-concave clearance

iv) Drying:

- Sun dry crops up to moisture content suitable for grain storage (10-12%)
- Crop must be protected from unanticipated rains
- Efficient mechanical and electric dryers save time

v) Transport:

- High pilferage during bag handling and transport
- Bulk handling and transport to be adopted
- Forklifting of bags prevents grain pilferage

vi) Primary Processing:

- Quality grains fetch better market prices

- Dried, cleaned and graded grains are less prone to infestation
- Ease to control losses at village level

vii) Storage:

- Drying grains to safe storage moisture prevents infestation
- Field level infestation to be curbed before storage
- Regular inspection and monitoring help in timely insect control measures

viii) Milling:

- Adopting suitable pre-milling treatments
- Mechanical or electric drying system reduces weather dependence
- Using appropriate emery size to reduce scouring loss

Activities

Visit a nearby godown or warehouse and observe the post-harvest losses during storage.

Material required: Pen, pencil, notebook, etc.

Procedure:

- Visit a nearby godown or warehouse
- Discuss with the farmer/ manager about post-harvest losses during storage
- Discuss with the farmer/ manager about precautions taken during storage to minimize post-harvest losses
- Note down your observation and present them before class

Check Your Progress

Fill in the Blanks

1. Threshing, cleaning, grading, storing, handling, and processing are involved in……..
2. Postharvest management refers to……
3. Postharvest losses include ……
4. Storage losses range between …….
5. Milling losses range between …….

Multiple Choice Questions

1)Threshing losses range between:

a) 1-3%

b) 1-7%

c) 0.5-5%

d) 5-10%

2) Suitable grain moisture for safe storage range between:

a) 4-7%

b) 10-12%

c) 13-14%

d) Above 14%

3) Maximum storage loss is contributed by:

a) Birds

b) Rodents

c) Insects

d) Mites

4) Milling of pulses improves culinary properties such as:

a) Cooking quality

b) Palatability

c) Digestibility

d) All the above

5) Pre-milling treatment is given to:

a) Quick cooking

b) Insect control

c) Loose husk

d) All the above

Match the Columns

	A		B
1)	Storage losses	a)	15-20%
2)	Milling losses	b)	1-3%
3)	Harvesting losses	c)	5-10%
4)	Absorption/Desorption	d)	Cleaning and grading
5)	Primary Processing	e)	Equilibrium Moisture Content

Subjective Questions

1. Describe post-harvest losses in pulse crops.

2. Describe methods of post-harvest management for pulse crops.

Session 3: Pulse Storage and Storage Pests

The importance of storage of pulses in post-harvest operation can be understood from the very fact that the pulses are grown in crop season but are consumed all-round the year. Pulses are susceptible to insect infestation at every post-harvest stage. Thus, storage of whole pulse grains becomes a crucial stage to protect and prevent it from insect activities. Initial level of field infestation and methods adopted in preventing storage losses play an important role. High level of field infestation and poor storage practices can lead up to 50% grain loss. Therefore, storage is the area that gives scope to reduce losses by paying attention to storage management and practices.

Factors influencing the safe storage of pulses:

Purpose of safe long-term storage is to minimize or stop deterioration process in grain quality of product. Degradation in grain quality during storage depends upon five factors:

i) Temperature
ii) Relative humidity
iii) Grain moisture
iv) Oxygen
v) Light

Combined effect of these factors may cause extreme storage losses.

Grain moisture content is associated with ambient relative humidity. Grains are hygroscopic in nature that absorbs or lose moisture depending upon ambient relative humidity until grains reach the equilibrium moisture content.

Temperature plays an important role in insect activities. Insect activities cease at lower and high temperatures. Air, in between the grain mass, is source of oxygen to insects. Lowering the temperature or reducing oxygen levels can enhance shelf life of the grains but it is not feasible in large godowns.

Methods of storage

There are two methods of grain storage commonly adopted in the country:

i) Bag Storage
ii) Bulk Storage.

In bag storage system, bags can either be stored inside warehouses or in open air. In bulk storage system, grains are stored in bins or silos of various capacities. Storing grains in jute bags is prevalent in the country. Bulk storage system gives higher degree of technological control in preventing and managing insect activities. However, high investment in creating bulk storage infrastructure is major bottleneck in adoption of the method. At farm level, traditional storages stores grains in mud structures prepared by rural artesian with locally available materials.

Bag storage:

Bags storage method offers flexibility in adaptation depending upon time and space availability. This system requires warehouses to stack bags. Warehouse structures protect bags from getting wet and exposure to harsh climatic conditions. There structures should be such that it must prevent entry of birds and rodents. It must provide effective protection against atmospheric factors, viz., sun, rain, temperature and humidity. This method is widely adopted in developing countries as compare to developed countries. The main advantage of this method is that it can be set up in less time and quite easily. It is economically cheaper and well adapted to local transport and marketing conditions. In this method, cleaned and dried grains are conserved in bags made of plant fibre or plastic threads. Bags are then stacked in pyramid shape inside the warehouses. Stacks arrangement must allow ease of inspection and insecticidal application. Bags can be stacked and placed inside storehouses, sheds or warehouses. When covered space is limitation, bags can be stacked outdoors under the tarpaulin. Stored stacks are checked periodically for any kind of insect activity and timely spray of insecticides. Stacks can be fumigated after covering with plastic sheet and sealing the sides to make it air tight as much as possible.


Fig. 4.1: **Bag storage godown and stack of gunny bags**

Bulk storage:

Bulk storage system of grains consists of storing unpackaged grain in special structures built for this purpose. Usually, these structures are in form of bins or silos. Bin and silos are similar kind of structure. Bins are made-up of metals whereas silos are concrete structures. In general, bulk-storage structures are either low-capacity bin or silos for storage at farm level or high-capacity silos for commercial or industrial storage. It is quite common in developed countries as it significantly controls the storage losses. High initial investment and lack of bulk material handling systems prevent adoption of this technology in the developing countries. Traditional storage structures made from locally available material are used for on-farm storage. Small capacity metal bins are used to store grains for domestic consumption purpose. Low-capacity metal drums are best adapted for rural storage. Rectangular silos made of bricks are easy to construct and maintain. Reinforced concrete silos have also gained popularity in rural areas. The metal bins and concrete silos are rodent proof. Relatively higher degree of air tightness protects grains from external atmospheric conditions in bins and silos. Facility of aeration and fumigation make these bulk storage structures more versatile in controlling grain moisture, temperature and insect activities. Ventilation or aeration system lower down the grain temperature in order to slow down biochemical degradation process. Dry and hot air can also be used for drying the rains. The system can also be used to fumigate the bin whenever any insect activity is observed. In airtight structures, insect or microbial activities can be controlled by depleting oxygen level. Low oxygen level creates an environment where survival of insects becomes difficult. This system is referred as controlled atmosphere storage (CAS). Injecting bins or silos with inert gases (nitrogen or carbon dioxide) in airtight structures is another technique to lower chamber oxygen and control infestation. Despite the various advantages bulk storage systems still finds limited application due to its

technological complexity, lack of bulk handling and transport system, and high initial cost.

Fig. 4.2: **Bulk storage system – Mettalic Bins and Concrete Silos**

Storage grain pests

I. Rodents:

Rodents are the second most pest causing storage loss to the pulses. They live inside or the nearby areas of the godowns where food is available in abundance. Rodents not only consume grains but also destroy the packaging materials. Black rat (*Rattus Rattus*), Brown or Norway rat (*Rattus norvegicus*), and Mouse (*Mus musculus*) are three common rodent species found in Indian godowns. Control of rodents is important to avoid grain wastage as rats and mice consume about 25 g and 3-4 g food per day respectively. Rodents not only consume grains but also contaminate it with faeces, urine and hair leading to serious qualitative loss. This contamination adversely affects product quality from health and hygiene viewpoint. Rodents are also vector of numerous serious diseases. Rats damage the nutritional value and germination ability of seeds. Therefore, grains contaminated by rats are often declared as unfit for human consumption. Moreover, rodents also damage the packaging materials, tarpaulin, pallets, walls, floors and doors of storage structures.

Control measures for rodents:

Control of rodents is a difficult task. Control of rodents involve combination of various methods. One can use the following measures in combination to check rodent activities:

- **Sanitation:** Keeping the storage and surrounding area clean
- **Exclusion:** Keeping them out

- **Killing:** Killing those that get in

Sanitation, both outside and inside, prevents entry of rodents and birds to the godowns. Exterior of godowns must not provide shelter to rodents or birds. Building must adopt provisions for rat proofing by preventing vertical movement of rats. The godowns need to be clean from inside. Smooth walls and floor help in easy cleaning. All the waste or spillage must be removed immediately. The stack of bags should be stacked on pallets and not directly on the floor. Minimum distance of 75 cm should be maintained between wall and stacks for ease of movement and inspection. Although it is difficult to make rat proof structure, but raising the godown floor up to height of truck bed can help in preventing entry of rats. Rats inside the structure must be killed immediately after its entry. Zinc phosphide can be used for poisoning rats. Other common rodenticides are like barium carbonate, red squill and ANTU (alpha-naphthylthiourea), which can be used to kill the rats. Baits with slow reaction rate and anti-coagulant poisons are more acceptable by rats than fast killing poisons. Initially, baits should be offered without poison to lure the rats. After consumption of bait rats search for water, hence water should not be kept inside the structure. Rat burrows inside or outside godown must be filled and sealed. Physical, chemical and mechanical methods of rat traps can also be used.

II. Bruchids:

The insect that causes maximum damage to pulse crops are bruchids or pulse beetles. Bruchids attacks the crop from the fields and are carried to the storage godowns, where they multiply during favourable hot and humid conditions. Apart from field, various sources like carried over commodities, grains left inside agricultural machineries and processing plants, means of transport and alternate insects hibernation sites within the structure provide a way for bruchid to get into a storage godown. The insect lay eggs on the maturing pods in the field or on the seed coat of whole grain after threshing. The genus *Callosobruchus* has large number of species. *C. maculatus*, *C. chinensis*, *C. analis* and *C. phaseoli* are common species in the subtropical region. Some other species of tropical regions are *C. rhodesianus* and *C. sunnotatus*. *C. theobromae* is also found in pods of pigeon pea. The deterioration rate gets hasten when fungi from genera of *Penicillium* and *Aspergillus* associate with these insects. Since pulses are mostly consumed in form of dehusked spilt, i.e., dal, husk removal reduces possibility of bruchid infestation. However, during storage, split pulses are attacked by *Trogoderma granarium*, *Rhyzopertha dominicia*, *Tribolium castaneum* and *Cadra cautella*. These insects cause quantitative, nutritive and qualitative losses. Physical weight loss is considered as quantitative loss, whereas reduction in

carbohydrates and proteins result into nutritional loss. Presence of uric acid, fragments and faecal matter, considered as qualitative loss, contaminate the grain quality making it unfit for consumption.

***Fig.* 4.3*:* Bruchid (Pulse Beetle) and infested Green gram grains**

Control measures for storage pest

Monitoring and Inspection of stored products are the first step towards control of insects. Regular visit and inspection of stored stacks helps in early detection of any kind of pest activity. The extent and nature of infestation can be determined on the basis of visible or trapped number of insects and pests. These observations will help in adopting suitable method for pest control. Inspection should be made frequently and thoroughly to detect potential and seriousness of the problem. Trained and qualified staff with adequate knowledge of insects and pests must visit the godowns as per scheduled routines.

Monitoring insect infestation:

Adopting one or combination of the following methods can do monitoring for insect infestation:

- Visual observations (sampling, sifting and counting)
- Use of chemical pheromones/attractants to attract insects
- Use of food bait to attract moth and beetles
- Use of light traps for early warning indicators

Further, the presence of either of the following states in the grain sample indicates presence of insects:

- Lumps of grains
- Grain decay or powdering
- Foul smell

- Rise in grain bag temperature compare to ambient temperature
- Presence of insect egg (white spots) on seed coat
- Larvae skin

In order to minimize damage due to infestation, it is important to develop a control strategy. Identification of insect species helps in developing the suitable control measure as one method will not work for all the insect species. The measures to control insects are of two types:

- Preventive measures
- Curative measures

Preventive measures are taken even before the grain arrival when there is no visible infestation. Curative measures are taken during the storage when insect activities are visible. Curative measures can also be taken before storage. In both the measures, insects must be destroyed before it deteriorates the quality of the food grains.

Insect Control measures can be one or a combination of following methods:

- Physical and mechanical methods
- Chemical methods
- Sanitation
- Exclusion
- Integrated Pest Management

Physical and mechanical methods:

i) Drying and disinfestation: All agricultural commodities, to be stored for longer duration, need to be dried below safe moisture level i.e., 10-12%, before storage. Crops are harvested at high moisture to avoid shattering losses. Sun drying involves wind but in solar drying wind is not involved. Sun drying on cemented floor is quite prevalent for drying of pulses. By elevating grain temperature to 60^0C and maintained for 10-15 minutes, initial field-level infestation can be controlled. This method kills all the live stages of bruchids present with the grains. Solar absorbance surfaces, like plastic sheets, can effectively be used to raise the grain temperature for disinfestation of grains.

ii) Reducing inter-granular space: Filling the inter-granular gaps by the inert materials, such as sand or dry activated clay, prevents the multiplication of insects. These materials reduce the availability of oxygen for insects' respiration and preventing their movement for mating which lead to their mortality. To

prevent mixing of sand or clay with grains, 7.5 to 10.0 cm thick layer of sand is placed on polythene sheet on the top of the grain surface. This can be adopted for household or domestic storage of pulses where small quantities are stored.

iii) Coating with clay or oil: Small quantities of pulse, stored at farm or domestic level for consumption or seed purposes, may be coated with clay or mixed with plant oils before storing in mud structures or metal bins. Pulse grains can be treated with 1-2% clay before storing in close container. Non-drying vegetable oils like castor, Niger, sesame etc., can also be mixed with grains @ 0.5 to 1.0% before storing them. Neem oil @ 2.0 to 5.0 ml/kg was found effective in preventing insect activities. Surface coating prevents insects to lay egg on the seed coat of the grains. However, this is not effective in controlling insect stages already present in the grains.

iv) Improved storage structures: Improvements have been made in traditional storage structures by making it moisture proof, air tight and thermally insulated so that it reduces the possibility of insect infestation during storage. Pusa Bin, Pusa Kother, Pusa Cubical and improved bamboo basket with plastic liner are some of such improved storage structures. These structures are effective for pulses in dry regions. The seed retained high viability and damage due to infestation was below 1%. Moisture proofing of these structures made it acceptable at farm level storage. Polythene lining in gunny bags creates barrier for moisture movement. In airtight structures, frequent fumigation is not required.

v) Airtight storage: Airtight structures prevent moisture transfer from ambient environmental conditions. In gunny bags, moisture increases or decreases according to relative humidity of atmosphere. Increase in moisture triggers insect activities and fungal growth. In air tight structures, oxygen depletes due to respiration of grains and insects. Accumulation of carbon di-oxide prevents the growth of insect population.

Chemical methods:

Most of the physical methods discussed above may control insect growth but sometimes it becomes essential to achieve complete insect mortality. Preventive and Curative measures are adopted for insect control in warehouses. For the purpose, chemical methods are applied as:

- Insecticides
- Fumigants

i) Use of insecticides: Commonly contact insecticides are sprayed to form a film over grain so to kill the insects. Insects are killed after coming in contact

with these insecticides through absorption by their waxy insect skin. These chemicals are available in different forms, viz., powder for dusting, water soluble powder and liquid concentrates. Storage structures are surface treated to eliminate hidden and hibernating insects within the structure. To avoid re-infestation, repeat the application of these chemicals at regular schedule intervals. For powder type materials, dusting machines are used. Mechanical sprayers are used to spray chemicals. In large godowns, compressor equipped with mist nozzles are used for fine spray. Although contact insecticides are very effective on fully developed insect, they have no or little effect of egg or larvae of the insect. Due to residual toxic effects insecticides have limited usage. Due to increasing awareness, certain chemicals were banned for use in food grain storage. Presently use of insecticides are Malathion 50% EC, Deltamethrin 2.5% WP and Dichlorvos (DDVP) 76% EC for prophylactic treatments of warehouses. Use of chemicals poses health hazards to the operators and leaves residual toxicity on grains, which is harmful for consumers. Incessant use of these chemical pollutes the environment as well. Despite drawbacks, chemical applications are the most effective method of disinfestation for stored grains.

ii) **Use of fumigants**: Fumigants are used for curative treatment of stored grains. Fumigation is the method of killing insects stored in grain using poisonous gas. The chemicals which produce such gas are referred as fumigants. These gases are lethal to specific species. Unlike contact insecticides, fumigants penetrate entire grain mass and reaches to invisible egg and larval forms. Fumigants spread throughout the volume after release, therefore, it requires sealed chamber for better efficacy. It is very effective in bulk storage systems like bins and silos, where structures are airtight. In case of bag storage system, that is prevalent in the country, stacks are covered with tarpaulin or plastic sheets. Edges are sealed to make the cover airtight as much as possible. Effectiveness of fumigation depends upon gas concentration, degree of airtightness and length of exposure time. Atmospheric relative humidity, temperature and grain moisture plays an important role in efficiency of fumigation. After completion of exposure time, the stack must be aerated to remove gas before entry of workers. Fumigants are cheap, effective and convenient in use. Aluminium phosphide (Alp) is most widely used fumigant for both bag and bulk storage methods in the country. It is applied @ 9.0 gram (three tablets are used) per tonne of grain stored with an exposure period of 7 days. Pulses are relatively more susceptible to insect attack. Therefore, one round of pre-monsoon fumigation ensures better maintenance of stocks. It is recommended to

maintain a close watch of stored grains and preventive or curative measures must be taken as and when required. Aluminium Phosphide does not leave any residual effect thus it can safely be used for storage of food grains.

Activities

Visit a nearby godown or warehouse and enlist the different types of storage structure and storage pest.

Material required: Pen, pencil, Notebook, etc.

Procedure:

- Visit a nearby godown or warehouse.
- Observe and note down the types of storage structure.
- Discuss with the farmers/ manager about care and maintenance of storage structures.
- Identify major storage pests.
- Discuss with the farmers/ manager about the control measures for storage pests.
- Enlist the precautions taken during the application of chemicals in storage.
- Note down your observations and present it before the class.

Check Your Progress

Fill in the blanks

1) Grains absorb or lose moisture depending on relative humidity until……
2) Temperature, relative humidity, grain moisture, oxygen, and light are major factors in……
3) …… are two common methods of grain storage.
4) Agricultural commodities need to be dried below the safe moisture level i.e., …… before storage.
5) …… are adopted for insect/pest control in warehouses.

Multiple Choice Questions

1) Common species of bruchids are:

a) *C. maculatus*

b) *C. chinensis*

c) *C. analis*

d) All the above

2) Effective physical method of insect control is:

a) Drying

b) Disinfestation

c) Air tightness storage

d) All the above

3) Contact insecticides are very effective on:

a) Insect

b) Egg

c) Larvae

d) All the above

4) Effectiveness of fumigation depends upon:

a) Gas concentration

b) Airtightness

c) Exposure time

d) All the above

5) Aluminum phosphide (Alp) is applied at the rate of _____ g/tonne:

a) 3 g

b) 6 g

c) 9 g

d) 12 g

Match the Columns

	A	**B**
1)	Bruchids	a) Fumigation
2)	Insecticide	b) Callosobruchus
3)	Fumigant	c) ANTU
4)	Curative measures	d) Malathion
5)	Rodenticide	e) Aluminum phosphide

Subjective Questions

1) Describe the factors affecting the safe storage of pulses. Also, explain the bag and bulk grain storage systems along with the advantages and limitations of bulk storage system.

2) Describe physical and chemical methods of insect control. Explain preventive and curative measures of insect control in godowns.

3) Explain the storage loss caused by rodents and describe the control measures for rodents.

Module 5
Package and Practices of Pulse Crops Production

Module Overview

The pulses are the most significant food crops after cereals. They are also called as grain legumes. The term pulse is derived from the Latin word "Puls" which means "pottage" (thick soup). For vegetarian people, pulses are a main and a cheap source of dietary protein (18-25%). The major pulses of the country are Pigeon pea or Red gram (tur, arhar), Chickpea or Gram, Black gram (Urd bean), Green gram (Mung bean) and Lentil (Masur, Mallika). Minor pulses include Rajma (Common bean or French bean or Kidney bean), Cowpea (Lobia, Chaula), Horse gram (Kulthi), Moth bean (moth), Khesari (Chickling vetch or Lathyrus or Grass pea) etc.

Learning Outcomes

After completing this module, you will be able to:

- Understand and apply cultivation techniques for various pulse crops, including soil preparation, planting methods, and crop management practices to optimize growth and yield.

Module Structure

- Session 1: Cultivation Techniques of Different Pulse Crops

Pulses are grown in all three agricultural seasons (*kharif, rabi* and *zaid* or summer). Pulses are a key source of staple in most of Indian diets (as *dal chawal, dal roti, khichdi*). That is what makes India the biggest consumer of pulses in the world. Pulses are also rich in complex carbohydrates, vitamins, micronutrients and digestible fibre. They are low in fat and help to manage the cholesterol levels, digestive system and energy levels. Some of the pulses have marginal medicinal properties. Vegetative parts of pulses like leaves, pod coat / shell and bran become supplementary feed and fodder for animals. Some of pulse crops, like cowpea, are regular green fodder for farm animals. These crops can also be used profitably used as green manure that adds valuable nutrient to the soil as well as improves soil health physically.

Identification of different pulses:

S. No.	English/ Botanical name	Others Names	Types	Image
1.	Chickpea (*Cicer arietinum* L.)	Bengal Gram, Gram, Chana	Kabuli	
			Desi	
2.	Field pea (*Pisum sativum* L.)	Garden pea, Safed matar, Chhola matar	Matar	
3.	Lentil (*Lens culinaris* L.)	Masoor	Lal Masoor	
			Kali masoor	

4.	Pigeon pea (*Cajanus cajan* L.**)**	Arhar, Tur, Red gram	--	
5.	Black gram (*Vigna mungo*)	Urd bean, Biri	Black seeded	
			Green seeded	
6.	Green gram (*Vigna radiata*)	Moong	--	

Session 1: Cultivation Techniques of Different Pulse Crops

Cultivation of Chickpea (*Cicer arietinum* L.)

Introduction:

It is one of the oldest pulse cash crops and is cultivated since ancient times. In India, it is also known as Bengal gram, gram, or chana. It belongs to family Fabaceae. Humans consume it as vegetables and livestock consume it as fodder. It is used to make Chana dal and Besan and variety of sweets, dishes and snacks can be made out of it.

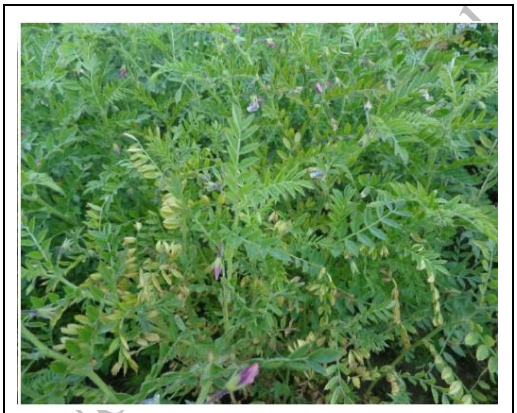

Fig. 5.1: **Chickpea**

Nutritive value:

- Protein -18.22%,
- Carbohydrate - 61-62%,
- Fat - 4.5%,
- Calcium - 280mg/100g,
- Iron - 12.3mg/100g,
- Phosphorus - 301mg/100g, 396 Kcal/100g

It has two types of varieties:

- **Desi Chana**: Smaller in size and angular seeds and is cultivated under dry lands.
- **Kabuli Chana**: Large in size with thin coats.

Verities:

Desi Chickpea varieties: KWR-108, KPG-59 (Pragati), Avarodhi, Pant G-186/114, Pusa-209/372/391, KGD-1168, GJ-11 etc.

Kabuli Chickpea varieties: C-104, L-144, Pusa-1003, K-4, KAK-2, Sadabahar etc.

Climate:

It requires good moisture condition with optimum temperature between 24-30°C. This crop is a winter season crop and does not tolerate frost, mainly at flowering stage, as it damages the seed development setting in pods. This crop requires an average rainfall of 65-90cm.

Soil:

Best soil suitable for cultivation of this crop is fertile sandy loam to clay loam with good internal drainage. Ideal soil, which is suitable for chickpea farming, should have pH value ranging from 5.5-8.0.

Field preparation:

For heavy soil, rough seed bed is prepared to avoid packing of cloddy surface die to winter rain and to accommodate soil aeration and easy seed germination. To retain sufficient moisture in soil, deep ploughing is required before the onset of monsoon.

Seed rate:

For small seed size: 60 kg/ha, medium seed size: 80-90 kg/ha, Bold seed size: 120-140 kg/ha

Plant density:

Timely sown: 30 x 10 cm^2, Late sown 25 x 10 cm^2, Irrigated 45 x 10 cm^2

Sowing time:

Optimum time for sowing is first fortnight of October, late sowing, up to the end of December, results in poor crop yield.

Crop rotation:

Crop rotation with other cereal crop is followed to control soil borne disease and to maintain the soil health. For example, Maize-Chickpea, Rice-Chickpea, Pearl Millet-Chickpea, etc.

Seed treatment:

Always employ FIR [Fungicide (2g Thiram+1g Carbendazim or Trichoderma @ 6-8g/kg of seed), Insecticide, and Rhizobium/PSB/PGPR] system.

Manures and Fertilizers:

It requires FYM @ 5t/ha and organic fertilizers N:P:K:Zn:S in the ratio 25:50:20:20:20 kg/ha. The fertilizers are applied using as basal application at the time of last ploughing.

Irrigation:

It requires light irrigation. Excessive irrigation reduces the crop yield. For better germination of seeds, it requires pre-sowing irrigation. Crop cannot tolerate water stagnation in field. First irrigation is at before flowering and second irrigation at pod filling stage.

Weed control and intercultural operations:

One hand is weeding is done after 4-5 weeks of sowing. After 2 months of sowing, second weeding is done. Pre-emergence herbicides Pendimethalin @ 1kg a.i./ha in 600-800 litres of water.

Harvesting:

As leaves turn reddish brown and starts shedding, the crop is ready for harvesting. Harvesting is done using sickle or hand.

Yield:

Average yield is 20-25 quintals/ha.

Plant protection measures:

Disease:

Ascochyta blight:

This disease is caused by *Ascochyta rabi,* a fungus that survives on plant debris left in the soil. Except the roots, all plant parts are affected. Small, round, yellowish-brown spots appear on the leaves in the months of January and February. The spots also spread to petioles and branches. The affected parts finally dried up.

Control measures

- Grow the resistant varieties.
- Follow a three-year crop rotation.
- Use only healthy seeds.
- Treat the seed with fungicides like Thiram or Captan (0.25%).

Wilt:

The symptoms of the disease appear at the seedling stage as well as at an advanced stage of plant growth. The wilting is characterized by gradual, sometimes sudden, yellowing, withering and drying of leaves followed by the drying of the entire plant or some of its branches. The main roots and base of stem tissues are blackened either uniformly, or especially in the early stages, in streaks.

Control measures

- Deep planting of gram about 8–10 cm deep in light soils reduces the incidence of gram wilt.

- Grow the resistant varieties.
- In fields with a heavy incidence of gram wilt, follow a three-year crop rotation.
- Treat the seed with Carbendazim or a mixture of Carbendazim and Thiram (1:1) at the rate of 2 g per kg of seed.

Insect-pest:

Cutworms:

Cutworm is a major pest in low-lying areas where fields are cloddy. The larvae of this insect remain hidden under these clods during the day and cause damage at night. The plants were cut at ground level by the caterpillars. For controlling cutworms, Lindane is applied as 6% granules @20-30 kg/ha mixed in the soil.

Gram pod borer:

This is the most serious pest of gram and causes damage up to 75 percent reduction in yield. The caterpillars not only defoliate the tender leaves but also make holes in the pods and feed on the developing grains. While feeding on the developing seeds, the anterior body portion of the caterpillars remains inside of the pods and rest half or so hanging outside. When the seeds of one pod are finished, they move on to the next pod. For controlling pod borer, spray endosulfan @35EC at the rate of 1.25 litres mixed in 1000 litres of water per hectare.

Cultivation technique of Field pea (*Pisum sativum* L.).

Nutritive value:

Field pea grains are highly nutritive and contain high content of digestible protein (7.2g/100g), Carbohydrate (15.8 g), Vitamin-C (9 mg), phosphorus (139 mg) and minerals.

Fig. 5.2: **Field pea**

Varieties:

The pea varieties may be grouped on various characters as given below:

1. Based on height of plant

- Bush or dwarf types
- Tall

Popular improved varieties of field pea are Rachana, Sapna, Shikha, Swati, Vikas, Pant matar 5, Malviya 5 & 15, Pusa Prabhat, Prakash, IPDF 10-12, Aman, Adarsh, Indra, Jai, etc.

Climate:

Optimum temperature for seed germination is 22°C. Even though seeds germinate at 5°C, their speed of germination is less. At high temperature, decaying and failure of seedlings is more. A crop may tolerate frost in its early stages, but it suffers, when it is in its blooming and fruiting stages. Optimum temperature for growth of field pea plants is 10-18.3°C. Temperature increase speeds up the maturation and thereby, decreases the crop yield. Quality of field pea grains also become poor at high temperature due to conversion of sugars into hemicellulose and starch.

Soil:

Field pea grows well in drained soil, whereas loose and friable loamy soil found suitable for higher growth and yield. Suitable pH is 6.0-7.5 for its cultivation. For better crop production, liming is recommended if soil is of acidic nature

Sowing time:

In North India, field pea is sown from the beginning of October to mid of November. Yield is drastically reduced when crop sowing is delayed. Early sowing of crop, in month of September, will be susceptible to wilt disease.

Sowing and seed rate:

Soil is prepared by one deep ploughing with soil turning plough followed by one or two harrowing. Seeds are sown in well-levelled and friable field through broadcasting or by dibbling at 2.5-5.0 cm depth. Early varieties are sown at a closer spacing of 30 x 5-10 cm and the seed rates is 100 - 120 kg/ha. Mid-season and late varieties are sown at wider spacing of 45 x 10 cm. Late varieties are sown on either edge of raised beds which are 120 - 150 cm wide with furrows in between them. Seed rate for late varieties is 80 - 90 kg/ha. Overnight soaking of seeds in water or GA_3 (10 ppm) improves germination percentage of seeds.

Manures and fertilizers:

Application of FYM @ 5t/ha and organic fertilizers N:P:K:Zn:S in the ratio 25:50:20:20:20 kg/ha as basal application at the time of last ploughing, and 25 kg/ha N at the time of pre-flowering.

Irrigation:

Two light irrigations at flowering and grain filling stages are required for optimum production of grain yield.

Weed Control:

Lasso (alachlor) @ 0.75 kg a.i. or tribunal @ 1.5 kg a.i./ha or pendemethalin 0.5 kg a.i. / ha as pre-emergence spray along with one hand weeding at 25-45 days after sowing is very effective for weed control.

Harvesting, threshing and storage:

Field peas should be harvested when the pods are ripped and threshed after drying in the sun. The clean seed should be dried under sun for 3-4 days so to reduce their moisture content up to 9-10% before storing it in bins.

Yield:

Field pea produces 25-28 quintals of grains per hectare.

Plant protection measures:

Disease:

1. Wilt

Symptoms

The symptoms of this disease appear during seedling stage. The symptoms include premature yellowing and withering of young leaves during seedling stage and advance stage. If crop is sown early, then this disease can cause maximum loss.

Control measures

- Seed treatment with Thiram (2gm.) + Carbendazim (1g/kg of seed)
- Adopt crop rotation
- Avoid early sowing in badly infested areas

2. Powdery mildew

Symptoms

The symptoms of this disease first appear on the leaves then on other green parts of the plant. They are characterized by patchy growth on both the surfaces of the leaf and also on the tendrils, pods and stem. In case of severe infestation, the plant dies prematurely.

Control measures

- Adopt resistant varieties like Pant Pea-5, Malviya-15, JP-885, HUP-2 etc.
- Spraying with Karathane @ 1 ml/liter or Wettable Sulphur @ 3 gm/litre or Dinocap @ 1 ml/litre of water and repeat after 10-15 days, if necessary
- Avoid late planting
- After harvest, collect the plants left in the field and burn them.

3. Rust

Symptoms

This disease is caused by fungus. The stem of the plant becomes malformed and the affected plant dies out. All the green parts of plant are affected. Yellow spots having aecia in round or elongated clusters. Then the uredo pustules develop which are powdery and light brown in appearance

Control measures

- After harvest, the affected plants trash should be burnt
- Spray the crop with Mancozeb 75 WP @ 2g/liter of water

Insect-pest:

1. Pea stem fly

The maggot of this insect damages the internal tissue and because of this, the entire plant dies. The damage is more acute when crop is sown early.

Control measures

- Mix 30 kg/ ha Carbofuran (Furadon) 3 % granules or 10 kg /ha Phorate (Thimet) 10 % granules in the soils before sowing the crop
- Avoid early planting.

2. Leaf miner

Larvae of this insect makes tunnel in the leaf causing severe damage. The damage is more during the month of December to March.

Control measures

- Spray 1 liter of Oxydemeton methyl (Metasystox) 25 EC in 1000 liter of water per hectare when the attack begins and repeat it at 15 days intervals.

3. Pea aphids

They suck the sap of the cells, owing to which the leaves turn pale and yellow. In case of severe infestation, the plant growth is checked. Ultimately, plant growth get stunted.

Control measures

- Spray 1.25 litre of Dimethoate 30 EC or Oxydemeton Methy (Metasystox) 25 EC in 1000 litre of water per hectare. Repeat the spray after 10-12 days.

4. Spiny pod borer

It is a polyphagous insect. Caterpillar makes hole in pods and feed upon developing seed. Late varieties are prone to more damage than earlier one.

Control measures

- Picking of green pods should be done 15 days after spraying.
- Spray of 1.25 liter of cypermethrin in 1000 litre of water per hectare is safe and effective.

Cultivation technique of Lentil (*Lens culinaris* L.)

Introduction:

Lentil, also called as Masur, is one of the major pulse crop rich in protein. It is mostly consumed as dal and also used to prepare various dishes. Dry leaves, stems and broken pods are useful as cattle feed. They are also a good source of starch for textiles and printing. It is mixed with wheat flour for production of bread and cake. At present, India is the highest producer of lentil in the world.

Varieties:

LL 699: This plant variety is short size with dark green leaves and matures early. This plant can be harvest in 145 days and they are resistant to pod

borer. They are also tolerant to rust and blight disease.

LL 931: This plant variety is short with dark green leaves and pink flowers. This plant can be harvest in 146 days and are resistant to pod borer.

Bombay 18: This plant can be harvest in 130-140 days.

DPL 15: This plant can be harvest in 130-140 days.

Pusa 4076: This plant can be harvest in 130-135 days.

Other varieties include Pusa Vaibhav, VL-4, Pant Masoor-4 & 5, KLS 218, Shekhar 2, Shekhar 3 and Pant Lentil 6, 7, 8, etc.

Land preparation:

For light soils, less tillage or manipulation of soil is needed for preparation of seedbed. For heavy soils, one deep ploughing followed by 3-4 cross harrowing. For soil pulverization, 2-3 ploughings are sufficient. For levelled field, proper distribution of water is required. At sowing, sufficient moisture is needed.

Climate:

Optimum temperature is 18-20°C with rainfall of 100cm and temperature of sowing and harvesting is 18-20°C and 22-24°C respectively.

Soil:

All type of soil is suitable except saline, alkaline and waterlogged soil. For proper placing of seed with uniform depth soil should be friable and free of weeds.

Sowing Time:

Mid of October to First week of November.

Spacing:

It is sown in lines 22 cm apart. In late sowing conditions, row spacing is reduced to 20 cm.

Sowing Depth:

Seeds is sown at depth of 3-4 cm.

Method of Sowing:

Pora method or seed-cum-fertilizer drill is used. It can also be sown by manual broadcasting.

Seed rate:

Optimum seed rate is 40-45 kg/ha.

Seed treatment:

Before sowing, seeds are treated with Captan or Thiram @ 3gm/kg as fungicide. For insecticide, chloropyriphos 20EC @ 8ml/kg of seed.

Cropping system:

Both sequential and intercropping is followed. In sequential cropping systems, paddy-lentil, maize-lentil, cotton-lentil, bajra-lentil etc. In intercropping systems, lentil + linseed (2:2), lentil + mustard (2:6) etc, is followed.

Fertilizers:

At sowing time, manuring with N:P:K:S:Zn is 20:50:20:20:20 (kg/ha) as basal application. Seeds treated with bio fertilizer viz. Rhizobium @ 25gram per kg of seed gives effective yield.

Weed management:

Main weeds are *Chenopodium album* (Bathua), *Vicia sativa* (ankari), Lathyrus *spp*. (chatrimatri) etc. It is managed by two hoeing at interval of 30 and 60 days. For effective weed control, pre-emergence application of Stomp 30EC @ 550ml/acre with one hoeing at 50 days after sowing is done.

Irrigation:

It is a rainfed crop and in irrigated conditions, it requires 2-3 irrigations. First irrigation should be 4 weeks after sowing and second irrigation at flowering stage. Pod formation and flower initiation are the critical stages of water requirement.

Harvesting:

When plant dry up and pods mature harvesting is done. At the time of storage, moisture content should be 12%. For threshing, plant is beaten with sticks and seed is cleaned and then dried in sun. Over-ripe seed is avoided as it results in yield loss.

Yield:

Average yield is 20-24 quintal of grain/hectare.

Plant protection measures:

Diseases:

1. Rust:

Yellow white pustules grow on branch stem, pods and leaves of plants. Plants dry up and show burnt appearance.

Control:

Spray of 400 gm M-45 @ 200 litre water per acre and use of tolerant varieties.

2. Blight:

Spots of dark brown colour forms on stem, leaves and pods and elongates to form concentric rings.

Control:

Spray of 400 gm Bavistin @ 200 litre water per acre. After harvesting, diseased plant debris is to be destroyed. Use of disease resistant varieties.

Insect - Pest

1. Pod borer:

Pod borer is a major pest that cause excessive loss of yield. It fed on green plant leaves, flowers, pod-grains, etc.

Control:

At flowering time, spray 900 gm Hexavin 50WP in 90 litre of water per acre and it can be repeated after 3 weeks, if necessary.

Cultivation technique of Pigeon Pea (*Cajanus cajan* L. Millsp.)

Introduction

Pigeon pea (*Cajanus cajan* (L.) Millsp.), commonly known as Arhar, red gram or tur, is a very popular old crop. After gram, Arhar is the second most important pulse crop in the country. People consumed it in the form of split pulse as 'dal'. Grains of Arhar are rich in iron, iodine, essential amino acids like lycine, threonine, cystine and arginine etc.

***Fig. 5.3:* pigeon pea**

Nutritive value:

Pigeon pea is a rich source of different essential nutrients

Protein - 22.3 %	Calcium -73 mg/100 g
Fat -1.7 %	Phosphorus -304 mg/100 g
Minerals -3.5 %	Iron -5.8 mg/100 g
Fiber -1.5 %	Moisture -13.4%
Carbohydrate -57.6 %	Calorific value -335 Kcal/100 g.

Varieties: The cultivars/varieties of pigeon pea are based on crop duration as given below:

• **Short duration (110-140 days):** UPAS 120, T 21, Manak, Paras, Pusa 992, Pusa arhar 16.

• **Medium & medium late duration (150-180 days):** WB 20, Asha, DA 11, MA3.

• **Long duration (230-270 days):** T 7, T 17, Bahar, Pusa 9, Amar, NDA 1,2&3, Azad, MA 6 &13, IPA 203.

Climate:

Pigeon pea is a crop of tropical areas, mainly cultivated in semi-arid regions in India. It can be grown with a temperature ranging from 26^{0}C to 30^{0}C in the rainy season as a main Kharif crop (June to October), and 17^{0}C to 22^{0}C in the post rainy as a pre-rabi season crop (November to March) season. Pigeon pea is very sensitive to low radiation at flower and pod initiation stage therefore, during the monsoon and cloudy weather, it leads to flower drop and poor pod formation.

Soil:

Pigeon pea successfully grows in well-drained black cotton soils with a pH ranging from 7.0 - 8.5. One deep ploughing with soil turning plough followed by two ploughing with cultivator or desi plough and planking is good to proper growth and development of crop.

Sowing time:

- **Early maturing varieties** - First fortnight of June
- **Medium & late maturing varieties** - Second fortnight of June.

Sowing method:

Line sowing by desi plough/seed drill or by dibbling on the ridge are recommended as per the need of a particular area and cropping system.

Seed rate:

The seed rate of pigeon pea depends on the desired plant density and variety (early, medium or late) and cropping system (pure crop, mixed crop, or inter crop).

- **For Early Maturing Variety**: 20 - 25 kg/ha (Row to Row - 45 - 60 cm & Plant to Plant - 10 - 15 cm)
- **For Medium/Late Maturing Variety**: 15 - 20 kg/ha (Row to Row - 60 - 75 & Plant to Plant - 15 - 20 cm)

Seed treatment:

Seed should be treated before sowing with fungicide like Thiram (2gm) + Carbendazim (1gm) or Thiram @ 3 gm or *Tricoderma virdie* 5 - 7g/kg of seed.

They should also be inoculated with bio-fertilizers/culture like Rhizobium and PSB culture @ 200g (one packet) with 10 kg of seed.

Inter-cropping:

Pigeon pea is commonly intercropped with a wide range of crops. In India, it was estimated that 80-90 % of the pigeon pea were intercropped:

- With cereals (like sorghum, maize, pearl millet, finger millet and rain-fed rice).
- With legumes (like groundnut, cowpea, Mung bean, Black gram and soybean).
- With long-season annuals (like caster, cotton and sugarcane).

Manures and fertilizers:

It requires FYM @ 5 Tonnes / ha and organic fertilizers N:P:K:Zn:S in the ratio 25:50:20:20:20 kg/ha. The whole number of fertilizers are applied as basal application at the time of last ploughing.

Irrigation:

Two light irrigations are required at flowering and grain-filling stages are required for optimum production of grain yield.

Weed control:

Pre-emergence application of Lasso (Alachlor) @ 0.75 kg a.i. or Tribunal @ 1.5 kg a.i./ha or Pendimethalin 0.5 kg a.i. / ha as a spray is very effective for weed control. First 60 days is very critical for the growth and development of Arhar crop. Two mechanical weedings, first one at 20 - 25 days and another at 45 - 50 days after sowing but before flowering, are sufficient to control the weeds up to its economical production.

Harvesting & threshing:

Best time for harvesting pigeon pea is when two-third to three-fourth of its pods are matured and changes its colour from green to brown colour. The plants are usually cut with a sickle within 25 cm above the ground. Harvested plants should be left in the field for sun drying for 3-5 days depending on season.

Threshing is done either by beating the pods with stick or using Pullman thresher. The proportion of seed to pods is generally 50-60%. The clean seeds should be sun dried for 3-4 days to bring their moisture content at 9-10% so to safely store it in appropriate bins.

Yield:

Early and medium maturing crop produced 15-20 quintal/ha, and Late maturing crop produced 25-30 quintal /ha according to particular area, cropping system and variety.

Storage:

To avoid further development of bruchids and other storage pests, fumigate the storage material before onset of monsoon and again after the monsoon with ALP @ 1-2 tablets per tonne. The small quantity of the produce can also be protected by mixing inert material (like soft stone, lime, ash, etc.) or by smearing edible/non-edible vegetable oils or by mixing plant products like neem leaf powder at the rate of 1-2% w/w basis

Plant protection measures:

Disease:

1. Wilt

Symptoms

Black streaks and dark purple bands appear on the stem surface of the plants that are extending upwards from the base. The main stem of such plants is split open and in it intensive blackening of the xylem can be seen. In humid weather, a pinkish mycelial growth is commonly observed the basal portions of the wilted plants. It may be seen in seedling, flowering & at vegetative stage.

Control measures

- Seed Treatment with *Trichoderma viride* @ 10 g/kg of seed or Thiram (2 gm) + Carbendazim (1gm) / kg of seed
- Soil application - *T. viride* – 2 .5 kg/ ha + 50 kg of well decomposed FYM or sand at 30 days after sowing
- Mixed cropping with sorghum
- Uproot wilted plants
- Avoid over or under watering plants
- Amendment of soil with oil cakes, appliances of trace elements such as boron, zinc and manganese and heavy dose of green leaf manure crops
- Grow resistant varieties like Amar, Azad, Asha (IPCL - 87119) etc.

2. Sterility mosaic disease

Symptoms

Mosaic virus is the cause of this disease. It spreads from plant to plant under field conditions through Eriophyid mite. Leaves become small and cluster near branch tips, and reduced in size. Plants are pale green and bushy in appearance, without of flowers and pods. Diseased plants are usually in groups. It may be seen in vegetative growth and pre-flowers stage

Control measures

- Spray Fenazaquin 10 EC (Magister) @ 1 ml/litre of water on 45 and 60 DAS
- Rogue out the infected plants in the early stages of growth
- Crop rotation with non-host crop like tobacco, sorghum, pearl millet, cotton
- Grow resistant varieties like Pusa-885, Asha, Sharad (DA11), Narendra Arhar1, Bahar, etc.

3. Phytophthora blight

Symptoms

Foliage blight symptoms are circular or irregular water-soaked lesions on leaves. The lesions on stems and branches increases rapidly, girdles, cracks and dries the stem. Infected stem and branches break easily in the wind.

Control measures

- Seed treated with Metalaxyl 35 WS @ 3 g/ kg of seed
- Good drainage in the fields and the plants should be protected from stem injury
- Follow crop rotation

4. Alternaria blight

Symptoms

Symptoms of this disease appear on all aerial part of plants are small, circular, necrotic spots that develop quickly, forming typical concentric rings. The spots are initially light brown and later turn dark brown. In severe infection, defoliation and drying of infected leaves, branches and flower buds.

Control measures

- Spray the crop with Mancozeb 75 WP @ 2g/liter or Carbendazim 50 WP @ 1g/liter of water;
- Cultivation of pigeon pea on ridges with proper drainage system and avoiding the sowing in heavy soil helpful in disease management;
- Grow resistant varieties like MA 128-1, MA 128-2.

Insect-Pests

1. Pod Borers

Nature of damage

It is widely distributed and is the most injurious pest of early and medium maturing varieties. The larvae, after hatching, feed on tender leaves and twigs but, at pod formation, they puncture pods and feed on developing grains. It may be seen in vegetative and podding stage.

Control measures

- Use *H. armigera* pheromone trap @12/ha
- Spray the crop with Emamectin benzoate 5% SG @220 g/ha. or Indoxacarb 15.8% SC @ 333 ml/ha
- The caterpillar should be picked by hand after shaking the plants and destroyed in the early stages of attack.

2. Tur Pod Fly

Nature of damage

Stripes can be seen on the surface of the affected grains while the attacked pods are somewhat twisted or deformed. In case of severe damage, as many as 80 percent pods and 60 percent grains may be damaged respectively.

Control measures

- Spraying Neem seed kernel extract (NSKE) 5 per cent at 50% flowering stage to manage the insect's populations
- Pest can be controlled by spraying the crop with Monocrotophos (Nuvacron) 36 SL 1 litre in 800 - 1000 litres of water per hectare.

3. Plume Moth

Nature of damage

Plume Moth larvae damages seed as well cause the flowers, buds and pods to drop. The caterpillar is of greenish - brown in colour and fringed with short hairs and spines. It also enters into the pod and feeds on developing grains.

Control measures

- Apply the Neem oil 2%
- Spray the crop with Azadirachtin 0.03 % WSP 2500 - 5000 g/ha or Emamectin benzoate 5% SG @220 g/ha or Indoxacarb 15.8% SC @ 333 ml/ha.

4. Pod-sucking bugs

Nature of damage

Damaged seeds become shriveled, and develop dark patches. Shedding of green pods.

Control measures

- Soil application of carbofuran 3G @15 kg/ha at sowing;
- Spray the crop with Ha NPV 3 x1012 POB/ha in 0.1% teepol;
- Immature bugs can be handpicked and destroyed;
- The main natural enemies of bugs are egg parasitoids, ants and birds reported reduce feeding by green shield bugs;
- Spraying with aromatic plants (e.g. gums, lantana, Neem-based pesticides)

Cultivation technique of Black Gram (*Vigna mungo*)

Introduction:

Black gram, also known as Urd, is another major pulse crop grown in India. It is rich in phosphoric acid and also contains 25% protein, 60% carbohydrate and 1.3% fat. Mainly it is consumed as dal and is the main constituent of idli, dosa, papad. It act as a nutritive fodder for milch cattles. It is a good green manuring crop as it improves fertility of soil and provides a good foliage cover that helps in controlling soil erosion.

***Fig. 5.4:* Black gram**

Varieties:

- BDU-1 is a bold seeded variety with 70-75 days.
- Pant U-35 is a medium black seeded variety with high yield with 80-85 days.
- Pusa-1 is resistant to yellow mosaic virus.
- Pant U-30 is hairy and black pod variety with 68-75 days.
- KU 92-1, KU-301, KU- 96-3, KU 309, Pant U 31, KU 99-2.1

Climate:

It requires hot and humid condition for its best growth with optimum temperature of 25-30°C and having annual rainfall of 60-75 cm. It grows mainly in kharif/rainy and summer season. Heavy rain is harmful during flowering stage.

Soil:

Best soil suited for urban is loam or slightly heavy soil with neutral pH but it can also be grown in all types of soil except alkaline and saline soils. For better plant growth, soil should have good water holding capacity and should be well drained. Avoid waterlogged soil as it reduces yield.

Land preparation:

For kharif season, land is ploughed in summer season followed by 2-3 harrowing at pre-monsoon. Well-levelled land is needed. Clean the field by collecting weeds, previous stubbles of crops, and stones before sowing. At last harvesting, 5-6 tons

of FYM or compost is mixed into the soil. One pre-sowing irrigation is given, if needed.

Sowing:

For sowing, selected seed should be free from insect, pest, diseases and inert material like dust particles, weed seeds and vegetative part of weeds etc.

Sowing method:

It is done through either in-line sowing or drilling method with tractor drawn Seed-cum-fertilizer drill for application of fertilizers and seed sowing at a time. Sowing depth should not be more than 5-6 cm.

Sowing Time:

- For kharif season: 2nd fortnight of June (15-30 June).
- For summer season: 3rd week of Feb - 1st week of April Avoid late sowing.

Seed treatment:

Treat the seeds with Thiram @ 2.5 g / kg seed or with Rhizobium culture for atmospheric N fixation.

Seed rate and spacing:

- For kharif season, seed rate is 12-15 kg/ha with 30×10cm spacing.
- For summer season, seed rate is 20-25 kg/ha with 20-25×10cm spacing.

Fertilizer management:

Optimum dose required is in the ratio of N:P:K:S:Zn is 20:50:20:20:20 (kg/ha) at sowing time as basal application.

Irrigation Management:

In summer and Kharif season, irrigation is given as per critical stages and availability of water. Irrigation is given at an interval of 10-15 days. There is a need for sufficient moisture from flowering to pod development stage.

Weed management:

Depending on weed intensity, 1-2 hand weeding is done up to 40 days of sowing. Use herbicides i.e. Fluchloralin (Basalin)/ Pendimethaline 1 kg a.i. / ha in 800-1000 litres of water as pre-planting application.

Harvesting:

At harvesting, moisture percentage should be in range of 20-22. The crops are said to be ready for harvesting when both pod and plant dries and grains become hard. Common problem occur during harvesting is shattering of pods therefore picking is done as soon as pods get mature. Threshing is done manually or through machine, when pods or whole crops become dry.

Yield:

Optimum yield is 12-15 quintal of grain/hectare.

Disease and pest management-

Disease:

1. Leaf spot:

Appearance of angular brown or red spots, with grey or brown centre and reddish-purple border on leaves, stalk and pods.

Control measures:

Spray Bordeaux mixture (5:5:50) or 0.2% Ziram.

2. Powdery mildew:

On leaves and other green parts, white powdery patches appear which become dull and studded with black dot.

Control:

Dust with finely powdered sulphur (200-mesh) @ 20kg/ha.

Insects-Pests:

1. Aphids:

Aphids affected leaves turns yellow, wrinkled and distorted. They also exude honeydew that develops fungus and rapidly covers plant with sooty mould that interferes with photosynthesis of plant.

Control measures:

Spray 0.05% Endosulfan, 0.02% Phosphamidon, 0.03% Dimethoate, Methyl demeton or Thiometon.

2. Thrips:

Light brown patches appear on infested leaves that curl and become dry.

Control:

Spray 0.05% Endosulfan, 0.02% Phosphamidon, 0.03% Dimethoate, Methyl demeton or Thiometon.

Cultivation technique of Green Gram (*Vigna radiata*)

Introduction:

Green gram, also known as Moong, is another major pulse crop grown in India. It is consumed as pulse/ dal and also made into flour. It is rich in protein. Straw and husk part of the green gram is used for cattle feed. For aged or ill people, kichadi, made out of moong dal, is easily digestible. It helps to lose weight, is a good source of fibre and iron, and helps in controlling blood pressure as well.

***Fig.5.5: Green* gram**

Varieties:

T-44, K-851, KM-2195, KM-2241, ML-613, Asha, IPM 2-3, IPM 0-14, IPM-99-125, HUM-1, HUM-16, Pusa Vishal, Pant Mung-4 are some of the major varieties of green gram.

Climate:

Warm humid climate with temperature ranging between 25-35°C and with moderate rain of 85-100cm is the best-suited climate for growing green gram. During flowering, heavy rain is harmful.

Soil:

In northern India, a deep well-drained loams in the alluvial are best suited whereas in southern India, red and black soils of peninsular are best suited for cultivation of green gram. Light or shallow stony soils to clayey soils can also use for cultivation of green gram.

Land preparation:

In kharif season, land is ploughed once or twice and harrowed to obtain a rough tilth for pure crop. For summer crop, it is sown dry in furrows and in between the rows of the previously grown crop and then it is irrigated.

Sowing time:

- **For Kharif** - sowing is done in June to July.
- **For Rabi -** sowing is done in September or 1st week of October.
- **For Summer -** sowing is done by March to 15 April.

Sowing method:

Seed is sown by broadcasting or can be drilled in furrows behind a plough or in rows with 25-30 cm apart.

Seed rate: Optimum seed rate is 12-15 kg/ha.

Seed treatment:

Seeds are first treated with biocontrol agent and then with Rhizobium. One day before sowing, seed is treated with Thiram or Carbendazim at 2 gm/kg of seeds. It is also treated with Pseudomonas fluorescence @ 10 gm/kg of seed or with talc formation of *Trichoderma viride* @ 4 gm/kg of seed.

Fertilizer management:

At sowing time, manuring with N:P:K:S:Zn is 20:50:20:20:20 (kg/ha) as basal application. Seed is treated with bio-fertilizer viz. Rhizobium @ 25 gm/kg of which makes seeds to give effective yield.

Irrigation:

In summer, irrigation is given at an interval of 8-10 days. As it is kharif crop, it does not require irrigation unless there is dry spell. Critical stage of irrigation is flowering and pod filling stage.

Weed management:

Spray weedicide within 3 days of sowing i.e., 2ml of Basalin per litre of water is used. It can damage the crop, if done late. For managing later emergence of weeds in crop, manual weeding is done 1 month after sowing.

Harvesting:

To avoid losses due to pod shattering, crops are harvested before it is dead ripe. 1-2 rounds of picking of pods are recommended. The plants are uprooted or cut by the use of sickle and then dried on threshing-floor for a week or 10 days. Threshing is done by beating with sticks and then winnowed with baskets.

Yield:

For a pure crop, average yield is 6-8 quintal/ha in Zaid/spring season. Optimum yield is 10-15 quintal/ha in kharif season.

Pest and disease management:

Pest and disease management same as Black gram.

Activities

Demonstrate cultivation practices of pulse crops.

Material required - Seed, Field, Fertilizer, Measuring tape, Pen, Pencil, Notebook, etc.

Procedure:

- Select the field for cultivation of pulse crops.
- Prepare the field as per crop requirements.
- Apply manures and fertilizers at the recommended basal dose
- Treat and sow the seed in field.
- Demonstrate the processes of fertilizer application, irrigation, weed management, insect-pest and disease management, and harvesting of chickpea.
- Note down your observations in a practical notebook.

Check Your Progress

Fill in the Blanks

1. Vigna mungo is the botanical name of ……
2. Pigeon pea was intercropped with cereals viz…… & ……
3. LL 669 & LL 931 varieties are resistant to……in lentil.
4. India ranked …… in area and production in chickpea.
5. UPASI 120 is the short duration variety of ……

Multiple Choice Questions

1) Protein content in chickpea is…… %.

   a) 12-15

   b) 17-20

   c) 22-25

   d) 27-30

2) Seed rate of green gram or moong is ……. kg/ha.

   a) 20-25

   b) 18-20

   c) 8-10

d) 12-15

3) BDU-1 is a bold seeded variety of .....
   a) Greengard
   b) Black gram
   c) Bengal gram
   d) red gram
4) Avarodhi is a variety of .....
   a) Chickpea
   b) Pigeon pea
   c) Field pea
   d) Garden pea
5) Sterility mosaic disease is a serious problem in .....
   a) green gram
   b) Black gram
   c) Pigeon pea
   d) Lentil

Match the Columns

A	B
1) Lentil	a) 22.3
2) Pigeon pea	b) Pusa 1
3) Kabuli chickpea	c) Bombay 18
4) Greengard (Moong)	d) C-104
5) Field pea	e) Digestible protein (7.2g/100g)
6) Black gram	f) Vigna radiata

Subjective Questions

1) Describe the improved cultivation practices of chickpea.
2) Write short notes on the following:
   a. Seed treatment
   b. Land preparation for pulses

c. Wilt disease in pulses

d. Powdery mildew in pea

3) Describe the improved cultivation practices of pigeon pea.

Module 6
Basics of Farm Management and Marketing

Module Overview

It is the need of hour to go for sustainable regenerative agriculture by judicious use of all available farm resources. Efficient farm management is must for reducing the cost of cultivation with rational use of all available farm resources to make the agriculture more productive without deteriorating the quality of natural resources. Beside this, there should be proper knowledge about the price and demand of the produce in the market for maximizing the farm profitability.

Learning Outcomes

After completing this module, you will be able to:

- Explain pulse cultivation operations, various cropping systems and their benefits.
- Demonstrate financial management practices for pulse farming.
- Explain different markets and marketing channels for pulse crops.

Module Structure

- Session 1: Farm Management of Pulse Cultivator
- Session 2: Cropping System
- Session 3: Financial Management
- Session 4: Classify Markets and Marketing Channels
- Session- 5: Basic Market Information

Session 1: Farm Management of Pulse Cultivator

Information related with farm management will help in development of proper farm planning as per the available fund and farm resources, which will facilitate in increasing farm productivity and profitability.

Farm: It is a piece of land that is cultivated for raising crops and rearing of livestock enterprises.

Management: It is the process of farm planning and maintaining an environment to accomplish selected aims within the timeline with the available

resources. It involves technological interventions, farm mechanization and judicious use of available farm resources for sustainable agriculture production.

Farm plan: It is a strategic programme comprising entire farm activities to be taken for achieving the set production target. Farm plan is having detailed information pertaining various enterprises to be taken up on the farm along with their cultural practices, besides determining need of capital, manpower and other infrastructures.

I. Farm management:

Farm Management may be defined as the science that deals with the efficient utilization of the available farm resources to maximise the farm productivity and profitability in sustainable manner. It deals with the principles of farming on an individual farm. It applies the judicious use of available farm resources for sustainable crop production and profit maximization.

Scope of farm management:

Farm Management prioritize the allocation of available resources at each individual farm for their judicious use. Individual farm act as a unit of farm management. It helps the farmer in finalizing the plan like what to produce, how to produce and how much to produce etc. It covers all aspects of farming which can have effects on the economic efficiency of farm.

II. Farm resources requirement

Farm resources fall into two broad categories:

a) Fixed resources

b) Short-term or variable/operational resources

Fixed resources: It includes the permanent items that provide services over a number of years. For example, land, machinery, irrigation system, etc. These services either may be used by an individual or an enterprise to maintain the farm as a whole.

Short-term or variable/operational resources: These are those items that are used up in the annual production cycle. For example, seed, fertilizer, fuel, pesticides, man-days, etc.

The major difference between fixed and short-term resources are that the former provide a stream or flow of services over time while the later consist primarily of quickly exhaustible material things or time-bound institutional sanctions.

Farm resources fall into five categories based on planning and operational, as below:

(1) ***Long-term material:*** It consists of items that provide their services for a relatively longer period. Generally referred as fixed resources or fixed capital e.g. Land. Other examples of resources in this category are irrigation systems and farm sheds generating their services over 20 to 30 years.

(2) ***Short-term material:*** This category includes items such as seed and other seasonal inputs. In a commercial environment, where these items are purchased, the production constraint is generally set by the amount of money available to buy them, not by the supply of these items in themselves.

(3) ***Financial:*** This category consists of cash, debts receivable, and access to credit from formal (banks, cooperatives) and informal (shops, traders, relatives) sources.

(4) ***Institutional:*** It consists essentially of rights of access to materials, markets and services. It accounts the form of land and road taxes, water-use license fees, payments for production-quota rights.

(5) ***Labour:*** This consists of family labours available for general farm work or which might be available only for specific activities.

III. Crop Planning

It includes the decision regarding selection of crops to be grown, determination of crop acreage and their allocation to plots as per the soil type, resource availability, risk taking ability and market demand. It clearly mentions about the nature of crop selection (cereal/pulse/oilseed or drought/flood tolerant or seasonal/annual/perennial) and suitable area for the crop cultivation as per the topography, soil type and resource availability.

Wet-Land	(suitable for paddy)	0.75	ha
Upland	(suitable for pulse)	0.75	ha
Orchard	(inter-cropping with pulses or vegetables is profitable)	0.50	ha

It includes the consideration of spatial and temporal availability of available farm resources, demand and supply in the market and accordingly selection of crops and other enterprises used to be worked out to maximizing the farm productivity and profitability in sustainable manner.

Activities

Activity 1: Visit a nearby farm and demonstrate farm management process.

Material required: Pen, Pencil, Notebook, etc.

Procedure:

- Select and visit a nearby farm.
- Note down the names of different types of farm resources.
- Discuss with the farmer about utilization of farm resources.
- Discuss with the farmer about crop planning.
- Note down your observations and present them before class.

Activity 2: Visit a nearby farmer field

Material Required: Farmers field, pen, pencil, notebook, etc.

Procedure:

- Visit farmers field and note down the observations of following details:
  - Name of the Farmer
  - Size of the land holding
  - Season
  - Cropping system and cropping intensity
  - Name of the crop
  - Name of the variety and date of sowing
  - Crop insurance
  - Soil health
  - Source of irrigation
  - Tools/Implements used
  - Seed rate and crop spacing
  - Seed treatment (mention the fungicide and rate)
  - Fertilizers and manures applied
  - (time, quantity and source)
  - Insect-pest and disease management
  - Harvesting and Yield
  - Any other remarks

Check Your Progress

Fill in the Blanks

1. Farm management may be defined as the science that deals with the…… and…… of the farm.

2. Farm Management help the farmer in deciding the issues like..... to produce.
3. ..... includes the permanent items which provide services over a number of years.
4. ..... consists of items which provide their services for a relatively longer period.
5. ..... includes the decision regarding selection of crops to be grown.

Multiple Choice Questions

1. Suitable area for the crop cultivation is selected as per the...

(a) Topography

(b) Soil type

(c) Resource availability

(d) All of the above

2. ...farm resource consists essentially of rights of access to materials, markets and services.

(a) Institutional

(b) Financial

(c) Short - term

(d) Long-term

3. Short-term or variable/operational resources are

(a) Seed

(b) Fertilizer

(c) Fuel

(d) All of the above

4. Crop planning includes the consideration of.....and..... availability of available farm resources.

(a) Spatial

(b) Temporal

(c) Both

(d) None

5. ..... is the process of farm planning and maintaining an environment to accomplish selected aims within the time line with the available resources.

(a) Farm

(b) Management

(c) Farm Plan

(d) Resource

Match the Following

A	B
1) Short-term resources	a) Paddy
2) Fixed resources	b) Pesticides
3) Wet-land	c) Intercropping
4) Orchard	d) Land

Subjective Questions

1. What is farm management?
2. Describe the different farm resources.
3. Define the scope of farm management.

Session 2: Cropping System

Remunerative and location specific cropping system coupled with financial management skill will pave the path for sustainable agriculture production and increasing farmer's income. Good financial management will help in best utilization of available funds and government schemes thereby improving socio-economic conditions of the farmers.

Cropping systems

It involves cropping pattern of a farm and their interaction with available farm resources, various farm enterprises with the use of suitable technologies for maximising the productivity and profitability of farm.

Basic principles of cropping systems

1. Selection of complement crops.
2. Adoption of crop rotation to utilize available farm resources judiciously.
3. Selection of crops and cropping system that maintains/improves soil fertility.

4. Selection of crops having diversity in growth pattern.
5. Strategically plan, with needful and timely modification in the production technology in the cropping system, on the basis of regular and frequent monitoring of the farm to maximize crop productivity and profitability.

Types of cropping systems

Cropping systems are broadly classified into three types depending on the resources and technology available as follows:

1. Sole cropping: Growing of only a single crop during one agricultural year.

2. Mono cropping or monoculture: Mono Cropping refers to growing of only one crop, may be more than once in an agricultural year, on same piece of land year after year. Generally growing of paddy, sorghum etc. crops under rainfed conditions year after year due to limitation of rainfall. Similarly, cultivating rice/makhana/jute crops in water logged areas are known as Mono cropping or Monoculture.

3. Multiple cropping: Multiple Cropping refers to growing of two or more crops on the same piece of land in succession within one agriculture year. For example, Rice-Wheat-Moong or Maize-Wheat etc. It aims to maximize the production per unit area per unit time while offering the multiple use of available farm resources. It is the intensification of cropping in time and space dimensions. It includes inter-cropping, mixed cropping, sequence cropping, etc.

I. Intercropping

Growing of two or more than two crops simultaneously on the same piece of land in a definite row ratio. It acts as an insurance against crop failure under rainfed/adverse conditions. For example, Wheat + Mustard in 8:1 ratio or Sorghum & Tur in 4:2 ratio. It may be further classified as:

i) Additive series: Intercrop is introduced in the base crop with 100% plant population of base crop. It is done by adjusting or changing crop geometry. It is mostly used in India. For example, Rabi Maize + potato (1+1)

ii) Replacement Series: Both the crops are component crops. It is done by sacrificing certain proportion of population. It is mostly used in western countries. For example, Wheat + Mustard (8:1).

Advantages of intercropping: Improvement in yield and soil fertility with inclusion of legume crop in intercropping system, minimizing crop diseases and pests' problem, increase in income and higher profit, reduction in soil runoff and controls weeds, results in more climate resilient crop production.

Disadvantages of Intercropping: Difficulty in fertilizer application in one crop, adoption of farm mechanization or improved implements, difficulty in harvesting.

There are two prominent interactions in intercropping:

Allelopathy: Some crops may be unsuitable to be grown as intercrops because they may produce and excrete toxins into the soil that are harmful to other components.

Annidation: The complementary interaction between intercrops in the intercropping system that occurs in both space and time.

Principles to be followed for realizing the benefits of intercropping:

1. Component crop should be less competing with the base crop
2. Peak nutrient demand period of component crop should be different from the base crop.
3. Minimum difference of 30 days should be there in between the components crop and base crop.
4. Selection of compatible genotypes of component crops increases the complementarities of intercropping system.
5. Diversity in growing pattern and nutrient requirement in component and base crops.

Evaluation of intercropping system: Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) helps in evaluation of the yield advantage in intercropping system.

II. Mixed cropping

When two or more crops are grown simultaneously, either by mixing seeds or sowing component crops separately without any definite row arrangements on the same piece of land, the practice is known as mixed cropping. For example, Groundnut + Sunflower, Groundnut + Mustard, or Wheat + Gram.

Crop Rotation

It is the cultivation of crops in a sequential order on the same piece of field during an agriculture year.

Principles of crop rotation:

1. Leguminous crops, like moong, urd, chickpea, lentil, etc., should be grown before or after non-leguminous crops because legumes fix atmospheric nitrogen into the soil and helps in improving the soil fertility status.
2. Crops having deep tap root system, like cotton, should be followed by those which have fibrous and shallow roots, like sorghum or maize, to ensure better nutrient uptake from entire root zone of the soil.
3. Less exhaustive crops should be cultivated after harvesting of exhaustive crops, like potato, sugarcane, maize etc., which need more inputs especially heavy fertilizer doses.
4. Crops of same family should be avoided in succession as they act as alternate hosts for insect pests and diseases.
5. The crop selected should suit the soil and Agro-ecological conditions.
6. Selection of crops should be based on the situations such as;
   a. Raising of drought tolerant crops under rainfed situations to overcome drought conditions.
   b. Salt tolerant crops/varieties should be grown in salt affected soils.
   c. In low-lying and flood prone areas, crops that can tolerate water stagnation should be selected.
   d. Erosion resisting crops should be grown on sloppy lands.

Advantages of ideal crop rotation:

i. Crop rotation restores soil fertility by fixing atmospheric nitrogen, encourages microbial activity and maintains physio-chemical properties of the soil.

ii. Alternate cropping with other crops helps in controlling crop bounds weeds.

iii. Suitable crop rotation aids in judicious and efficient use of all available inputs and resources.

iv. The farmer gets a better price for his produce because of its higher demands in the market.

v. Growing crops of different nature utilizes residual moisture, fertilizer and organic residues in best way.

vi. Need of the family i.e., feed, food, fuel, fibre, spices and condiments, sugar etc., should be fulfilled to the extent possible.

Legume effect: Legumes increases the soil nitrogen (N) status through fixation, excretion or in absence an effective N fixing system. Thus, they have potential for self-sufficiency for N, the nutrient most limiting to productivity. Hence, with the overall view of maintaining soil fertility and economizing on fertilizer, it is beneficial to include legumes as components of intensive cropping systems.

Cropping intensity

Cropping intensity is defined as the number of crops grown by farmers on the same piece of land in a single agriculture year. It is another means for intensifying production on the same piece of land.

Gross cropped area: the total area that has been sown once, twice, or more in a given calendar year is counted for each sowing that took place during that year. This total area is sometimes referred as the total cultivated area or the whole area that has been sown.

Net cultivated area: It indicates the total area that has been cultivated with crops. The area that is cultivated more than once in a single year is only counted once.

$$\textbf{Cropping intensity (\%)} = \frac{\textbf{Gross cropped area}}{\textbf{Net cultivated area}} \times 100$$

Activities

Activity 1: Visit a nearby farmer field and collect the information on cropping system.

Material required: Pen, Pencil, Notebook, etc.

Procedure:

- Select and visit a nearby field.
- Observe and note down the different types of cropping systems followed by farmer.
- Discuss with farmer about intercropping and crop rotation.
- Discuss with farmer about principle of crop rotation.
- Observe and identify the crop suitable for intercropping and crop rotation.
- Note down your observation and present them before class.

Activity 2: Calculate cropping intensity

Material required: Pen, Pencil, Notebook, etc.

Exercise 1. If farmer has 10 ha of land in which Black gram is grown in 10 ha in kharif season and chickpea is grown in 10 ha in rabi season calculate cropping intensity of the land.

Procedure:

Answer 1.

It refers to raising of a number of crops from the same field during one agricultural year. It can be expressed through the following formula.

$$\text{Cropping Intensity} = \frac{\text{Gross Cropped Area}}{\text{Net cultivated Area}} \times 100$$

Gross cropped area= 10 ha in kharif + 10 ha in rabi

Net cropped area = 10 ha

$$\text{Cropping intensity} = \frac{20}{10} \times 100 = 200\%$$

Check Your Progress

Fill in the Blanks

1. Cropping system are broadly classified into ..... depending on the resources & technology.
2. ..... growing of only a single crop during one agricultural year.
3. ..... growing of two or more crops on the same piece of land in succession within one agriculture year.
4. ..... was originally practiced as an insurance against crop failure under rainfed condition.
5. There are ..... prominent interactions in intercropping.

Multiple Choice Questions

1. Growing of two or more crops simultaneously on the same piece of land with a definite row arrangement is known as

A) Intercropping

B) Sole cropping

C) Mixed cropping

D) Multiple cropping

2. Complementary interaction which occurs both in space and time is called

A) Annidation

B) Allelopathy

C) Both (A) and (B)

D) None of these

3. Cultivation of crops in a sequential order on the same piece of field during an agriculture year is called…

A) Land rotation

B) Cropping pattern

C) Cropping system

D) Crop rotation

4. It refers to growing of only one crop may be more than once in an agricultural year on same piece of land year after year

A) Monoculture

B) Mono cropping

C) Both (A) and (B)

D) Sole cropping

5. Intercrop is introduced in the base crop with 100% plant population of base crop

A) Additive series

B) Replacement series

C) Both (A)and (B)

D) None of the above

Match the Following

A	**B**
1) Leguminous crops	a) Sorghum or maize
2) Shallow rooted crops	b) Moong, urd, chickpea
3) Additive Series	c) Wheat + mustard (8:1)
4) Replacement Series	d) Rabi Maize + potato (1+1)

Subjective Questions

1. What are cropping system?
2. Write principles of cropping system.

3. Write advantages & disadvantages of intercropping.

Session 3: Financial Management

Farm Financial Management is concerned with the planning and execution of decisions that affect the profitability of individual farm. It should consider various points like, what should be produced, how much should be produced, how much to invest, whether land and permanent equipment should be rented or purchased, which production technology should be adopted and where to sale the produce, etc. Better understanding of the above-mentioned queries will help in good financial management by doing mid-term corrections that will result in better agricultural practices and increasing farmer's profitability.

Tools required for farm financial management

1). Farm records: It helps in understanding and identifying the problems and opportunities to increase the farm productivity and profitability.

2). Farm budgeting: It helps in comparing and prior analysis of various farm alternatives on paper before capital investment.

Need of farm records

- It helps in getting information for making better business plans and decisions.
- It helps in determining most suitable and profitable production practices.
- It guides in identifying problems in individual crop and livestock enterprises.
- Proper analysis of farm records helps in determining most profitable and promising farm enterprises.

Input and output requirement

1. **Inputs in agriculture:** Agricultural inputs (or Agri-Inputs) are any external source put into soil that can help a farmer's upcoming yield. They can be anything from quality irrigation water, high-quality seeds, fertiliser, manpower to high-tech machines, etc. that one uses to increase their crops' success.

   Types of agri-inputs

   The types of agricultural inputs are endless but majorly they are separated into these two categories that are:

   a. Consumable inputs

   b. Capital inputs.

a) **Consumable inputs:** Consumable inputs are required on frequent/daily basis by smallholder farmers. They are usually natural materials that will be "consumed" by the crops. These are considered as necessary aids for good crop harvest. Examples of consumable inputs include high-quality seeds, agrochemicals-fertilizers, insecticides, pesticides, irrigation water, diesel, manpower etc.

b) **Capital inputs:** Capital inputs are such farm materials that often needs a larger investment. They cannot be consumed and are often mechanical and technologically more advanced. Some common forms of capital inputs include Land, Farm Building, Farm implements/machineries, Irrigation system, Poly house etc.

2. Benefit cost ratio

The benefit cost ratio (or benefit-to-cost ratio) compares the present value of all benefits with that of the cost and investments of a project or investment. These benefits and costs are treated as monetary cash flows or their equivalents, for example, for non-monetary benefits or company-internal costs. Its meaning depends on the value it is indicating.

Benefit Cost ratio is net return (Rs/ha) divided by the total cost of cultivation (Rs/ha).

Value range of benefit cost ratio	Generic interpretation
BCR < 1	Investment option generates losses
BCR = 1	Investment option is neither generation profit nor loss
BCR > 1	Investment option generates profit

3. Farm record keeping

Need of farm record keeping:

1) Income tax reporting: A good set of records is required for the preparation of complete and accurate tax documents.

2) Obtaining credit: If you decide to borrow money for your farm business operation, the loan officer or bank will ask to see your financial records including

a balance sheet, an income statement and a cash flow statement. The creditor will require these statements in order to determine your repayment capacity.

3) Management tools: Accurate financial records along with production data helps the farm business operator to analyse the information, pinpoint the weaknesses in farm business, and make the necessary adjustments to operate more efficiently thereby increasing farm's profitability.

Record keeping system should include the following;

- A business checks account to handle business transactions.
- An income ledger by calendar month.
- An expense ledger by calendar month.
- An inventory ledger for physical counting and valuation.
- A depreciation schedule for pro-rating original costs of assets.
- A balance sheet to determine net worth.
- An income statement to determine net profit or loss.
- A cash flow statement to measure flow of funds.

Record keeping methods: Basically, there are two primary methods for record keeping:

1) Cash method: In this method, all items received during the year are included in the gross income and expenses are deducted in the tax year they are paid.

2) Accrual method: Income is generally reported in the year it is produced or earned, and expenses are deducted or capitalized in the year they were incurred, not necessarily in the year received or paid. The accrual method is very useful because it provides inventory reconciliation and computation for "actual" net income, thereby helpful in making managerial decisions.

Phases of record keeping:

1. Maintaining the records and balance sheet of receipts and expenses

2. Maintaining and using inventories

3. Maintaining the information of crops, livestock and other enterprises

4. Critical

Activities

Activity1: Visit a nearby farm and observe financial management process.

Material required: Pen, Pencil, Notebook, etc.

Procedure:

- Visit a nearby farm
- Discuss with farmer and note down the following observations;
- Note down the observations about tools required for farm financial management
- Enlist the type of Agri-inputs
- Enlist the Record keeping methods
- Note down your observation and present them before class

Activity 2: To calculate gross returns, net returns and benefit cost ratio.

Material Required: pen, pencil, notebook, etc.

Exercise 1. Calculate gross returns, net returns and benefit cost ratio if the chickpea crop is produced 2000 kg per hectare (sale price = Rs. 60 per kg), cost of cultivation is Rs. 33,000.

Procedure:

Gross returns = Produce x sale price

=2000 x 60 = Rs. 1,20,000

Net returns = Gross returns - Cost of cultivation

= 120000-33000

= Rs. 87,000

BC ratio = Net returns / Cost of cultivation

= 87000/33000= 2.6

Check Your Progress

Fill in the Blanks

1. ..... is concerned with the planning and execution of decision that affect the profitability of individual farm.
2. ..... are Agri-inputs that are often mechanical and more technological advanced.
3. There are..... record keeping methods.
4. Benefits and costs are treated as .....
5. ..... are any external source put into soil that can help a farmer's upcoming yield.

Multiple Choice Questions

1. …are any external source put into soil that can help a farmer's upcoming yield.

A) Agricultural inputs

B) Capital Inputs

C) Consumable inputs

D) None of the above

2. Identify problems and opportunities for improving profitability.

A) Farm Budgeting

B) Farm Records

C) Farm planning

D) None of the above

3. Compare farm alternatives on paper before investing money.

A) Farm Budgeting

B) Farm Records

C) Farm planning

D) None of the above

4 …inputs are Agri-inputs that are often mechanical and more technologically advanced.

A) Capital Inputs

B) Agricultural inputs

C) Consumable inputs

D) All the above

5. Tools of Farm Financial Management are

A) Farm Budgeting

B) Farm Records

C) Both (A) and (B)

D) None of the above

Match the Following

A	B
1) BCR < 1	a) Investment option generates profit.
2) BCR > 1	b) Investment option generates losses
3) Consumable inputs	c) Land, Farm Building
4) Capital inputs	d) Fertilizer, insecticides

Subjective Questions

1. What is farm financial management?
2. Why farm records are necessary?
3. Write different types of Agri-inputs analysis of the farm business

Session 4: Classify Markets and Marketing Channels

Proper farm planning knowledge will help in better understanding of demand and supply along with the best market conditions for selling the farm produce at any given instance of time to obtain maximum profit. It will also help in market-based agriculture production to make the agriculture more remunerative.

I. Market

Market word derived from the Latin word "maracatu's" which means a place where business is conducted. It is as a place or a building where commodities are brought, sold and purchased, for example, super markets, local mandis etc.

Components of a market:

Market constitutes of four main components namely:

1. The occurrence of a commodity for sale

2. The existence of buyers and sellers

3. Association/linkage between buyers and sellers

4. Well earmarked area physically/online for sale and purchase

Dimensions of a market:

Every market used to have several dimensions, mentioned as below:

1. Location and area

2. Time of opening and closing

3. Volume and nature of transactions

4. Number of commodities

5. Degree of competition

6. Nature of commodities

7. Stage of marketing

8. Extent of public intervention

9. Accrual of marketing margins

Classification of markets:

Markets may be classified on the basis of each of the eleven dimensions mentioned below:

1. On the basis of location:

a) Village markets: These markets are usually located in a small village where major transactions occur between the buyers and sellers of a village.

b) Primary wholesale markets: These markets are located in big towns and here producer-farmers themselves brought major part of the produce for sale.

c) Secondary wholesale markets: These markets are generally located in district headquarters or important trade centres and the majority of the items to be sold in these markets are from other markets. Major transactions in these markets take place between the village traders and wholesalers.

d) Terminal markets: In these types of markets, the produce is either finally disposed of to the consumers or processors, or assembled for export.

e) Seaboard markets: These markets are usually located near the seashore and are for the import and/or export of goods. Examples of these markets in India are Mumbai, Chennai, and Kolkata.

2. On the basis of area:

On the basis of the area to which buyers and sellers belongs:

a) Local markets: In such markets, buyers and sellers are from the same or nearby villages and buying and selling activities are confined locally. It mostly accounts perishable commodities.

b) Regional markets: In such markets, buyers and sellers are drawn from a larger area than the local markets and normally deals in sale and purchasing of food grains.

c) National markets: Buyers and sellers in these markets are of the national level. National markets are found for more durable goods, like jute and tea.

d) World market: In these markets, buyers and sellers usually appear from the entire world and are the biggest markets from the area point of view. These markets normally deal in the commodities having world-wide demand and/or supply.

3. On the basis of time span:

a) Short-period markets: These types of markets are operational for a few hours and only dealt with highly perishable nature of products, such as fish, fresh vegetables, and liquid milk.

b) Long-period markets: These markets held for a comparatively longer period as compared to the short-period markets. In these markets, less perishable commodities are traded which can be stored for longer time like food grains and oilseeds.

c) Secular markets: These markets are of permanent nature and deals with commodities that are of durable in nature and can be stored for many years, like machinery and manufactured goods.

4. On the basis of volume of transactions:

a) Wholesale markets: A wholesale market is the market where commodities are bought and sold in bulk and the transactions take place mostly between traders.

b) Retail markets: A retail market is the market where commodities are mainly purchased by the consumers in lesser quantity, as per their need, and are situated very near to the consumers. Transactions mostly take place between retailers and consumers. The retailers purchase the commodity from the wholesale market and sell to the consumers as per their requirements.

5. On the basis of nature of transactions:

a) Spot or cash markets: Goods, in such markets, are exchanged through money immediately after the sale.

b) Forward markets: A market in which the purchase and sale of a commodity takes place at time 't' but the exchange of the commodity takes place on some specified date in future i.e., time 't + 1'. Sometimes, even on the specified date in the future (t+1), there may not be any exchange of the commodity. Instead, the differences in the purchase and sale prices are paid or taken.

6. On the basis of transaction of number of commodities:

a) General markets: Such markets dealt with various types of commodities required by the family on daily basis, such as food grains, oilseeds, fibre crops, jaggery, soap, detergents, etc.

b) Specialized markets: These markets dealt in one or two commodities and separate markets exist for every group of commodities such as food grain markets, vegetable markets, cotton market, etc.

7. On the basis of degree of competition:

Each market can be placed on a continuous scale, starting from a perfectly competitive point to a pure monopoly or monopsony situation. On the basis of competition, markets may be classified into the following categories:

a). Perfect markets: A perfect market is one in which the following conditions hold good:

- Large number of buyers and sellers prevails in the market.
- All the buyers and sellers in the market have perfect knowledge of demand, supply and prices.
- Prices at any one time are uniform over a geographical area, plus or minus the cost of getting supplies from surplus to deficit areas.
- The prices are uniform at any one place over periods, plus or minus the cost of storage from one period to another.
- The prices of different forms of a product are uniform, plus or minus the cost of converting the product from one form to another.

b). Imperfect markets: Imperfect markets are those markets that lacks the conditions of perfect competition. On the degree of imperfection, the following situations may be recognized:

i. **Monopoly market:** In this condition, there is only one seller for one commodity and thus have sole control over the quantity/price of the commodity. Price of commodity is usually higher in such markets. Indian farmers operate in a monopoly market when purchasing electricity for irrigation. While, if there is only one buyer of any product in the market then it is termed as a **monopsony** market.

ii. **Duopoly market:** In this condition, there is only two sellers of a commodity and they may mutually agree to charge a common price, which is higher than the realistic price in a common market. Similarly, when there are only two buyers of a commodity in the market, then it is termed as the **duopsony** market.

iii. **Oligopoly market:** A market in which there are more than two but still a few sellers of a commodity are termed as an oligopoly market. Similarly, a

market where there are a few but more than two buyers is termed as **oligopsony** market.

iv. **Monopolistic competition:** It is the condition where large number of sellers deal in heterogeneous and differentiated form of a commodity. Different trade marks on the product create the conspicuous difference in the price of the commodity. Prices prevailing in the market vary for the same basic product. For example, prices of various makes of agrochemicals and farm machineries.

8. On the basis of nature of commodities:

On the basis of the type of goods dealt, these markets may be classified into the following categories:

a) Commodity markets: Commodity markets deal in goods and raw materials, such as wheat, barley, cotton, fertilizer, seed, etc.

b) Capital markets: Capital markets deal in buying and selling of bonds, shares and securities. For example, share markets.

9. On the basis of stage of marketing:

On the basis of the stage of marketing, markets may be categorized as below:

a) Producing markets: In these markets, commodities are generally assembled for further distribution to other markets and are situated in producing areas.

b) Consuming markets: These markets sale the produce for final disposal to the consumers and these are generally located in areas where production is inadequate, or in populated urban areas.

10. On the basis of extent of public intervention:

On the basis of extent of public intervention, markets have been categorized in the following two classes:

a) Regulated markets: In these markets, business is performed as per the rules and regulations framed by the statutory market organization. The marketing costs in such markets are standardized and practices are well- regulated.

b) Unregulated markets: In these markets, business is conducted without any set rules and regulations. Traders form their own rules for the conduct of the business and operate the market. These markets suffer from unstandardized charges for marketing functions through price hikes of the products to be sold.

11. On the basis of type of population served:

On the basis of population served by a market, it can be classified as below:

a) Urban market: These markets serve mainly the population residing in an urban area and meets demand for agricultural products of the urban population.

b) Rural market: Such markets usually meet the demand of the rural population. Considerable differences prevail in the services required with a farm product between urban and rural demands.

II. Marketing channels

Marketing channels are routes through which agricultural products move from producers to consumers. A marketing channel is the people, organizations, and activities necessary to transfer the ownership of goods from the point of production to the point of consumption. It is through distribution channel the consumer receives the products. It is a chain of intermediaries through which the various commodities pass from producers to consumers.

Factors affecting channels:

On the basis of the type of produce or commodity, there are several channels of distribution. Slightly different channel is found as per the nature of the commodity. The factors that affect these channels are:

I. Perishability of the produce like fruits, vegetables, flowers, milk, meat, etc.

II. Bulk and weight like cotton, fodders are bulky but light in weight.

III. Need of storage facilities

IV. Weak or strong marketing agency

V. Distance between producer and consumer

VI. Nature of goods that may require processing prior to consumption

VII. Demand of goods as per consumption pattern.

Factors affecting length of marketing channels:

Marketing channels for agricultural products vary from product to product, place to place, and time to time.

Marketing channels of distribution:

It is the route taken by a product in its passage from its first owner i.e. producer to the last owner, the ultimate consumer.

Important channels of distribution:

A. Producer or manufacturer – Retailer – Consumer

B. Producer or manufacturer – Consumer

C. Producer or manufacturer – Wholesaler – Retailer – Consumer

D. Producer – Commission agent.

Channels of pulse:

A. Producer–miller->consumer (village sale)

B. Producer–miller->retailer–consumer (local sale)

C. Producer–wholesaler->miller–retailer–consumer

D. Producer–miller–cum-wholesaler-retailer-consumer

E. Producer–village merchant–miller–retailer–consumer

F. Producer–govt. procurement–miller–retailer–consumer

Factors considered while choosing a channel:

1. Nature of the product.

2. Price of the product.

3. No. of units of sale.

4. Characteristics of the user.

5. Buyers and their buying units

Activities

Visit a nearby grain mandi and note down the following observations

Material required: Pen, Pencil, Notebook, etc.

Procedure:

- Visit a nearby grain market, observe and note down the following information.
- Write down the name of pulse crops that are being sold in the market.
- Enlist the different channels of marketing that you find there.
- Observe the different types of transaction taking place in the market.
- Present your observations before the class.

Check Your Progress

Fill in the Blanks

1. ...are routes through which agricultural products move from produces to consumers.

2. A market which serves mainly the population residing in an urban area is called as …
3. The word … usually refers to the demand originating from the rural population.
4. Marketing channel is the way products get to the end-user, the consumer, and is also known as a …
5. A market in which transaction take place only in one or two commodities is known as a …

Multiple choice Questions

1. A……. market is one where the produce is either finally disposed of to the consumers or processors, or assembled for export

A) Terminal market

B) Seaboard market

C) Urban market

D) Rural market

2. These are the markets in which business is conducted without any set rules and regulations.

A) Regulated market

B) Unregulated market

C) Secular market

D) Forward market

3. ……. is the people, organizations, and activities necessary to transfer the ownership of goods from the point of production to the point of consumption

A) Marketing channel

B) Product channel

C) Both A and B

D) None of the above

4. On the Basis of Nature of Commodities markets are of …. types

A) 1

B) 3

C) 4

D) 2

5. A market which deals in goods and raw materials, such as wheat, barley, cotton, fertilizer, seed, etc., are termed as commodity markets

A) Commodity markets

B) Capital markets

C) Consuming markets

D) None of the above

Match the Following

	A	B
1)	Large buyers and sellers	a) Monopolistic market
2)	Large number of sellers	b) Monopolistic market
3)	Deals in goods and raw materials	c) Capital market
4)	Bonds, Shares and Securities	d) Commodity market

Descriptive Questions

1. Describe the market and marketing channels.
2. Write the dimension of a market.
3. Describe classification of markets on the basis of location.

Session- 5: Basic Market Information

Market information is an important marketing function that ensures the smooth and efficient operation of the marketing system. Accurate, adequate and timely availability of market information facilitates decision about when and where to market the products. Market information creates a competitive market process and checks the growth of monopoly or profiteering by individuals. It is the lifeblood of a market.

I. Market information: Market information may be broadly defined as a communication or reception of knowledge or intelligence and have all the facts, estimates, opinions and other information that affect the marketing of goods.

Market information is useful for all concerned society members as follows:

a) Farmer-producers: Market information helps in improving the decision-making power of the farmer regarding sale of his produce and buying the agricultural inputs.

b) Market middlemen: Market middlemen need market information to plan the purchase, storage and sale of goods according to the demand and supply in the market.

c) General economy: Market information is also beneficial for the economy as a whole. There is need for a competitive market process for a commodity, which regulates the prices of the product.

d) Government: Market information is essential for the government in framing its agricultural policy relating to the regulation of markets, buffer stocking, import export and pricing.

Types of market information

Market information is of two types

a) Market intelligence: This includes information relating to such facts as the prices that prevailed in the past and market arrivals over time. These are essentially a record of what has happened in the past. Market intelligence is therefore, of historical nature.

b) Market news: This term refers to current information about prices, arrivals and changes in market conditions. This information helps the farmer in taking decisions about when and where to sell his produce. The availability of market news in time and with speed is of the utmost value.

Criteria for good market information:

Good market information must meet the following criteria so that it may be of maximum advantage to the users:

a) Comprehensive
b) Accuracy
c) Relevance
d) Confidentiality
e) Trustworthiness
f) Equal and Easy Accessibility
g) Timeliness

II. Sources of agriculture market information

1. AGMARK net (Agricultural Marketing Information System Network): It is a Government of India's portal for agricultural marketing having a wide area information network connecting agricultural markets, State Marketing

boards/Directorates and providing linkages to the websites of the important National and International Organizations. The Portal provides both static and dynamic information relating to agricultural marketing in India. The static information is about infrastructure- related (Storage, warehousing, Cold Storage, grading and packing facilities), Market – related (market fee/ charges, weighment, handling, market functionaries, development programmes, market laws, composition of market committees, income, and expenditure, etc.) and Promotion-related information (Standards, Grades, Labelling, Sanitary and Phyto-Sanitary requirements, Pledge Financing, Marketing Credit, and new opportunities available, etc.). The dynamic part comprises Price-related information comprising maximum, minimum and model prices of varieties, total arrivals, and dispatches with destination.

2. Ministry of statistics and programme implementation

Government of India has constituted the Ministry of Statistics and Programme Implementation on 15.10.1999 as an Independent Ministry with the merger of the Department of Statistics and the Department of Programme Implementation. It comprises two wings, one concerned to Statistics and the other deals with the Implementation of the Programme. The National Statistical Office (NSO), a Statistics Wing, consists of the Central Statistical Office (CSO), the computer centre and the National Sample Survey Office (NSSO). The Programme Implementation Wing consists of

(i) Twenty Point Programme

(ii) (ii) Infrastructure Monitoring and Project Monitoring and

(iii) (iii) Member of Parliament Local Area Development Scheme.

Besides it, there is National Statistical Commission created through a Resolution of Government of India (MOSPI) and one autonomous Institute, viz., Indian Statistical Institute.

3. National portal of India

It is the official portal of the Government of India, that has been designed, developed and hosted by the National Informatics Centre (NIC), Ministry of Electronics & Information Technology, Go. It provides a single window access to the information and services being provided by the Indian Government for citizens and other stakeholders.

4. National Agriculture Market (e NAM)

e-NAM is a national level electronic trading portal which networks the existing APMC mandis and develops a unified national market for agricultural

commodities. It helps in getting better price of the produce/item through transparent auction process, based on quality of the produce, along with provision of online payment.

5. The Agricultural and Processed Food Products Export Development Authority (APEDA)

APEDA was established by the Government of India in December 1985. APEDA also functions as the Secretariat to the National Accreditation Board (NAB) for implementation of accreditation of the Certification Bodies under National Programme for Organic Production (NPOP) for organic exports.

6. NCDEX

National Commodity & Derivatives Exchange Limited (NCDEX) (NCDEX/the Exchange) is a leading agricultural commodity exchange in India. The Exchange has a broad-based bouquet of permitted commodities aggregating to a total of 23 (which is also the highest), and includes commodities such as pulses, spices and guar, which are not traded on any platforms in the global scenario, and are economically relevant to India, forming an important component of India's global trade. NCDEX is regulated by Securities and Exchange Board of India (SEBI).

7. Directorate of Economics and Statistics

The Directorate of Economics and Statistics (DES), an attached office of the Department of Agriculture and Cooperation, collects, disseminates, and publishes statistics on diverse facets of agriculture and related sectors required for policy formulation by the Government. Among the various functions of the DES, the most well-known is perhaps the one relating to Minimum Support Prices (MSPs), which are fixed on the basis of recommendations made by the Commission for Agricultural Costs and Prices. The most important factor considered by the CACP in making its recommendations on MSPs for different crops is the cost of cultivation/production for which the database is provided by the DES through its plan scheme on cost of cultivation.

8. Directorate of Marketing and Inspection

The Directorate of Marketing and Inspection (DMI), an attached Office of the Department of Agriculture, Cooperation and Farmers Welfare, under Ministry of Agriculture & Farmers Welfare, was set up in the year 1935 to implement the agricultural marketing policies and programmes for the integrated development of marketing of agricultural and other allied produce in the country with a view to safeguard the interests of farmers as well as the consumers. It maintains a close liaison between the central and the state governments.

III. Demand and Supply

In a market, where price is not controlled, market price for a product or service is determined by the interaction of demand and supply, i.e., the consumers' willingness and ability to buy the product, and the sellers' willingness and ability to produce and sell the product. The next several sections review these two basic economic concepts.

Determinants of demand:

The level of demand for a product is determined by the following factors:

- **Consumer tastes and preferences** - Consumer tastes and preferences is the consumer interested in Product A or Product B. For example, will the consumer prefer a food product wherein the consumer can identify who, where, and how the underlying agricultural commodities were produced, or will the consumer be satisfied with a food product without knowing who, where or how it was produced?
- **Number of buyers in the market:** An increased number of interested buyers or consumers will lead to an increased demand for the product.
- **Consumer income:** Will an increase in the consumer's income led to more consumption of the product (then the product would be considered a *normal* product) or less consumption of the product (then the product would be considered an *inferior* product)
- **Price of related goods:** such as substitutes, complements, or independent (with no impact)

Determinants of Supply:

The level of supply for a product or service is determined by the following factors.

- Resource or input costs
- Production technology
- Taxes and subsidies
- Price of other goods the supplier could produce
- Supplier's expectation about the future
- Number of sellers/suppliers in your market

An increase in the demand for your product without an increase in supply will lead to a higher market price for your product. An increase in supply of your

product without an increase in demand will lead to a lower market price for your product

Activities

Visit to nearby pulse market and observe different mechanism of market information.

Material Required: market, pen, pencil, notebook, etc.

Procedure:

- Visit a nearby pulse market
- Note down the price of pulse crops that are sold in the market
- Observe and identify the different sources of market information
- Observe demand and supply of pulses
- Note down your observation and present them before class

Check Your Progress

Fill in the blanks

1. …is an important marketing function which ensure the smooth and efficient operation of the marketing system.
2. Market information may be broadly defined as a …of knowledge.
3. …is a Pan-India electronic trading portal.
4. …is a leading agricultural commodity exchange in India.
5. AGMARK Net provides both …information relating to agricultural market in India.

Multiple Choice Questions

1. It refers to current information about prices, arrivals and changes in market conditions.

A) Market News

B) Market information

C) Market intelligence

D) None of the above

2. ..... implement the agricultural marketing policies and programmes for the integrated development of marketing of agricultural and other allied produce in the country

A) Directorate of Marketing and Inspection (DMI)

B) APEDA

C) e-NAM

D) Directorate of Economics and Statistics (DES)

3. ..... implementation of accreditation of the Certification Bodies under National Programme for Organic Production (NPOP) for organic exports.

A) e-NAM

B) APEDA

C) NCDEX

D) Directorate of Economics and Statistics (DES)

4. ..... information helps in improving the decision-making power of the farmer regarding sale of his produce and buying the agricultural inputs

A) Farmer produce

B) Market information

C) Market middlemen

D) None of the above

5. Agricultural and Processed Food Products Export Development Authority (APEDA) was established by the Government of India in

A) December 1986

B) December 1985

C) December 1987

D) December 1988

Match the Following

A	B
1. Directorate of Marketing and Inspection (DMI)	A. 1935
2. Ministry of Statistics and Programme Implementation	B. 1999
3. APEDA	C. 1985
4. NCDEX	D.23 Commodities

Subjective Questions

1. What is market information?
2. Write criteria for good market information.
3. Define Agricultural Marketing Information System Network (Agmark net).

Answer Keys

Module 1: Irrigation Management in Pulse Crops

Session 1: Importance and Methods of the Irrigation

Fill in the Blanks

1. Irrigation
2. 6.5 to 8.5
3. Sodium Adsorption Ratio (SAR)
4. Boron
5. Sprinkler

Multiple Choice Questions

1.(c) 2. (d) 3. (c) 4. (a)

Match the columns

1.(d) 2. (c) 3. (a) 4. (f) 5. (e) 6. (b)

Module 2: Weed Management in Pulse Crops

Session 1: Identify Common Weeds of Pulse Crops

Fill in the Blanks

1. Weed
2. 72,000
3. *Eichhornia crassipes*
4. Noxious weed
5. deep to very deep

Multiple Choice Questions

1.(d) 2. (a) 3. (c) 4. (a) 5. (d)

Match the Columns

1.(b) 2. (d) 3. (c) 4. (a)

Session 2: Integrated Weed Management in Pulse Crops

Fill in the Blanks

1. Integrated weed management
2. Weed eradication
3. Power weeder and kono weeder
4. biological methods
5. time, quantity and herbicide

Multiple Choice Questions

1. (d) 2. (a) 3. (a) 4. (b) 5. (c)

Match the Columns

1.(c) 2. (d) 3. (b) 4. (a)

Module 3: Integrated Insect -Pest and Disease Management in Pulse Crops

Session 1: Identify Major Insect-Pest of Pulse Crops and their Management Strategies

Fill in the Blanks

1. polyphagous pests
2. dark brown to black
3. 5
4. rostrum

Multiple Choice Questions

1.(b) 2. (d) 3. (a) 4. (a)

Session 2: Identify Diseases of Pulse Crops and their Control Measures

Fill in the Blanks

1. cost-effective and eco-friendly
2. soil and seed borne
3. chickpea
4. *Sclerotinia sclerotiorum*
5. @ 2.5 g/kg

Multiple Choice Questions

1.(a) 2. (b) 3. (c) 4. (a)

Match the columns

1. (c) 2. (d) 3. (b) 4. (a)

Module 4: Harvest and Post-Harvest Management of Pulse Crops

Session 1: Harvest and Threshing

Fill in the Blanks

1. rabi
2. kharif
3. crop moisture and physical grain characteristics
4. crop maturity
5. Threshing and winnowing

Multiple Choice Questions

1. (a) 2. (b) 3. (d) 4. (c) 5. (d)

Match the columns

1. (c) 2. (a) 3. (b) 4. (e) 5. (d)

Session 2: Importance of Post-Harvest Management

Fill in the Blanks

1. postharvest activities
2. minimizing losses at different postharvest stages
3. quantitative, qualitative and economic loss
4. 5-10%

5. 15-20%

Multiple Choice Questions

1.(c) 2. (b) 3. (c) 4. (d) 5. (c)

Match the Columns

1.(c) 2. (a) 3. (b) 4. (e) 5. (d)

Session 3: Pulse Storage and Storage Pests

Fill in the Blanks

1. equilibrium moisture content
2. grain deterioration
3. Bag and bulk storage systems
4. 10-12%
5. Prophylactic and Curative measures

Multiple Choice Questions

1. (d) 2. (d) 3. (a) 4. (d) 5. (c)

Match the Columns

1. (b) 2. (d) 3. (e) 4. (a) 5. (c)

Module 5. Package and Practices of Pulse Crops Production

Session 1: Cultivation Techniques of Different Pulse Crops

Fill in the Blanks

1. Black gram or urad
2. Sorghum, Maize & Pearl millet
3. pod borer
4. first
5. pigeon pea

Multiple Choice Questions

1.(b) 2. (d) 3. (b) 4. (a) 5. (c)

Match the Columns

1.(c) 2. (a) 3. (d) 4. (f) 5. (e) 6. (b)

Module 6: Basics of Farm Management and Marketing

Session- 1: Farm Management of Pulse Cultivator

Fill in the Blanks

1. Organization, operation
2. What to produce, how to produce and how much
3. Fixed resources
4. Long-term material
5. Crop planning

Multiple Choice Questions

1.(a) 2. (a) 3. (d) 4. (c) 5. (b)

Match the Columns

1. (b) 2. (d) 3. (a) 4. (c)

Session- 2: Cropping System

Fill in the Blanks

1. three types
2. Sole cropping is
3. Multiple cropping is
4. Intercropping
5. two

Multiple Choice Questions

1.(a) 2. (a) 3. (d) 4. (c) 5. (a)

Match the Columns

1. (b) 2. (a) 3. (d) 4. (c)

Session-3: Financial Management

Fill in the Blanks

1. Farm financial management
2. Capital inputs
3. Two
4. Monetary cash flow
5. Agriculture inputs

Multiple Choice Questions

1. (a) 2. (b) 3. (a) 4. (a) 5. (c)

Match the Columns

1. (b) 2. (a) 3. (d) 4. (c)

Session – 4: Classify Markets and Marketing Channels

Fill in the Blanks

1. Marketing Channel
2. Urban market
3. Rural market
4. Distribution channels
5. Specialized market

Multiple Choice Questions

1.(a) 2. (b) 3. (a) 4. (d) 5. (a)

Match the Columns

1. (b) 2. (a) 3. (d) 4. (a)

Session- 5: Basic Market Information

Fill in the Blanks

1. Market information
2. Communication

3. National Agriculture Market (eNAM)
4. National Commodity & Derivatives Exchange
5. Static and Dynamic

Multiple Choice Questions

1. (a) 2. (a) 3. (b) 4. (a) 5. (b)

Match the Columns

1. (a) 2. (b) 3. (c) 4. (d)

Glossary

Alkali soil: Alkali, or Alkaline, soils are clay soils with high pH (> 8.5), a poor soil structure and a low infiltration capacity.

Bio-agents: Biocontrol agents are mass-produced agent manufactured from a living microorganism for the biological control of insects, plant pathogens, and weeds.

Bioherbicide: an organism that is toxic to unwanted vegetation and is used to destroy weeds.

Cereal: Cereal, also called grain, any grass (family Poaceae) yielding starchy seeds suitable for food. The cereals most commonly cultivated are wheat, rice, rye, oats, barley, corn (maize), and sorghum.

Chlorosis: Chlorosis is a complete yellowing of the leaf due to lower-than-normal amounts of Chlorophyll. When the veins are green and the area between the veins are yellow, this is properly termed interveinal chlorosis.

Crop rotation: The practice of growing different crops in succession on the same land chiefly to preserve the productive capacity of the soil.

Drought tolerance: Drought tolerance is the ability to which a plant maintains its biomass production during arid or drought conditions.

Eradicate: To destroy completely, put an end to, eliminate.

Fertigation: It is the process of direct application of water-soluble solid fertilisers or liquid fertilisers with irrigation water.

Fungicides: A fungicide is a specific type of pesticide that controls fungal disease by specifically inhibiting or killing the fungus causing the disease.

Hybrid varieties: Hybrid varieties are the result of crossing two different breeding lines. They represent the first generation originating from the cross (F_1).

Insect: A small animal of the insect class with three pairs of legs, two pair of wings, and body divided into three segments head, thorax and abdomen.

Insecticides: A substance or chemical used to kill or control insects.

Intercropping: Intercropping involves cultivating two or more crops in a field simultaneously.

Irrigation interval: A break in the number of days between two consecutive irrigations during the critical period of consumptive use of the crop. The interval depends on the crop, soil and climate.

Irrigation scheduling: It is the frequency of water application in which water is to be applied based on the needs of the crop and nature of the soil.

Maturity indices: It is a measurement that can be used to determine whether a particular commodity is mature.

Micro-organisms: Microbes include fungi, bacteria and viruses, many microbes are beneficial. Soil microbes (bacteria and fungi) are essential for decomposing organic matter and recycling old plant material.

Mixed cropping: Mixed cropping, including intercropping, is the oldest form of systemized agricultural production and involves the growing of two or more species or cultivars of the same species simultaneously in the same field.

Necrosis: Necrosis is the death of plant tissue.

Net returns (Rs/ha): It is obtained by subtracting the cost of cultivation from gross returns for each treatment and expressed as rupees per hectare.

Parasite: An organism which lives in or on another living organism (its host) and benefits by drawing nutrients at the other's expense.

Pathogens: Any organism that causes disease in another organism.

Pest: a destructive being that attacks crop, livestock, food, etc.

Pesticide: A substance used to control pests.

Pheromone trap: As trap that uses pheromones to lure insects.

Pheromone: A chemical that is secreted or excreted to trigger a social response in members of the same species.

pH: A measurement of the level of acid or alkali in a substance.

Plant Growth: Plant growth is usually associated with development (cell and tissue specialization) and reproduction (production of new individuals).

Processing: Agricultural processing means transforming, packaging, sorting, or grading livestock or livestock products, agricultural commodities, or plants or plant products into goods that are used for intermediate or final consumption including goods for non-food use.

Productivity: Productivity, in economics, measures output per unit of input.

Rainfall: The primary source of water for agricultural production for most of the world is rainfall.

Relative humidity: It is the ratio of actual water vapour content to the saturated water vapour content at a given temperature and pressure expressed in percentage (%).

Salt tolerance: The salt tolerance of a plant is often defined as the degree to which the plant can withstand, without significant adverse effects, moderate or high concentrations of salt in water on its leaves or in the soil within reach of its roots.

Seed Germination: Germination is the fundamental process by which sprouting of seedling takes place from embryo of a seed or seed material. Agronomically germination means the capacity of seeds to give rise to normal sprouts within a definite period fixed for each crop under proper conditions.

Soil borne: inhabitant of soil; lives and grows in soil.

Systemic insecticides: Insecticides translocated to various parts of the plant irrespective of the part applied to.

Trap crop: A crop that you add to your garden to attract pests away from the main crop.

Vectors: Carrier of pathogens.

Waterlogging: Waterlogging is the saturation of soil with water.

Weedicides: Chemicals sprayed over the fields to get rid of weeds.

List of Credits

Fig. 1.1: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.2: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.3: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.4: https://bit.ly/2WLpwdG

Fig. 1.5: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.6: https://bit.ly/2E8y9bX

Fig. 1.7: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.8: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.9: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.10: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.11a: https://bit.ly/2pcDdEj

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Fig. 1.12: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 1.13: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 2.1: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.2: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.3: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.4: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.5: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.6: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.7: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.8: Shweta Gupta, RARI- Jaipur, Rajasthan

Fig. 2.9: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 3.1: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

Fig. 3.2: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

Fig. 3.3: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

Fig. 3.4: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

Fig. 3.5: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

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Fig. 3.8: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

Fig. 3.9: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

Fig. 3.10: R.K. Mishra, IIPR- Kanpur, Uttar Pradesh

Fig. 4.1: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 4.2: R.K. Pathak, DAAH, PSSCIVE, Bhopal

Fig. 4.3: Prasoon Verma, IIPR- Kanpur, Uttar Pradesh

Fig. 5.1: L.B. Yadav, GBPUA&T, Pantnagar, Uttarakhand

Fig. 5.2: L.B. Yadav, GBPUA&T, Pantnagar, Uttarakhand

Fig. 5.3: L.B. Yadav, GBPUA&T, Pantnagar, Uttarakhand

Fig. 5.4: L.B. Yadav, GBPUA&T, Pantnagar, Uttarakhand

Fig. 5.5: L.B. Yadav, GBPUA&T, Pantnagar, Uttarakhand