Draft Study Material

Pulses Cultivator

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SECTOR: AGRICULTURE

Grade 11

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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
Introduction to Pulse Crops

Module Overview

Plant growth is largely dependent upon mineral nutrient availability in right quantity, right place and right time. Plants take up nutrients either from the soil through their roots or from the environment through their aerial parts especially the leaves or aerial roots and manufacture their food using carbon dioxide and water in the presence of sunlight and green pigment called chlorophyll If plants do not get the essential nutrients for their growth, their growth and development will be poor and deficiency symptoms develop, ultimately leading to death of the plant. Therefore, it is essential that the medium in which plants grow (generally the soil) should contain adequate nutrients for proper growth of the plants. Manures and fertilizers are applied in the soil in case there is deficiency of any nutrient.

Animals and plants sustain their lives with water which constitutes about 35-95% of the plant. Application of controlled amount of water to plants at desired intervals is called Irrigation. Water helps in transportation of nutrients to the plant; regulation of temperature and maintaining turgidity of plant cells.

Learning Outcomes

After completing this module, you will be able to:

- Describe the importance of pulse crops in agriculture, including their nutritional benefits, role in crop rotation, and contribution to soil fertility through nitrogen fixation.
- Explain the economic and social significance of pulse crop cultivation, highlighting their impact on food security, farmer livelihoods, and market demand.

Module Structure

- Session 1: Importance and Scope of Pulse Crops Cultivation

Session 1: Importance and Scope of Pulse Crops Cultivation

It may be recalled that pulses are low in fat, high in fibre and also, they are a major source of plant protein and carbohydrates. Thus, the pulse crops as a commodity group, play an important role to address the national food and nutritional security. They are a healthy part of any balanced diet as it includes nutrients like phosphorus, minerals, vitamin C, riboflavin and essential amino acids. Pulses are also good as body building food by virtue of the fact that proteins are a rich source of essential amino acids for the body. These crops constitute a relatively cheap source of plant protein and contribute to a diverse and versatile array of food like entrees, salads, breads and as desserts.

Because of their low water requirement and low carbon footprint, pulses are an important means to meet the climate change and environmental challenges. They are deep rooted and help maintain fertility, physical and biological health of the soil. These qualities of pulse crops assign to them a position of significance in agricultural systems and practices like crop rotation, mixed cropping and intercropping.

Importance and scope

1. Among the cultivated food crops in the world, pulses are perhaps the richest in protein content (18-25%). India enjoys number one position in pulses production which is so important for the poorer section of the society.
2. Pulse crops have a unique ability to fix atmospheric nitrogen into the soil as they provide a symbiotic relationship to nitrogen fixing bacteria in their roots. These bacteria known as *Rhizobium spp.,* can be seen as root nodules of these crops during the growth period. The phenomenon of symbiosis, is a special feature of plants in the leguminaceae group of families. These bacteria draw and help convert atmospheric Nitrogen into plant nutrition molecules, which help plants to grow better and produce better yields.
3. Increases in supply of soil nitrogen through nitrogen fixation goes up to about 40 to 45 kg/ha out of which about 10 to 15 kg/ha is left behind by the pulse crops into the field itself.
4. The nitrogen left behind in the field by pulses makes them ideal as part of a crop rotation system. The crop succeeding a pulse crop in the rotation, gets better soil micro environment and is thus able to produce better yield.
5. Pulses are grown all over India on all types of soil and climate, except in hazardous alkali or acid soils or extreme cold (<5-6^{0}C).
6. Pulses are important for intensifying and enriching the cropping systems, like mixed cropping, intercropping, *zaid* solo cropping.
7. Since the pulses require less manuring, less irrigation and also add organic matter to the soil, they are protectors of our living environment and environmental concerns.
8. Due to more leafy growth and closer spacing pulse crops help to check soil erosion.
9. As a basic raw material, pulses also support to growth of industries like dal milling, roasted grain industry, p*apad* industry etc.

Important major pulses growing zones/states in India

With the initiation of All-India Co-ordinated Research Improvement Programme (AICRP), in India in 1967, variety Development program of pulses got strengthened. Through this programme, the varieties suitable for one or more agroclimatic regions of the country have been developed. India has 16 distinct agroclimatic regions, defined by their soil and climatic conditions. But because of some overlapping similarities, these agroclimatic regions can be clubbed into few zones. For the purpose of pulse crop cultivation, recognized agroclimatic zones of India are the following:

1. **Hills zone**: J&K, Himachal Pradesh, North West of Uttar Pradesh;
2. **North west plains zone**: Haryana, Punjab, Rajasthan, Western Uttar Pradesh.
3. **North east plains zone**: Eastern Uttar Pradesh, Bihar, West Bengal, Assam, Mizoram, Eastern Odisha.
4. **Central zone**: Madhya Pradesh, Maharashtra, Telangana, Northern Karnataka.
5. **North east hill zone**: Nagaland and Tripura.
6. **South zone** – Andhra Pradesh, Tamil Nadu, Kerala, Karnataka and South-west Odisha.

Global scenario of total pulses:

The total world acreage under pulses was recorded 89.40 Mha with production 84.69 Mt and productivity 947 kg/ha during 2019-20. It reveals that the India ranked first in area and production with 34.56% and 25.44% respectively of world area and production. The productivity of pulses has increased 17 per cent at 892 kg/ha during 2020-21 from the level of 757 kg/ha during 2018-19. Main contributors to accelerated growth of pulses are the new varieties and the improved production technology.

Present status of pulse crops in India

- It is a paradox but it is true that India, is the highest producer of pulses and at the same time it is also the biggest importer of pulses because of our high per capita consumption (>50 g/person/day) and high population pressure.
- As per the Agricultural Statistics at a Glance 2021 Govt. of India, Madhya Pradesh contributes 16.95% of the country's pulse area with 20.60% production followed by Rajasthan, Maharashtra and Uttar Pradesh.
- During 2020-21, cultivation of pulses in 28.83 million ha (Mha) area and recorded the highest ever production of 25.72 million tonnes (Mt) at a productivity level of 892 kg/ha.

- Major 8 states to contribute more than 85 *per cent* pulse production have been Madhya Pradesh (5.30 Mt), Rajasthan (4.31 Mt), Maharashtra (4.30 Mt) Uttar Pradesh (2.56 Mt) Karnataka (2.12 Mt) and Gujarat (1.76 Mt) followed by Andhra Pradesh (1.09), Jharkhand (0.94) during 2020-21.
- Chickpea is first rank in area (35 %) among the all-pulses followed by Green gram (17 %), Pigeon pea (16 %), and Black gram (14 %).
- Chickpea is first rank in production (46 %) among the all-pulses crops followed by Pigeon pea (17 %), Green gram (12%) and Black gram (8%).

Table1.1: Area, production of pulse crops in India

(Area-Million hectares, Production-Million tonnes and Yield- kg/ha)

Year	Area	Production	Yield
2016-17	29.45	23.13	786
2017-18	29.81	25.42	853
2018-19	29.16	22.08	757
2019-20	27.99	23.03	823
2020-21*	28.83	25.72	892

(*Source:* Directorate of Economics & Statistics, DA&FW * 4th Advance Estimates 2020-21)

Table1.2: Crop contribution to total pulse production

(Area-Million hectares, Production-Million tonnes and Yield- kg/ha)

Crop	2020-21*			Contribution (%)	
	Area	Production	Yield	Area	Production
Chickpea	9.85	11.99	1217	34.16	46.61
Pigeon pea	4.80	4.32	892	16.64	16.79
Green gram	5.13	3.08	601	17.79	11.97
Black gram	4.14	2.23	538	14.36	8.67
Lentil	1.45	1.45	1001	5.02	5.63
Other pulses	3.46	2.73	870	12.00	10.61

Total	**28.83**	**25.72**	**892**		

(*Source:* Directorate of Economics & Statistics, DA&FW * 4th Advance Estimates 2020-21)

Table1.3: States' contribution in area & production total pulses

(Area-million hectares, production-million tonnes)

States	Area	% Contribution	Production	% Contribution
Madhya Pradesh	4.89	16.95	5.30	20.60
Rajasthan	6.15	21.32	4.31	16.75
Maharashtra	4.47	15.49	4.30	16.71
Uttar Pradesh	2.38	8.24	2.56	9.97
Karnataka	3.12	10.82	2.12	8.25
Gujarat	1.38	4.80	1.76	6.86
Andhra Pradesh	1.24	4.31	1.09	4.22
Jharkhand	0.86	2.99	0.94	3.64
Others	4.35	15.07	3.34	12.98
All India	**28.83**		**25.72**	

***Source:* Directorate of Economics & Statistics, DA&FW * 4th Advance Estimates 2020-21**

Nutrition value of pulses

As important group of food crops, Pulses play a vital role in addressing the national food and nutritional security and helps to tackle the environmental challenges. Total food grain basket is around 9-10 *per cent* and the major share is contributed by pulses as it is inexpensive source of plant-based proteins, vitamins and minerals. Pulses are a smart Food and most liking food for diet and food basket (dal-roti, dal-chawal), and a very rich source of protein *i.e.* 20-25% which is double the protein content of wheat and thrice that of rice and it helps to address obesity, diabetes malnutrition etc. Per capita availability of pulses in India is 52.9 g *per* day and 19.3 kg per year. Chickpea is called as 'King of Pulses'. It contains 22-23% protein. Pulses are known as the poor man's meat because they are rich in nutrition and low in cost. Therefore, most low-income populations can use this nutritious crop as their staple food.

Table1.4: Nutritional level of various pulses *(Unit– mg/ 100 g)*

Name of foodstuff	Chickpea	Black gram	Green gram	Horse gram	Lentil	Pea	Pigeon pea	Moth	Kesari	Cow pea
Protein (%)	20	24	25	22	25	22	22	22.5	31	23
Vit. A (I.U.)	316	64	83	119	450	31	220	16	200	60
Vit. C	3	-	-	1	-	-	-	2	-	-
Vit. K	0.29	0.19	-	-	0.25	-	-	-	-	-
Thiamine	0.3	0.41	0.72	0.42	0.45	0.47	0.45	0.45	0.39	0.5
Ribo-flavin	0.51	0.37	0.15	0.2	0.49	0.21	0.51	0.09	0.41	0.48
Nicotinic-acid	2.1	2.0	2.4	1.5	1.5	3.5	2.6	1.5	2.2	1.3
Biotin (g/100 g)	10	7.5	-	-	13.2	-	7.6	-	7.5	202
Choline	194	206	-	-	299	-	183	-	-	-
Folic-acid (g/100g)	125	144	-	-	107	-	83	-	100	-
Inositol	240	90	-	-	130	-	100	-	140	-
Pantothe nic-acid	1.3	3.5	-	-	1.6	-	1.5	-	2.6	-
Total No. of Vitamins /Minerals	**12**	**11**	**5**	**6**	**11**	**5**	**10**	**6**	**9**	**6**

Source: Indian Council of Medical Research (ICMR), Hyderabad, 2012.

Table1.5: Per capita availability of pulses in India

Year	(g *per capita per* day)	(kg *per capita* per year)
2017	54.8	20.0
2018	51.2	18.7
2019	42.4	15.5
2020	43.8	16.0
2021*	44.9	16.4

Source: **Directorate of Economics & Statistics, DA&FW * 4th Advance Estimates 2020-21**

Caution: *Khesari* crop (*teoda, Lathyrus*) has a history of being toxic and causing lathyrism which in effect, is like polio of the lower limbs. This is because of the presence of a neurotoxin (ODAP or BOAA). New varieties like Ratna, Mahateoda, Prateek contain less than the toxic level of neurotoxin, which is within prescribed safe limits. So, no danger of lathyrism.

Pulses are also contain a good amount of slow digesting starch (SDS) or resistant starch (RS) and oligosaccharides. This makes them highly recommendable for patients of diabetes and obesity. But because of these very constituents, pulses may also cause flatulence to a section of sensitive people, especially in the western countries, where sensitivity levels are high.

Economic importance of pulses

The top five countries that account for 50% of global production are India, Canada, China, Myanmar and Nigeria. India's import of pulses was 27.69 Million tonnes during April, 2020 to March, 2021 worth Rs. 1977.63 crores (Table below) but during the same period India also exported 24.66 Million tonnes of pulses worth Rs. 11937.57 crores. Major export destinations are the United Arab Emirates, China, U.S.A, Nepal, Canada and Iran etc.

Table1.6: India's imports and exports of pulses *(Million tonnes, Values – Rs Crore)*

Year	Import		Export	
	Import Quantity	Import Value	Export Quantity	Export Value
2016-17	13.67	1277.70	66.09	28523.18
2017-18	17.96	1469.63	56.07	18748.57

2018-19	28.71	1801.51	25.27	8035.30
2019-20	23.20	1511.80	28.98	10221.45
2020-21*	27.69	1977.63	24.66	11937.57

***Source:* Directorate of Economics & Statistics, DA&FW * 4th Advance Estimates 2020-21**

Classification of pulse crops

Pulses have many of different type of varieties, shapes, sizes and colors. But they are primarily classified according to the season in which they are cultivated and the manner in which they are consumed or utilized.

1. **Classification of pulses based on cultivation seasons-**
   Pulses are commonly grown the three crop seasons i.e.

   I. ***Kharif*:** Pigeon Pea (Arhar), Black Gram (Urd bean), Green Gram (Moong bean), Cowpea (Lobia), Kulthi (Horse Gram) and Moth.

   II. ***Rabi*:** Chickpea, Lentil, Pea, Lathyrus and Kidneybean (Rajma).

   III. **Summer (*zaid*):** Green Gram, Black Gram, Cowpea.

Pulses have vast variations in climate adoption e.g., *rabi* crops required mild cold climate during sowing (October-November), cold to mild cold climate during vegetative to pod development (December to February) and warm climate during maturity and harvesting (March to May). In the same way *zaid*/summer season (February to June), warm climate is required by pulse crops throughout their life span from sowing to harvesting. In order to successfully face the hazard of heat, they need to be irrigated. *Kharif* crops are adapted to both heat and humidity which are characteristic of a monsoon season which coincides with *kharif* crops. They are most likely to face biotic or abiotic stress or both, during their life cycle.

2. Classification based on plant uses-

Pulse crops offer various uses according to which, they are classified as below-

I. **Green fodder crop:** Lobia (Cow pea) crop is grown in most of areas as green fodder to supply the rich and palatable for the animal sp. The varieties fit for this purpose have property of high herbage and are often grown mixed with graminaceous forages like sorghum, bajra, maize also to improve and balance the animal ration. They also prevent soil erosion and improve soil quality by addition of organic residues.

II. **Green manure crop:** Being legumes, pulses have unique quality to fix the atmospheric nitrogen into the soil, therefore, Green gram in Uttar Pradesh and guar in Punjab is most popular used as a green manure crop, very much like the regular green manure crops (Sunhemp and *Dhaincha*). Green manuring with legumes has a good effect on buffering the pH in the soil.

III. **Ground cover crop:** Their tap root system binds the soil particles tightly, which helps to develop both, binding of soil by roots and ground cover foliage over the soil surface, finally check the soil erosion very efficiently. Pulses are popularly grown in hilly areas to check the soil erosion. The great amount of biomass produced by them smothers weeds, helps to break pest cycle and is also a source of ready fodder.

Table1.7: Pulse crops description

S. No.	**Pulse Crops**	**Scientific Name / Chromosome No.**	**Synonyms**
1.	Pigeon pea	*Cajanus cajan*	Congopea, Fio-fio, Noeyepea, Kadios, Red gram, Tur, arhar, etc.
2.	Green gram	(*Vigna radiata* (L.) R. Wilczek var. *radiata*	Moong
3.	Black gram	*Vigna mungo* L.Hepper	Biri, Mash, Urd
4.	Moth bean	*Vigna aconotifolia*	Moth,
5.	Horse gram	*Macrotiloma unilorum* (Lam) Verdi (= *Dolichos biflorus*)	Kulthi, huruli, kollu
6.	Chickpea	*Cicer arietinum* L.	Gram, Bengalgram, Chana and Garbonzo
7.	Lentil	*Lens esculanta*	Masoor and Malka
8.	Fieldpea	*Pisum sativum*	Garden pea, pea and matar.
9.	Lathyrus	*Lathyrus sativus* L.	Khesari, Teora, Grass pea & chickling pea,

10.	Rajma	*Phasealus valgaris* L.	Kidney bean & Haricot bean (green stage) French bean)
11.	Cowpea	*Vigna unguiculata L.*	Lobia, Black - eye - pea and Barbati
12.	Broadbean	*Vicia faba*Linn.	Bakla, Fababean
13.	Ricebean	*Vigna umbellata* (Thunb.)	Japanese rice bean, bomboo bean, climbing bean and mountainbean
14.	Lablab bean,	*Dolichos lablab L.* (*Lablab pupureus*)	*Avare*, *Sem,* Bonavist bean, Hyacinth bean and Indian butter bean,

Figure 1.1: Pigeon pea

Figure 1.2: Chickpea

Figure 1.3: Black gram

Figure 1.4: Moong bean

Figure 1.5: Moong bean

Figure 1.6: Moong bean


Figure 1.7 Black gram


Figure 1.8: Black gram


Figure 1.9: Black gram


Figure 1.10: Flower of Pigeon pea


Figure 1.11: Flower of Pigeon pea


Figure 1.12: Pod of Pigeon pea

What you have learned

Now I am able to:

- Explain importance and scope of pulse crop cultivation
- Know about the important major pulses growing zones in India
- Know about global scenario and present status of pulse crops
- Know about nutrition value of pulses
- Explain classification of pulse crops

Activities

Material required: Pen, pencil, practical notebook, herbarium file, etc.

Procedure:

- ➢ Visit to nearby pulse growing farm
- ➢ Collect available specimen of various pulse plants and / or seed
- ➢ Identification and listing of collected plants and /or seed

Maintain herbarium record or paste plant or seed images on practical note book

Check Your Progress

Fill in the blanks

1. Protein content in pulses is ____to______ %.
2. Chickpea and pea crops are grown in _______season.
3. Indian Institute of Pulse Research is situated at__________.
4. ___________is largest producer, consumer and importer of pulses in the world.
5. Chickpea is also called as________.
6. Rabi crops required mild cold climate during ________month at sowing time.
7. Dhaincha is _________crop.
8. Cowpea is also used as_________crop.

Multiple Choice Questions

1. "Puls" belong to word

   (a) Greek (c) Latin

   (b) Arab (d) French
2. Green gram is grown in .... season

   (a) Rabi (c) Kharif

   (b) Summer (d) All of the above
3. Highest pulse producing state is

   (a) Uttar Pradesh (c) Madhya Pradesh

   (b) Rajasthan (d) Maharashtra
4. Pulse crop with highest production in India is

   (a) Black gram (c) Pigeon pea

   (b) Mungbean (d) Chickpea

Match the Column

A	B
1. Pigeon pea	a- *Vigna mungo* L.Hepper
2. Cowpea	b- Rajmash
3. Black gram	c- *Cajanus cajan*
4. Central zone	d- *Vigna sinensis* L
5. Rabi season	e- Madhya Pradesh, Maharashtra

Subjective Questions

1. Describe importance and scope of pulse crop cultivation

2. Describe present status of pulse crops in India

3. Describe nutrition valve of pulses.

4. Explain classification of pulse crops?

5. Explain economic importance of pulse crops?

Module 2
Field Preparation for Pulse Crops Cultivation

Module Overview

Soil is a product of disintegration, degradation and weathering of rocks exposed to the long term atmospheric and terrestrial changes. Soil is the most important growing medium for crop plants. Soils are of different types depending upon their origin as well as on their chemical and physical properties. Soils provide nutrients, moisture and a hospitable environment for growth and development of plants. It provides support to growing plants by holding their roots. Application of manures and fertilizers is done to maintain and sustain the nutrient pool in soils. This ensures a congenial environment to the plant and maintains productivity as well as fertility of the soil. Judicious use of manures and fertilizers is always recommended to avoid common crop and soil related hazards. Soil testing and appropriate soil treatment or amendment is part of the cultivation practices on a sustainable basis.

Soil has to be pulverized, leveled and brought to fine tilth for cultivation of crops. This process is called tillage operation or preparation of land. Now-a-days different mechanized implements are used for land preparation. Pulse crops do not require too much water for crop cultivation but it is advisable to apply need-based irrigation which is a means of increasing crop yield by substantial margins.

Learning Outcomes

After completing this module, you will be able to:

- Describe the essential steps and techniques for field preparation in pulse crop cultivation, including land clearing, tilling, and bed preparation to optimize growth conditions.
- Explain the soil requirements for pulse cultivation, including soil types, pH levels, and nutrient needs, as well as strategies for soil management and improvement.

- Discuss the climate conditions suitable for growing pulses, such as temperature, rainfall, and humidity, and how to adapt cultivation practices to varying climatic conditions.

Module Structure

- Session 1: Field Preparation for Pulses Cultivation
- Session 2: Soil and Climate Requirement for Pulses Cultivation

Session 1: Field Preparation for Pulses Cultivation

Land preparation involves tillage in order to provide a favorable soil environment for the crop establishment and proper plant growth. A well-prepared field further helps in weed control and provides congenial condition for direct seeding and for transplanting where necessary. Tillage involves ploughing, harrowing and leveling of field. In olden days, draft animals were used to operate harrows; however, today, in an era of mechanization, tractor operated implements are used for land preparation.

With introduction of modern technology in agriculture, innovative development of various machines and tools makes pulse cultivation easier and more profitable than in past. Shortage of labour force, compulsion to raise their wages every now and then, increases the cost of cultivation. Secondly, labour is often not available at the time they are most required. This results in loss of yield and income to the cultivator. These factors motivate the farmer to switch towards mechanized farming. By itself, mechanized farming has several advantages, like it completes tasks in less time, saves labour cost, ease of operations and ease of availability when needed.

Ploughing

Ploughing is a primary and important tillage operation. Timely ploughing is very important to achieve timeliness in all subsequent field operations. It is done soon after a rain and/or after a normal irrigation (7 to 8 mm). During kharif season, early ploughing helps in moisture retention and controls weeds. The weed biomass gets converted later on into manure that may actually improve soil health.

Advantage of ploughing

- Proper seed germination, crop establishment, good penetration and contact of roots with the soil.

- Enhance soil fertility by incorporating crop residues, stubbles and root in to soil.
- Uproot, cut and destroy weeds
- Create conducive soil conditions for soil aeration.
- Helps in destroying the insect, harmful pathogens at the outset.

Harrowing

It is a secondary tillage operation performed after the ploughing. In this, soil is tilled at a shallow depth with the help of harrows which smoothen and pulverizes soil by breaking large clods (lumps of soil) into smaller fine soil structures suitable for seed sowing. Harrowing also helps mixing of farmyard manure and compost in the soil and also in cutting up weeds in the field,

Land leveling

Leveling helps to modify existing undulations of land for efficient agricultural production system and to provide adequate slope to a cropped area for surface irrigation coupled with unrestricted drainage.

Purpose of leveling

- Efficient application of irrigation water.
- Enhancing the conservation of rain water.
- Minimizing soil erosion.
- Encouraging the efficient mechanization.
- To control weed.
- To improve nutrient management.
- To improve crop stand and establishment.

The first ploughing with mould board plough should be done just after the harvest of the previous crop in the field with or without a light irrigation depending on soil moisture condition of the field. With the onset of monsoon, field should be again ploughed with local plough 2-3 times and finally levelled.

Tools and implements used in field preparation

There are some important tools and equipment which are used during field preparation

Plough: Various types of ploughs are used for field preparation.

1. **Mouldboard plough:** Mouldboard plough consist of carbon steel or steel alloy in a concave curved structure to cut and turn the soil upside down**.** This plough is prepared on right angle triangle base. The size of mould board plough is measured by the width of the furrow that is opened by the plough. Generally, it can open a furrow of about 20 cm. Tractor driven mould board ploughs can cut bigger slices and can be outfitted with more than one mould board plough at a time.

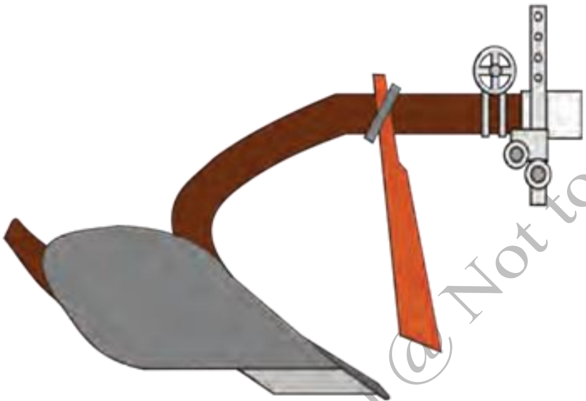


Fig. 2.1: Mouldboard plough

2. **Disc plough:** It consists of the moving circular edged steel discs of varying sizes (by its diameter and thickness). Discs in different ploughs used are 50-90 cm in diameter. Discs cut, turn and break furrow slices. It can work well in sticky soil as well as in too hard and dry soil. It is much heavier and leaves soil in rough and cloddy conditions.

Fig. 2.2: Disc plough

3. **Rotavator:** It consists of moving blades on triangular base. It is a tractor drawn implement. As the tractor moves forward, the rotavator spins its many tines to pulverize any packed soil and remove large obstructions. It is used for preparing fine tilth and incorporation of crop residues and

weeds into the soil**.** This is a heavy-duty version of cultivators with a deeper and stronger operation power.

Fig. 2.3: Rotavator

4. **Cultivator:** They are used to stir and loosen the soil, breaking the clods and destroying the weeds in surface soil (15-18 cm). Cultivator performs the intermediary ploughing and harrowing. It also maintains the good tilth on soil surface, adequate aeration, prevent surface run off, and evaporation losses. Cultivators may be shovel, disc and blade types. Tines and spike cultivators are used to prepare tilth on soils

Fig. 2.4: Cultivator

Harrows: These are used for preparation of finer soil by breaking clod, cutting weeds, pulverising the soil surface during field preparation. The harrows may be disc, spike, spring or blade types.

Fig. 2.5: Disc Harrows

Plank: It is a heavy wooden log, generally used for compacting and leveling used for seed-bed and field preparation for sowing the seeds. Planks are also used immediately after sowing the seeds, to ensure proper coverage of seeds with soil. It is also used for leveling the soil after ploughing.

Seed cum fertilizer drill: It is a line sowing equipment used for direct sowing of pulses and application of fertilizer simultaneously. It requires 30 – 45 hp tractors to operate. Important features are

- **i.** Adjustment of seed rate and fertilizer rate
- **ii.** Seed and fertilizer is placed at right soil depth
- **iii.** It helps to provide band placement of fertilizer (at a specified distance from seed) if necessary.
- **iv.** Separate application of pesticide is similarly possible for soil borne pests.

Fig. 2.7: Seed-cum-fertiliser drill

Bund maker: It is used to divide large cultivated field in to small leveled plots so that interculture operations and irrigations can be managed properly. It is very useful in field bunding to capture *in situ* conservation of rain water and not allowing excess water to run off from the field. Field bunds are often required for piecemeal irrigation. Slopy lands may require bunding for contour making this is required in all such situations.

Activities

Identify tools and implements used for field preparation

Materials Required: Practical note book, pencil, pen, implements, *etc.*

Procedure: Write following information

- Identify different types of tools and implement
- Write the name of the tools and implements
- Use of tools and implements

Draw a diagram, and show different parts of tools and implements

Check Your Progress

Fill in the Blanks

1. Ploughing, harrowing and leveling of field is known as____________.
2. _________is a secondary tillage operation performed after the ploughing.
3. Leveling helps to modify existing _________.
4. Equipment use for ploughing is called __________________.
5. _________ plough can help turn the soil.
6. Cut, turn and break furrow slices by_______plough.
7. Seed cum fertilizer drill equipment used for _________.
8. Cultivator performs _________ and ___________.

Multiple Choice Questions

1. Cultivator helps to maintain good
   a. Tillage
   b. Tilth
   c. Landscaping
   d. Fertility

2. An implement used for preparation of finer soil by breaking clods
   a. Harrow
   b. Plough
   c. Level board
   d. Rotavator

3. An implement used for leveling the fields

a. Harrows
b. Cultivator
c. Rotavator
d. Plank

4. Large cultivated field divided into small leveled plots by

a. Bund Make
b. Cultivator
c. Rotavator
d. Plank

Subjective Questions

1. Describe various types of implements used for field preparation.
2. Write in brief
   i) Harrow
   ii) Cultivator
3. Describe ploughing and its advantages.
4. Explain purpose of leveling.

Session 2: Soil and Climate Requirement for Pulses Cultivation

Soil may be defined as a natural body developed as a result of weathering of rocks; in which plants and other forms of life can grow very well. It is the upper loose layer of earth crust rich in nutrients and minerals upon which plants grow. Soil in the field is composed of minerals (45-50%), organic matters (0.5-5%), water (25%) and large number of living plants, animals and microbes.

Types of soils:

Different types of soil can be found in India. These are classified as;

1. **Black soil -** These soils are poor in nitrogen, phosphate and organic matter but rich in potash, calcium and magnesium. These soils occur in Deccan Plateau – Maharashtra, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, and Valleys of Krishna and Godavari River.
2. **Red soils -** These are porous, friable and neutral to acidic in reaction. These soils are poor in nitrogen, phosphate, lime and humus. Red soils cover eastern and southern part of the Deccan plateau, Odisha, Chhattisgarh and southern parts of the middle Gangatic plain.
3. **Lateritic (laterite) -** These show acidic character with pH of 5 to 6. These soils are porous and have low water holding capacity. Lateritic soils are poor in N, P, K, Mg and lime. Continuous stretch of laterite soils is found on the summits of Western Ghats, Eastern Ghats, the Rajmahal Hills, Vindhyan, Satpuras and Malwa Plateau.

4. **Alluvial soil -** These are very productive soils which are formed due to deposition of silt carried out by the Indo-Gangetic-Brahmaputra Rivers in course of their massive flow during rainy season. Due to meandering of river-course, a rich deposit of alluvial soil develops. They also receive a supplement of silt if rivers are flooded with too much rain. Alluvial soil shows its presence in the plains of Gujarat, Punjab, Haryana, UP, Bihar, Jharkhand etc.

5. **Arid and desert soil –** Arid desert soils are sandy soils found in low rainfall areas. Only drought resistant and salt tolerant crops such as pulses, barley, rape, cotton, millets and maize can be raised in these soils. But desert soils with high pH value (alkaline) are unproductive. Western Rajasthan, north Gujarat and southern Punjab share area under desert soil in India.
6. **Forest and hilly soils** - These are the soils of higher and lower elevation on the hills. These are stony and infertile for production of crop. Such soils distributed in Himalayan region, Western and Eastern Ghats of India
7. **Peat and marshy land -** These soils are highly acidic and black in colour. Excessive wetness of soil causing decay and degradation of dead vegetation forms a layer of partially decomposed organic matter. Peaty and Marshy soils cover a sizable area in Kerala, Odisha, Tamil Nadu, West Bengal, Bihar, Uttaranchal states of the country.

Soil suitable for pulse cultivation

Pulses can be grown on a variety of soils. Pulse crops are very much susceptible for high pH and salinity hence, soil should be free from excessive soluble salts and neutral in reaction

Table 2.1 Soil suitable for pulse cultivation

S. No.	Name of pulse crop	Soil types	Field preparation
1	**Pigeon Pea**	Pigeon pea can be grown on a variety of soils ranging from sandy loam to clay loam but well drained fertile medium to heavy loams is most suited. The saline-alkaline and water-logged soil condition have adverse effect on nodulation	Well prepared field with friable soil having optimum moisture. It is a deep-rooted crop so one deep ploughing fallowed by 2-3 harrowing are sufficient. It can be sown by various methods like flat sowing in rows 60 cm to 200 cm apart depending on variety and intercrop included in the cropping system. Raised bed (2.7 m wide), Ridges & furrow,

			furrows are other methods of seeding the crop.
2-	**Black Gram**	Black gram can be grown on sandy soils to heavy cotton soils. Well drained loam soil having pH of 6.5 to 7.8 is ideal for its cultivation. This crop is not suited for alkaline and saline soils.	Field preparation depends up on season, in general one deep ploughing followed by 2 harrowing are sufficient to create a moderate tilth in kharif season. When sown in rabi or in rice fallows, (Andhra Pradesh, Karnataka, Tamil Nadu and Odisha) field preparation depends on residual moisture in the soil or availability of irrigation.
3-	**Green Gram**	Same as Black gram	It can be grown as a solo crop in kharif and *zaid* season and also as an intercrop in cotton, sorghum, Pigeon pea, etc. It is planted closely (30 cm row to row as solo crop. Field should be well prepared, levelled, free from stubbles or clods & have good drainage management. A good tilth is needed for Black gram sowing in *kharif* as well as in summer (*zaid*) or as intercrop
4-	**Moth**	It grows on many soil types but most suitable is light sandy soil. It does not tolerate waterlogged condition. Up to some extent salinity and a wide range pH (5.5 to 8.5) are tolerated by moth crop	One ploughing with one or two cross harrowing are enough for preparing light texture soils.

5-	**Lobia**	Loam or slightly heavy soils with proper drainage are ideal for lobia crop. In colder climate sandy soil is good as crop matures earlier there. Lobia crop is sensitive to alkaline conditions.	For hard soils, one deep ploughing with soil turning plough and thereafter two or three cross harrowing and planking are sufficient. In normal soil only two harrowing & planking is enough. For summer season crop, a pre-sowing irrigation helps achieve fine tilth for close line sowing.
6-	**Chickpea**	Chickpea can be grown on poor to fertile soils with good drainage. It is very sensitive to saline and alkaline soils.	Rough seed bed is suitable for under heavy soil condition, however for other types of soil medium tillage with one /two harrowing is sufficient. Chickpea enjoys relatively deeper seed placement & has a robust germination capacity in proper moisture.
7-	**Rajma**	Rajma can be raised in light loamy sand to heavy clay soil under adequate moisture. Loamy soils with proper drainage are good for its cultivation. It is very sensitive to saline soils. gives best result when pH of soil is close to 6.	Rajma seeds are bold and containing hard seed coat need a good seed bed. One deep ploughing with soil turning plough followed by 2-3 harrowing is needed. Stagnation of water is harmful so levelling of soil & good drainage is required. Lime treatment is required for acidic soils of the hilly areas before sowing.
8-	**Pea**	Pea crop can be cultivated on light sandy to heavy clay soils. Peas have a low tolerance to saline and water-logged conditions.	A field should be prepared with one deep ploughing by soil turning plough followed by two cross harrowing & simultaneous planking.

9-	**Lentil**	Lentil crop enjoys light loamy sand to heavy clay soils. It grows very well in moderately deep light black soils in Madhya Pradesh and Maharashtra. Lentil is susceptible to waterlogged situation. A soil pH near neutral is best for lentil production	After harvest of kharif crop, land should be ploughed once with soil-turning plough. This should be followed by cross-harrowing and planking. Raised bed planting is more beneficial than flat bed sowing of lentil.

Classification of pulse crops

India enjoys a rather typical monsoon climate. Surface winds patterns undergo reversals to create two types of rainfall periods. The monsoons travel from the sea to the land in summers (south west monsoon) and from land to the sea during winters (North east monsoon), hence, this is a double system of seasonal winds for most parts of India, the rainfall by southwest monsoon between June and September contributes 70-95% of the annual rainfall. However, in the southern coastal areas near the east coast (Tamil Nadu and adjoining areas) a large portion of the rainfall (up to 70%) is contributed by the northeast monsoon during months October to December. These areas are also called rain shadow areas. Some of the major types of climates found in India are as follows:

Classification on the basis of season-

1. **Winter season (December to February):** January and February are the coldest months of this season. The temperature is between 10°C to 15°C in Northern India and about 25°C in Southern India.
2. **Summer season (March-May):** The North Indian region experiences a well-defined hot weather season during the month of April and May. Temperature starts rising from the middle of March and by mid-May, temperature reaches 41° to 42°C. Temperature even crosses 45°C in areas of central and north-west parts of India. "LOO" (hot wind) is the striking feature of the hot weather season in northern India. It is a hot and dry wind which can cause heat stroke. The southern part of India experiences hot weather season but the temperatures are slightly lower and without the occurrence of loo.
3. **Rainy season (June - September):** The inflow of south-west monsoon in India brings the rainy season almost all over India. The monsoon may arrive in the first week of June or even earlier in the coastal areas, while in the interior parts of the country it strikes late by the first week of July.

With the onset of rains in monsoon season, temperature starts decreasing.

4. **Retreating monsoon (October - November):** The south-west monsoon starts to retreat from northern parts of India by the second week of September. The period of retreat leads to high day temperatures, but nights are pleasant with the mean minimum temperature going down to 20°C ± 2°C.

Climatic requirement for pulses cultivation

Different pulse crops are genetically adapted to different seasons *i.e. Kharif*, *Rabi* and *Zaid*. *Rabi* crops require mild cold climate at sowing, cold climate during vegetative growth to pod development and warming up climate during maturity. However, *kharif* crops require warm climate throughout their crop duration. Summer pulses are able to tolerate a range of warm to hot climate.

Table 2.2: Climatic requirement for pulses cultivation

S. No.	Name of pulse crop	Climatic requirement
1-	Pigeon Pea	Moist and humid climate for vegetative growth and dry condition for flowering and pod setting. Suitable temperature ranges 18-29°C but can tolerate up to 35°C. When rains coincide with flowering stage then it leads poor pollination. Rainfall 600-1000 mm is good. It is also a drought resistant crop but is susceptible to frost.
2-	Black Gram	It is a tropical crop and can tolerate high temperature up to 42°C. In northern India it is cultivated during rainy and summer season. In the eastern and in Southern states, where there is not much variation in the climate, it is cultivated during winter and rainy seasons with temperature ranges 25° to 35°C. For this crop short day plant to day neutral cultivars are available.
3-	Green Gram	A hot humid with sufficient soil moisture is ideal for Green gram; it is grown as summer and kharif season crop in north India. Short -day and long-day cultivars of mungbean suitable for accompanying temperature ranges have been developed. However, it is grown in winter season in peninsular India. Green gram can tolerate drought but is susceptible to frost, water logging and salinity. Flowering stage is vulnerable to rains.
4-	Moth	This is the most drought-resistant pulse crop of India It is cultivated in a narrow niche of hot, arid to semi-arid climate in Rajasthan, Gujrat and some western parts of M.P. It can withstand day time temperatures up to 45°C. Moth bean thrives under a rainfall of up to 750 mm but

		is performs successfully with rainfall as low as 250–300 mm. Even with as little as 50–60 mm in 3–4 showers during the growing period, some yield can be obtained.
5-	**Cowpea**	Cowpea is warm weather and semiarid crop for areas, with temperature range of 20°C to 35°C. Temperatures exceeding on either side are detrimental for its optimum performance. It can grow under shade of tree but cannot tolerate cold or frost.
6-	**Chickpea**	Chickpea is a rabi crop in India and is grown as a summer or spring crop in Mediterranean countries. Optimum temperature regime for chickpea is 24-30°C. It needs sufficient bright sunshine. The period of cool temperature decides the duration of the crop, because of which in North India, it comes to harvest in 160-170 days whereas, in South India, its duration is about 90-110 days. Very low (<8°C) or high maximum daily temperature (>35°C) are not conducive for growth or seed development phases.
7-	**Rajma**	On high hills Rajma is commonly cultivated as kharif crop, but in lower hills and *tarai* areas, it is grown in spring season. Rabi is most suited for its cultivation specially for north-east plains and hilly tracts of Maharashtra. It is highly sensitive to frost and water-logged conditions. Above 30°C, the flower drop is a serious problem. Similarly, below 8°C, flowers, developing pods and branches are damaged.
8-	**Pea**	Pea requires a cool growing season with moderate temperature throughout its life span. Pea crop suffers more due to high temperature than frost. High humidity with cloudy weather conditions favour spread of fungal diseases like powdery mildew. Optimum day-night temperature suitable for growth is 13-20°C.
9-	**Lentil**	Its range of cultivation extends to an altitude of 1,000 to 3500 m above MSL. The optimum temperature for its growth and development ranges from 15 to 25°C. It is a rabi crop mainly suitable to Northern & eastern-India.

Activities

Depict the type of soils on map of India.

Material required: Pencil, Pen, Notebook, Map *etc.*

Procedure:

- Enlist the type of soils available in different states of India
- Show the different type of soils on map of India
- Write down important characteristics of different type of soils

Check Your Progress

Fill in the blank

1. Soil is a natural body developed as a result of__________of rocks.
2. Soil provides ____________for plant growth and production.
3. Southwest monsoon comes between month__________.
4. Full form of B.I.S. is________.
5. Rainy season occurs during the ________month.
6. Full form of M.S.L. is________.
7. "LOO" is the striking feature of the ________season.

Multiple Choice Questions

1- The cold season temperature varies in Northern India
   a) 15°C to 20°C
   b) 10°C to 15°C
   c) 0°C to 5°C
   d) 08°C to 10°C

2- Peat and marshy land soil is
   (a) Highly acidic and black in colour
   (b) Highly acidic and red in colour
   (c) Highly alkaline and black in colourd
   (d) Highly alkaline and red in colour

3- Optimum temperature ranges required of Black gram is
   a) 20 to 25 °C
   b) 35 to 40 °C
   c) 25 to 35 °C
   d) 15 to 20 °C

4- Arid desert soils are sandy soils found in
   a) Low rainfall areas
   b) High rainfall areas

c) Moderate rainfall areas

d) None of these

Subjective Questions

1. Describe types of soil.
2. Explain importance of soil
3. Explain soil types and field preparation of Pigeon pea, Black gram and chickpea.
4. Describe BIS climate classification.
5. Describe climate requirement of Pigeon pea, pea and chickpea.

Module 3
Seed Production of Pulses

Module Overview

According to the Food and Agricultural Organisation (FAO) an individual's protein requirement is 80 g per day. In India, however, the availability after including imports is about 50 g/day. Thanks to a significant rise in growth rate of pulses in the last 7 to 8 years, India grows nearly 29.9 million hectares of pulse crops and the production of pulse grains is nearly 25.2 million tonnes. However, for the previous 40 years, the yield of pulses was stagnant at below 16 million tonnes per year.

It is therefore important to increase the availability of pulses in India speedily by targeting both vertical and horizontal increase. The most important factor in increasing the yields of pulses is to get access to good quality seeds. The second session of this Module deals with seed production techniques of important pulses. During seed production maximum care has to be exercised for the maintenance of genetic purity. Seed production has to be carried out under well-defined and well-organized conditions. Techniques described here are for the grade called 'certified seed' which is normally sold in the market for cultivation purposes by the farmers.

Learning Outcomes

After completing this module, you will be able to:

- Describe the criteria for selecting high-quality seeds and suitable varieties for specific crops, including factors such as disease resistance, yield potential, and adaptability to local growing conditions.
- Explain the principles and practices of seed production, including isolation techniques, pollination control, and harvesting methods to ensure genetic purity and high germination rates

Module Structure

- Session 1: Selection of Seed and Varieties
- Session 2: Seed Production

Seed

Seed can be defined as a dormant embryo (micro seedling) which develops as a seedling and a plant, when grown under appropriate environmental conditions. In terms of crop production, the most valuable, inexpensive, and basic input is the seed. Being dicots, pulses have seeds with two cotyledons as against monocots which have seeds (caryopsis) with a single cotyledon (see Figure above).

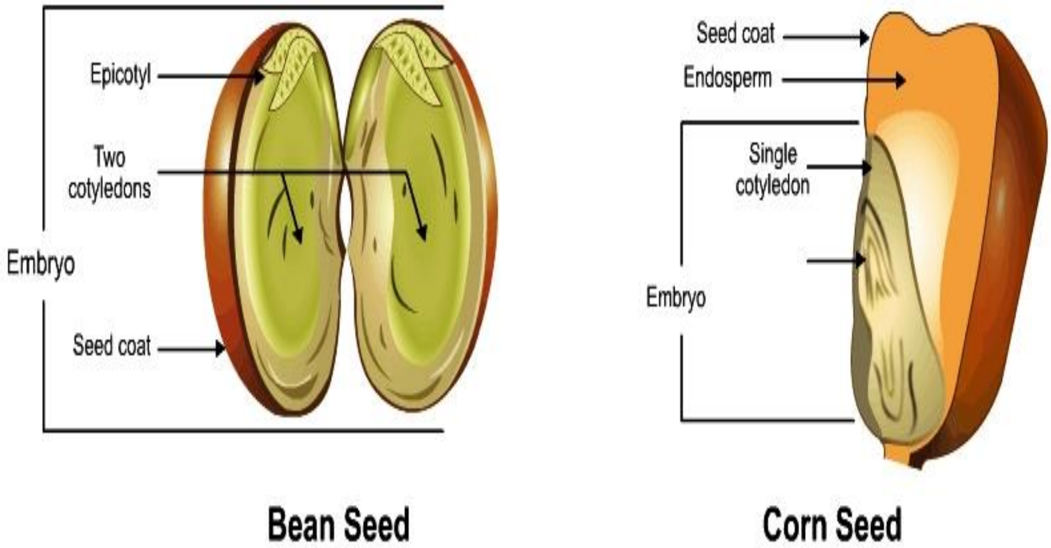


Fig. 3.1 Seed

Recognizing the vital significance of seed as a vital input in crop production, Govt. of India has instituted a law to control the quality. Utilization and marketing of good quality seed called the "Seed Act"

Types/Classes of seed

The development of crop varieties, which are genetically distinct from each other with assigned genetic traits, follows a generation-to-generation selection process. In self-pollinated species (seed production by self-pollination), a variety is supposed to have genotypic and phenotypic uniformity among all the plants grown. This is also called genetic purity.

During the progress of generations of seeds, there is a possibility of losing genetic purity by natural mutation, genetic drift, mechanical mixtures, etc.

In scientific seed production process, concrete steps are taken to ensure that these disturbances are minimized and the purity of a variety is maintained through generations and years (seasons). In order to satisfy purity as well as to multiply the seed to huge quantities required by the farming communities in India, an organized seed production protocol is followed.

Keeping in view the ultimate quantities required for the market, a work-back is adapted to as to ensure adequate production. This takes in to account the 'multiplication rate', which signifies how much seed is produced by sowing one kg parent seed. For example, if seed rate for sowing of chickpea is 20 kg per acre, and the production is 1,000 kg per acre (net after cleaning, grading, etc.), then multiplication rate is 1000/20 = 50. With this multiplication rate of 50, one kg seed of first (starting) generation will become 50 kg in next (2nd) generation, 2,500 kg in 3rd generation, 125,000 kg in still next and so forth.

The seed production process ensures getting the desired quantities of seed for the market by a particular seed producer by adopting appropriate seed production system. The final seed available for cultivation by farmer is generally the 'certified seed'.

The series of seed production process through one generation to the next, to reach certified seed, has been given specific names in the flow series, as per the following description:

Nucleus seed:

The nucleus seed is the starting point in the seed production chain (see Figure). It is hundred per cent genetically pure, true to type and has no phenotypic, genotypic or physical impurity. It is produced by authorised plant breeder located at Agriculture University or Research Institutes where the variety is originally evolved. Steps are scrupulously followed to ensure 100% purity during seed production process. Nucleus seed is not meant for growing by farmers. This is used by the plant breeder for further multiplication in the production chain, as breeder seed.

Breeder seed:

Breeder seed is developed from the nucleus seed under keen supervision of qualified plant breeder with same precautions and 100% level of purity, this seed has to be shared with commercial seed producing companies for further multiplication in larger quantities. Under the Seed Act, seeds in different levels of production chain have to be designated with prescribed labels and accompanying descriptive details. A golden yellow coloured tag certificate is issued by the breeder responsible to produce the Breeder's seed. This certificate protects the next generation seed producer who in turn, will be responsible for parameters of seed purity in the next generation.

Foundation seed:

Foundation seed is the progeny of breeder seed. Foundation seed is produced in huge quantities by non-plant breeders, often farmers contracted by the seed companies. So, the seed companies are obliged to invite an expert panel of scientists who visit the production plots at various stages of crop production to ensure purity and true to type characteristics of the variety. The Seed Act provides for a 99.5% level of genetic purity of foundation seed. A white coloured certificate tag is prescribed for foundation seed. This is a safeguard for the next generation seed producer, who will again be responsible for quality of seed produced by him for the next category.

Normally the parameters given on the certification label are found to be in order and it is very rare that a deviation may be observed while growing these seeds. In the case of a deviation, however, the supplier of the parent seed is liable for legal action under Seed Act.

Certified seed:

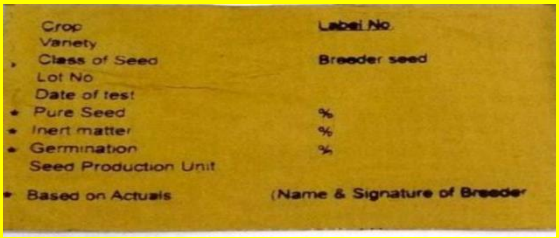
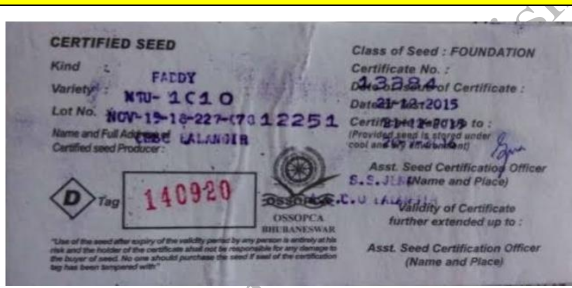
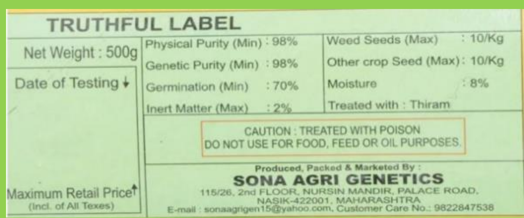
The progeny of foundation seed is a certified seed. Private Seed companies, State and National Seeds Corporation, and any of interested farmers can produce the certified seed. The genetic purity of certified seed should be 99%. This is a commercial seed, sold in open market. A blue colour tag certificate for the certified seed is issued by the seed certification agency. If the cultivator who grows certified seed finds any deviation from prescribed standards, he is entitled to compensation as per law (Seed Act).

Truthfully labelled Seed: There are prescribed standard norms to assign the name seed to any grain. In exceptional cases, where it may not be possible to follow the above series of seed production chain, like inability of Certification Agency to provide certification in time, the Seed Act provides that seed may be labelled truthfully as to the variety, and other requirements and standards under seed act. It is permissible to sale this seed in the market but producer has to duly subscribe to the Seed Act provisions. Responsibility of the seller remains the same as for selling certified seed.

Table 3.1: Differences between certified seed and truthful labeled seed:

Certified seed	Truthful labeled seed
Certification is voluntary. Quality is guaranteed by the certification agency.	For notified kinds of varieties, truthful labeling is compulsory. Conformity to seed act standards is necessary
Applicable to notified kinds only	Applicable to both notified and released varieties & research varieties
It should satisfy both minimum field and seed standards	Tested for physical purity and germination
Seed certification officer, seed inspectors can take samples for inspection	Seed inspectors alone can take samples for checking the seed quality.

Table 3.2 Types of seed tags

Class of Seed	Tag Colour	Tag Sample
Breeder Seed	Yellow	
Foundation Seed	White	
Certified Seed	Blue	
Truthful Seed	Green	

Session 1: Selection of Seed and Varieties

Good quality seeds play an important role to grow a healthy crop. While purchasing the seed, source of healthy seed should be trustworthy i.e., reputed seed company, research institute. Seed selection can be used to improve the quality of seeds. Farmers may also produce seed at their own farm. Since several diseases are transmitted via the seeds, seed plot should be free from any kind of disease or pest infestation. Also, full efforts should be made to achieve uniformity, true to type traits and free from mechanical mixtures. Small than normal size or uneven seed, shrivelled, immature, insect-damaged, and broken seeds must be eliminated. After removing the unhealthy seeds, the farmer can grow healthy seedlings. Even if seeds are selected carefully, still chances of presence of diseased seed are there. To make it disease free, seed treatment (e.g. fungicide or chemical seed treatment or hot water treatment, etc.) should be follow to improve the quality of seeds.

Producing seed at own farm: The seed production plot should be free from soil borne diseases, weeds, should be at least 10 meters away from another field of same crop and the seed producer should be prepared to cull out and remove by uprooting fully, any plants that do not conform to the variety characteristics at any, and all stages of crop growth. Selection of best performing true to type plants and uniformity of the crop is to be strictly enforced and maintained. Preferred plants (good size of pods, high number of pods, high number of branches per plant, etc.) may be tagged with paper or metal tags. At the time of harvest, the seeds of tagged plants should be collected for growing the next crop. This way, the farmer can easily improve the genetic purity and quality of the particular variety. The seed storage should ensure safety of seed from damage by moisture or pest, etc. Just before starting the next season, it is recommended that to select the seed once more, to remove off-type, damaged, discoloured or weed seeds, etc. Govt. of India is encouraging pulse farmers to produce seed at their own farms with assistance under three schemes viz., Seed Hub Scheme, Seed Village Scheme and NFSM.

Seed and variety replacement rate:

The major constraint in seed production is the availability of quality seed of improved varieties, to pulse farmers. Earlier, there was less willingness among the pulse farmers to purchase seeds of new varieties from the market even though their yields were low. Since 2012-13, however, the government has laid special emphasis on promoting new (less than 10-year-old varieties). This has helped to increase the replacement of old varieties by what is called a high variety replacement rate or seed replacement rate. As seen above, after passing through so many generations, in the seed production chain, the seed begins to deteriorate in quality of genetic uniformity. It is recommended to buy fresh seed of pulses every three years, viz., a replacement rate of 33%.

Chick Pea:

In India, all the agro-ecological zones of the country are growing chickpea (13.46 million ha). The crop maturity period varies among the zones (95-170 days), getting longer as we move towards northern latitudes. The better quality of nucleus seed and breeder seed of any varieties of pulses may be ensured by growing then in fields, which are free from weeds, diseases, insects and pests' infestation, salinity, and water logging problems. Of course, it is necessary to observe strict adherence to principles of seed production as per Seed Act. With a recent rise in price of chickpea and chickpea dal, there is a good demand for quality seed of this crop.

Green gram:

Area under Green gram crop has started to increase by virtue of varieties which are disease and drought resistant and also with varieties having a range of maturity within just 60 days to maturity in 80 days. This varietal diversity makes it possible to grow mungbean as a Summer (*Zaid)*, and *Kharif* and in addition to be cultivated as an intercrop with longer duration commercial crops *viz.,* cotton, sugarcane, sorghum, castor, etc. Accordingly, demand for quality and pure variety of seeds of different Green gram varieties has increased considerably.

Black gram:

Black gram is the third most important pulse crop of India and is only next to chickpea in achieving a rise in area under cultivation in the last 7 to 8 years. Like mungbean, Black gram is capable of cultivation in spring/summer, *kharif* all over India and in *rabi* season as a solo crop in southern zone. Apart from area increase, the current varieties of urd bean have pushed the mean yield of this crop above mungbean and a rise of almost 50% to a level of > 600 kg/ha. There is good demand of new seeds of urd bean.

Pigeon pea:

Pigeon pea is a widely cultivated crop in all the tropical and semi-tropical regions as drought tolerant crop with a large variation in (90-300 days) maturity. It is as high yielding as chickpea though it has longer duration. This crop is also unique in having determinate, indeterminate & hybrid varieties under cultivation. It is also the most versatile in its adaptation to diverse cropping systems. It is growing at a slow rate but is due for a big stride in rate of growth of production in the country.

Seed multiplication ratio in pulses:

The seed multiplication ratio plays an important role in planning the production of the breeder, foundation, and certified seeds. The multiplication ratio of chickpea, lentil, field pea, mungbean, Black gram, and Pigeon pea is given below:

Table 3.3 Seed multiplication ratio in pulses

Crop	Seed Rate for sowing	Minimum Multiplication ratio
Chickpea	60-75 kg/ha: desi; 100-150 kg/ha: *kabuli* chickpea	1:15
Lentil	40 kg/ha: small-seeded, 50 kg/ha: bold seeded or for rice fallow/ *utera*	1:15

Field pea	85-90 kg/ha	1:20
Mungbean/ Black gram	*Kharif* (12-15 kg/ha) Summer/spring (20-25 kg/ha)	1:30
Pigeon pea	12-15 kg/ha	1:40

Best practices to ensure quality seed production:

The physical purity of seed is observed by the presence of weed seeds, off type seed, damaged seed, and the percentage of other materials like dirt particles and plant residues. The germination capacity of the seed based on the standard test appears on the label. It should always be checked by a factual germination test before sowing the crop. If it is less by 10%, increase the seed rate at sowing by 10%/ If it is less than 75%, don't use this seed. Choose a field at least 10 meters away from another field of same crop on all sides. In case of Pigeon pea this field should be at least 250 meters away from another field of Pigeon pea all around. Carry out planting on a field which has not been used to grow the same crop last year. Sow in a well prepared, weed-free and disease-free field with a slightly higher inter-row distance to permit free movement for inspection, roguing, etc.

1. **Maintenance of genetic purity:**

   The various steps are needed to maintain genetic purity is as follows:

   a. Provide prescribed isolation distance to prevent contamination by out-crossing.

   b. Roguing of seed fields at least two times before flowering, once at peak flowering and once at peak pod formation is essential.

   c. Constant checking for uniformity and purity is essential.

   d. Certification of seed crops to maintain genetic purity and quality of seed.

   e. To make 100% sure that the seed obtained is pure send the seed to Seed testing lab for purity test.

2. **Distance and time isolation:**

   When seed production is undertaken in the same season when so many other farmers are also growing the crop for commercial purpose, a proper distance from any other variety has to be maintained to avoid pollinators or wind thrusts which can bring outside pollen and contaminate the genetic status of the seed variety. To avoid this, a minimum isolation distance is prescribed for each crop depending on known experiments. This is called distance or linear isolation.

In case of crops which can be grown in off-season at a non-traditional location, there is good chance that the seed crop will be surrounded by other crops only. This permits a high level of control to avoid possible contamination. Growing of a seed crop in a non-traditional season where this crop is not being grown by other farmers at this time is called time isolation.

Seed enhancement:

Seed enhancement refers to different technologies of seed treatment to increase the seed performance, to combat internally and externally seed borne diseases at germination time to provide vigour to seed for good crop yield and quality.

a) **Seed treatment:** Seed treatment for pulse crops is given with different chemicals fungicides, pesticides, and bio-agents *Trichoderma* etc.

b) **Seed pelleting:** Seed pelleting is involving a multi-layer treatment of seed with beneficial substances, which may be organic, biological or chemical based. The purpose is the same – to improvise ability of seed to fight soil borne hazards at initial stage of crop establishment.

3. **Proper storage conditions for quality seeds:**

The proper storage of seeds in godowns or in store rooms is needed special attention to keep the seed healthy. Seed stores should be hygienic, sanitized, dry and cool as per need and requirement. Proper seed protection measure against stored grain pests, rats, birds, with proper infrastructural facilities are necessary.

4. **Human resource development:**

India is one of the leading countries in the world in terms of seed production. After USA and China, India is the largest seed producer but unlike China and USA, it exports only small quantities of seed. That is because of huge home consumption. A huge manpower is employed by seed industry in India. Public sector as well as private seed companies employ contracted farmers and their families in production of hybrid seeds. So, Seed Industry is a big contributor to agricultural human resource development.

Varieties

A plant population of a given crop, having uniform phenotype and genotype (without any variation from generation to generation) and possessing unique traits or features distinguishable from population another population of the same species is called a variety or a cultivar.

Importance of new seeds and new varieties of pulse crops has been duly recognized by the Govt. of India. To popularise these new seeds, front line demonstrations have been carried out on the following varieties

Table 3.4 All India: Varieties Demonstrated under CFLDs (Cluster Front Line Demonstrations)

Crop	Variety
Pigeon pea	TJT-501, AL-201, Malviya Arhar-13, Asha, UPAS -120, NA-2, BSMR-736, GRG-811,
Black gram	Mash 114, UG 218, Shekhar, PU-31, AKU-15, IPU-94-1, Shekar, PU-19
Green gram	MH421, Pant Moong 5, IPM 2-3, Tripura Moong-1, MGG-347, Uttara, GM-4, KKM-3, SML-668, SML-832, HUM-16, Samrat
Horse gram	Birsa Kulthi, Pavur-2, Indra Kulthi.
Rajma	Wazej Rajmash, Tripura Rajmash Sel-1.
Mothbean	RMO-257, CZM-2
Lentil	HUL 57, DPL 62, L 4594.
Field pea	Prakash, Rachna, Anupam, Shalimar pea;
Chickpea	JG 16, HC1, GNG 1581, HC 1, HC 5, JAKI 9218, Vijay, Vishal, Digvijay, NBEG-3, BDNG-797, GG-2, GJG-3, GG-5, JGG-1, GG-5;

Source, Department of Agriculture and Farmer Welfare

Some of the popular varieties of pulse crops are as follows

Table 3.5: Suitable variety of pulses

Crop	Varieties
Field pea	HFP 9426, IPFD 1-10, Pant p 25, VL 45, HUDP 15
Green gram	Sweta, Pant Mung 6, Shalimar Moong 1, Samrat
Black gram	BDU 99-2, pant Urd 31, Pant Urd 40, Uttra

Mung bean	MH-421, Basanti, Sattya, SML-668
Lentil	HUL 57, Shalimar Masoor 1, VL Masoor 1, VLM 25, DPL62,
Pigeon pea	Bahar, Amar, Narendra Arhar 1, Pusa 9, MAL 13, NDA 2, MA 6, ICPL – 8791, ICP – 7035
Chick pea	BG 256, Udai (KPG 59), Pusa 372, KWR 108, Gujarat G 4 HK 2
Rajma	HUr 15, Udai, Utkarsh, Arun, Amber
Cow pea	CS-88, S-450 (Kohinoor), UPC-5286

Activities

Identification of different pulses seed

Materials Required: Seeds of different pulse crops, pen, pencil, eraser, etc.

Procedure:

- Visit nearby market or farmer field and collect seeds of various pulse crops
- Identification of collected seed
- Maintain record and preserve seed for next season
- Classify seed on the basis of size, shape and colour

Check Your Progress

Fill in the Blanks

1. Seed is a ____________ which develops into plant when subjected to required environmental conditions.
2. Bahar and Amar is variety of ____________.
3. 100% of genetic purity of the seed is maintained in the ____________seed.
4. Seed multiplication ratio of mung bean is ____________.

Multiple Choice Questions

1. Breeder seed is produced from
   a. Nucleus seed
   b. Foundation seed
   c. Certified seed
   d. Registered seed

2. BG 256 and Pusa 372 is variety of

   a. Cowpea
   b. Chickpea
   c. Lentil
   d. Rajma

3. Seed not for sale and farmers use is a

   a. Nucleus seed
   b. Foundation seed
   c. Certified seed
   d. Registered seed

4. Seed rate of field pea is

   a. 90-100 kg/ha
   b. 65-75 kg/ha
   c. 85-90 kg/ha
   d. 75-85 kg/ha

Subjective Questions

1. Differences between certified seed and truthful labeled seed.
2. Discuss the best practices to ensure quality seed production.
3. Write short notes on the following.

(a) Nucleus seed
(b) Breeder seed
(c) Foundation seed
(d) Certified seed

Match the column

A	B
1. Breeder seed	**a.** Opal green colour
2. Foundation seed	**b.** Azure blue colour
3. Certified seed	**c.** Golden yellow colour
4. Truthful labelled seed	**d.** White colour

Session 2: Seed Production

Seed is a prime input for enhancing production and productivity. Shortage of quality seed is a reason of low production and productivity of pulses in India. The use of quality seed alone can boost at least 20% higher yield. Access to good quality seeds is the most important factor in increasing the yields of pulses.

Seed production industry in India is well developed and is one of the leading seed industries in the world. India also has a well-organized seed production system backed by a legal support in the form of Seed Act. The supply of quality seeds in adequate quantity with correct time and at reasonable prices to the farmers is major factor that can lead to a quantum jump in the production of pulses in India.

Principles of seed production

- Varieties grown in areas of their adaptation can yield more seed.
- Seed crop must not be grown where same crop (any variety) was produced last year.
- Seed multiplication should be taken up for new promising varieties.
- Application of standardized seed production practices & other good agronomic practices should be adopted.
- Isolation to prevent contamination by natural crossing or mechanical mixtures is necessary
- Roguing of seed crop fields at prescribed growth stages and time intervals is necessary.
- Harvest the seed crop at full maturity but before shattering.
- Harvest and threshing methods should be able to safeguard seed against injury as well as preclude mechanical mixtures.
- Up-gradation of seeds by processing and grading is also essential.
- Provision for testing of seeds in the laboratory for moisture, germination, purity and health components is a must.
- Seed treatment with appropriate fungicides/ insecticides / bio-agents must be done to prevent possible infection/infestation.
- Packaging, labeling and sealing of the seeds to ensure the delivery of the quality seed produced through a rigorous system of quality control to the user.

Production of genetically pure seed is an important task; it requires high technical skills and dedication. During seed production maximum care has to be exercised for the maintenance of genetic purity. Seed production has to be carried out under standard (Table-3.8 & 3.9) and well-organized conditions. Several factors (both genetic and agronomic) are known to cause the deterioration of varieties during production cycles. The best means to ensure genetic purity is to overcome factors responsible for the varietal deterioration.

Genetic causes for deterioration of varieties

- Natural deterioration of varieties by mutation, genetic drift, etc.
- Natural crossing
- Developmental variation
- Mechanical mixtures
- Selective influence of diseases
- Inadequate care in handling seed production protocols

Agronomic principles

Considering the large number of pulse crops grown in different agricultural seasons and their reproductive characteristics, seed production programme requires the application of good farming practices along with careful management of crop. Following agronomic practices should be adopted for quality seed production of pulse crops:

1. **Selection of Agro-climatic Region:** Suitable site for seed production is one, to which of a crop variety under production is well adapted in terms of photoperiod, temperature, and other features.
2. **Selection of field:** Choose a well textured and fertile soil field having loamy soil without salinity & alkalinity with well drained facility. The field also is free from weeds, soil-borne diseases and insect pests.
3. **Isolation of seed crops:** For production of foundation and certified seed of all these crops, isolation distance is 10 m and 5 m, respectively while for pigeon pea it is 250 m and 100 m for foundation and certified seed production, respectively.
4. **Preparation of land:** A well-prepared field is highly desirable. Facility of water management and good uniform irrigation is necessary for best results.
5. **Selection of variety:** Seed production must be directed to high yielding varieties preferably with resistance or tolerance to biotic (disease/ pest) and abiotic viz., (drought) hazards.
   a. **Seed treatment:** As per requirement the seed treatment practices may apply chemical or bio-agent for seed protection and inoculation with appropriate *Rhizobium*, PSB, *Trichoderma*, etc. The inoculation should

be done only 10-12 hours before sowing. To inoculate 10 kg seed, 100 g gur should be added in one liter of water followed by heating up to prepare homogenous mixture. After cooling the mixture at room temperature, one packet of *Rhizobium* culture is added in it and mixed up thoroughly. Rubbing this mixture of the culture solution on seeds provides a uniform thin coating all over. After drying in shade for about 6-8 hours, seeds can be used for sowing. Seed must be sown on the same day.

Table 3.6: Different *Rhizobium* spp. are recommended for different pulse crops are as follows:

Chickpea	*Mesorhizobium spp.*
Green gram, Black gram & Pigeon pea	*Rhizobium & Bradyrhizobium*
Field pea, Lentil	*Rhizobium leguminosarum*
Cowpea	*Rhizobium spp.*

6. Time of planting: The crop should be sown well in planting time recommended for the particular area variety. Optimum time as recommended for getting maximum production of quality seed is as follows:

Table 3.7: Time of planting of pulses

Crop	**Sowing Time**
Green gram	2nd week of June to 1st week of July (with the onset of monsoon) - *kharif* March 1st week to March end - summer
Black gram	2nd week of June to 1st week of July (with the onset of monsoon)
Pigeon pea	Mid-June to July beginning (Mid-June is best)
Chickpea	Desi-25th October to mid-November Kabuli- Mid November
Lentil	November
Field pea	2nd fortnight of October to 1st fortnight of November
Cowpea	June- July

7. **Seed rate & method of sowing:** A lower (upto 10% lower) seed rates than normal is adopted for a seed crop because it is sown at a wider spacing than usual, both inter-row and inter-plant. More space is required to permit regular visits and inspections and roguing operations which are essential ingredients of seed production. Caliberated seed planter or seed drill should be used to arrive at uniform seed distribution in the field.

8. **Depth of sowing:** Depth of sowing depends upon seed size, structure of seed coat, soil moisture, and their growing season. Seed placement in moist soil is essential. A 7 - 8 cm depth is optimum for most pulses. Lentil is small seeded and should not be sown deeper than 7 cm and soil should be well tilled and contain optimum moisture. Chickpea is hardy, does not require fine land preparation and enjoys deep placement at 8-10 cm.

9. **Roguing:** A practice of identifying and removing plants of the seed crop, having deviating or undesirable characteristics is called roguing. It is the most important practice in any of crop in view of seed production. It should be done at the following stages as per crop.

    a. Twice during vegetative / pre-flowering stage

    b. Once at flowering and fruit formation stage

    c. Once at maturity stage

10. **Crop nutrition:** For the proper development of crop plant and seed, the application of required nutrients as per recommended package of practices should be adopted.

11. **Irrigation:** A pre-sowing irrigation is highly desirable as it ensures good and uniform germination and appropriate crop stands. If a spell of extended drought occurs, a light irrigation is again, highly desirable, because a low seed yield is a big discouragement.

12. **Weed control:** Weed control is the basic requirement of quality seed production. Weeds may cause contamination in crop seed, in addition to a reduction in yield. They are often an agent of disease or pest incidence.

13. **Disease and insect control:** All IPM practices must be scrupulously followed to forestall any losses. Do not hesitate to use chemical disease or pest control when economic threshold is reached.

14. **Harvesting of seed crops:** To obtain the good quality of seed, the crop should be harvested at the proper maturity stage having optimum moisture.

If machine harvesting is to be done, make sure that it is completely cleaned up before use in the seed field.

15. **Drying of seeds:** To maintain the viability and vigour of seed, it is necessary to dry seeds up to a safe moisture content level.

16. Storage of raw seeds: The seed material should be packed in new sacks. Never use old bags which carry contaminating damaged seeds and pests. Bags should be stored in a proper and safe place with temperature and moisture under control. Seed store should be dis-infected and sanitized with extreme care to prevent damage by insect pests, rats, birds, etc.

17. Seed standards: The provisions under Seed Act should always be kept in mind and must be an adhered to. For foundation and certified seed, the percentage of maximum physical purity should be 98% with minimum of 75% of germination capacity and 9-12 % of moisture content.

Table 3.8: Field standards of important pulse crops

Crops	Class of seed	Minimum		Maximum (%)	
		Isolation distance (m)	No. of Inspection	Plants of other crops	Plants of other sp.
Chickpea	Foundation (F)	10	2	Nil	0.10
	Certified (C)	5	2	Nil	0.20
Field pea, Green gram, Black gram, Lathyrus & Lentil	F	10	2	Nil	0.10
	C	5	2	-	0.20

Table 3.9: Seed standards of important pulse crops

Crops	Classes of seed	%				No. of seed/kg		
		Germination	Physical purity	Inert matter	Diseased seed	Other crop seeds	Seeds of other distinguish varieties	Weed seeds
Chickpea	F	85	98	2	Nil	Nil	5	Nil
	C	85	98	2	Nil	5	10	5
Field pea	F	75	98	2	Nil	Nil	5	Nil

	C	75	98	2	Nil	5	10	Nil
Green gram and Black gram	F	75	98	2	Nil	Nil	Nil	5
	C	75	98	2	Nil	Nil	Nil	10
Lathyrus	F	75	98	2	Nil	10	10	5
	C	75	98	2	Nil	20	20	10
Lentil	F	75	98	2	Nil	10	10	10
	C	75	98	2	Nil	20	20	20

Activities

Activity 1: Perform a germination test of seed of different pulse crops

Obtain soft paper, cloth or filter paper and seeds for this practical demonstration

Activity 2: Perform rouging in a pulse crop field

Materials Required: Sickles, khurpi, gumboot, gloves, herbarium file, pen, pencil, eraser, etc.

Procedure:

- Visit a nearby pulse crop field.
- Identify weeds and off-types of pulse plant being grown there.
- Rogue the off-type plants and weeds.
- Enlist of weeds found in growing field.

Check Your Progress

Fill in the Blanks

1. ________________.____ is a basic input for enhancing production.
2. A practice of identifying and removing undesirable characteristics in plants from a field is called ________.
3. Harvesting of the seed crops at _________ stage to get highly vigorous and viable seeds.
4. All pulses are self-pollinated except________.

Multiple Choice Questions

1. Isolation distance of certified seed for pigeon pea is
   a. 120 m
   b. 100 m
   c. 80 m
   d. 150 m
2. Seed production technique involves ______________.
   a. Isolation distance
   b. Roguing
   c. Seed standards
   d. All of the above
3. Standard of chick pea for minimum germination of certified seed is ________per cent.
   a. 85
   b. 80
   c. 95
   d. 90
4. Isolation distance of certified seed for Urd bean is
   a. 15 m
   b. 10 m
   c. 5 m
   d. 20 m

Subjective Questions

1. Explain principles of seed production.
2. Describe agronomic principles of seed production for pulse crops.
3. What are the precautions being taken in seed production?

Module 4
Integrated Nutrient Management (INM) in Pulse Crops

Module Overview

The elements necessary for normal metabolic activities in the body of an organism are known as nutrients. The process of nutrient supply and their intake is known as 'nutrition'. It has been observed that at least 17 essential mineral elements are necessary for the growth of plants. These nutrients are called 'essential elements. In the absence of any one of these, a plant fails to complete its normal life cycle, though the disorder caused can be corrected by adding that particular element. These 17 essential elements are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B), chlorine (Cl) and nickel (Ni). Green plants take carbon from atmospheric carbon dioxide, hydrogen from water and oxygen from atmosphere and water, whereas, the remaining elements are taken from the soil. On the basis of quantity present in the plant, they are grouped as macro- and micronutrients.

The elements present/required in large quantity are called macro-elements and those found in small quantities are termed as micro-elements or trace elements. Hence, iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), molybdenum (Mo) chlorine (Cl) and nickel (Ni) are micronutrients, as only traces of these elements are required. However, they are as important as macronutrients, which are required in abundance.

Learning Outcomes

After completing this module, you will be able to:

- Describe the essential plant nutrients, their roles in plant growth and development, and how to identify nutrient deficiencies and toxicities in crops.
- Explain the process and importance of soil sampling, including methods for collecting representative samples, analyzing soil properties, and interpreting results to inform nutrient management decisions.
- Discuss the application methods, benefits, and considerations for using manures, bio fertilizers, and chemical fertilizers to enhance soil fertility and crop productivity while promoting sustainable agricultural practices.

Module Structure

- Session 1: Plant Nutrients
- Session 2: Soil Sampling
- Session 3: Application of Manures, Bio Fertilizers and Fertilizer's

Session1: Plant Nutrients

Role of nutrients in plants

Plant nutrients can be classified according to their function or importance in plant life development and production. In this classification nutrients divided in to structural nutrients; accessory structural nutrients; regulators and carriers; and catalyst and activators.

Structural nutrients

Carbon (C), hydrogen (H) and oxygen (O) are structural nutrients. These are of vital importance and required in large quantities and mostly available naturally. These also called as non-mineral elements

Accessory structural elements

These are also called 'macro-elements', which can be supplied through manures and fertilizers. These are essential for the growth and production of plants and formation of proteins. These are nitrogen, phosphorus and Sulphur.

Regulators and carriers

These elements are potassium (K), calcium (Ca) and magnesium (Mg), which regulate plant growth and build resistance against crop pests.

Catalysts and activators

Iron (Fe), boron (B), nickel (Ni), manganese (Mn), molybdenum (Mo), zinc (Zn), chlorine (Cl) and copper (Cu) are act as catalyst and activators in various chemical process in the plant body. Although these are required in very small quantities, they are equally important. These activate various chemical changes within the cell.

Classification of plant nutrients

Nutrients can be classified according to their requirement and importance in plant life. They can be classified into basic nutrients, macro-nutrients and micro-nutrients.

Basic nutrients

The basic nutrients are carbon (C), hydrogen (H) and oxygen (O). These elements are obtained from air and water. Compounds made of these elements are called carbohydrates. Carbohydrates provide strength to cells.

Therefore, they are called sources of energy for plants and for organisms who consume plants.

Macro-nutrients

This is further divided into:

- **Primary nutrients:** These consist of nitrogen (N), phosphorus (P) and potassium (K). These nutrients are supplied through fertilizers and **organic manures.**
- **Secondary nutrients:** This group of nutrients includes calcium (Ca), magnesium (Mg) and Sulphur (S).

Micro-nutrients

They are also known as minor or trace elements. This group of elements comprised of iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B) molybdenum (Mo) and nickel (Ni).

Nutrients, their functions and deficiency symptoms

Nutrient deficiencies are often mistaken as disease. Classical example is *khaira* disease of rice which was considered to be a fungal disease until it was discovered to be actually a deficiency of Zn. Likewise, *laliya* (red leaf of cotton) disease of cotton was considered to be caused by mycoplasma until it was traced too Mg deficiency. So, it is important to get the confusion removed either way – disease confused with deficiency symptom or vice-versa

Nitrogen (N)

Functions

(a) Promotes the growth and development of leaves and stems

(b) Enhances the dark green colour in plants and improves the quality of foliage

(c)Necessary for the development of cell protein and chlorophyll

(d) Improves the uptake and assimilation of other nutrients, like phosphorus, potassium, magnesium and Sulphur

Deficiency symptoms

a. Loss of vigour and yellowing of green parts especially the new (meristematic) growth

b- Shortening of the stem, leaves become paler and remain small in size

c- Slow growth and a plant become dwarf

Phosphorus (P)

Functions

(a) Stimulates root formation and healthy growth of roots

(b) Source of energy and maintenance of vigour in the plants

(c) Vigorous growth and speedy maturity

(d) Necessary for enzyme action in many plants processes

Deficiency symptoms

(a) Growth of a plant is retarded at the early stage

(b) Older leaves curl up and become purplish in colour

(c)Scorching of leaf margin is observed sometimes

(d) Slow maturity and vegetative growth continue beyond normal time

Potassium (K)

Functions

(a) Helps in carbohydrates and protein synthesis

(b) Helps in the transfer of carbohydrates from leaves to roots called the transporter of elements

(c) Increases disease resistance, vigour and hardiness to drought and frost

(d) Improve the quality of produce

Deficiency symptoms

(a) Deficiency symptoms appear midway through the life cycle of the plant

(b) Symptoms appear as dark bluish green leaves and shortened internodes

(c) Terminal leaves show bronzing accompanied by necrotic spots

(d) In case of acute deficiency, leaf margins dry up and often premature death of a plant occurs

Sulphur (S)

Functions

(a) Promotes root growth and vigorous vegetative growth

(b) Essential for protein & oil formation

(c) Required in metabolic activities

Deficiency symptoms

(a) Shoots become light green; veins on the leaves also turn paler

(b) Yellowing of leaves and stunted growth of a plant

(c) Yellowing starts from upper leaves and the plant shows chlorosis

(d) Severe deficiency results in reddening of the stem and curling of leaves inwards

Calcium (Ca)

Functions

(a) Improves plant vigour

(b) Influences the intake and synthesis of other plant nutrients

(c) Important constituent of cell wall

(d) Increases the yield of large and medium-sized tubers

(e) Improves specific gravity of tubers, and thus, enhances tuber quality for processing

Deficiency symptoms

(a) Failure of development of terminal buds at apical tips

(b) Small leaves

(c) Leaves do not develop normally and have wrinkled appearance

(d) In mild deficiency, a light green band appears along the margin of leaves of terminal buds

(e) In severe deficiency, young leaves at the top remain folded and later their tips die

Magnesium (Mg)

Functions

(a) Influences the intake of other essential nutrients

(b) Helps in the assimilation of fats

(c) Assists in the translocation of phosphorus and fats

Deficiency symptoms

(a) Green parts between veins in leaves become pale, though the veins remain green

(b) Leaf tips curl up

(c) Leaf lamina turns brown red or maroon

(d) In severe deficiency, leaflets become thick, brittle, show bulging and roll upwards

Zinc (Zn)

Functions

(a) Synthesis of tryptophan

(b) Helps in enzyme action

(c) Essential for protein synthesis and seed production

(d) Fastens the rate of maturity

Deficiency symptoms

(a) Younger leaves become yellow

(b) Shallow pits develop in the inter-veinal portion on upper surfaces of mature leaves

(c) Leaves show inter-veinal necrosis, while midrib remains green

Iron (Fe)

Functions

(a) Essential in the enzyme system of plant metabolism

(b) Essential for the synthesis of enzymes which are responsible for chlorophyll synthesis in plants

Deficiency symptoms

(a) Yellowing of younger leaf blades, while veins and petioles remain green

(b) Affected plants remain small and do not respond well to normal fertilizer treatments

Manganese (Mn)

Functions

(a) Helps in the oxidation-reduction process during photosynthesis

(b) Essential element in respiration

Deficiency symptoms

(a) Plants show a light inter-veinal chlorosis of leaves

(b) Mature leaves when observed in light show netted veins

(c) Appearance of chlorotic and necrotic spots in inter-veinal areas of leaves

Copper (Cu)

Functions

(a) Essential for the synthesis of chlorophyll and other plant pigments

(b) Helps improve the flavour and the content of sugar in vegetables

(c) Increases the dark green colour of leaves and also the crop yield

Deficiency symptoms

(a) Necrosis on the tip of young leaves along the margin

(b) Defoliation

(c) Leaves of deficient plants curl up and their petioles bend downwards

Molybdenum (Mo)

Functions

(a) Involved in nitrogen fixation and nitrate assimilation

(b) Required by some microorganisms for nitrogen fixation in soils

Deficiency symptoms

(a) Chlorotic inter-veinal mottling of lower leaves followed by marginal necrosis and in folding of leaves

(b) Loss of turgidity, drooping & wilting of leaves

(c) In cauliflower, the lamina of new leaves fails to develop and gives a whiptail appearance

Boron (B)

Functions

(a) Helps in the synthesis of the bases of RNA (ribonucleic acid)

(b) Promotes root growth

(c) Enhances pollen germination and pollen tube growth, thereby, improving fruiting

(d) It has a role in fruit and seed development

Deficiency symptoms

(a) Loss of apical dominance

(b) Leaf blades develop pronounced crinkling

(c) Darkening and crackling of petioles

(d) Syrupy exudation from leaf blades

(e) The leaves may have thick coppery texture and sometimes curl up and become brittle

Chlorine (Cl)

Functions

(a) It has a direct role in photosynthesis

(b) It is necessary for shoot apex and root growth

Deficiency symptoms

(a) Chlorosis and wilting of young leaves

(b) Chlorosis of the inter-veinal area of leaf blade

(c) In severe deficiency, bronzing of the mature leaves on upper surface

Nutrient deficiency and Corrective measures

It is best to not allow the deficiency to occur in the first place. This is particular true of micronutrients because by the time their symptoms appear the damage has already occurred. Given below are the corrective measures when deficiency has been detected and traced to the concerned element. These are not to be confused with the crop's overall requirements of nutrients or fertilizers.

The soil application of corrective measure must be done only with irrigation or when soil moisture is adequate; otherwise, soil application may prove harmful for the crop or may remain ineffective.

It is advisable to apply 100 kg per hectare gypsum and 25 kg per hectare $ZnSO_4.7H_2O$ obviate chances of S or Zn deficiency, especially in black, red soils and lateritic soils.

Table 4.1: Deficiency of Nutrient and their Corrective measures

Deficiency of Nutrient	Corrective measures
N	**Use of nitrogen fertilizer in the soil** Nitrogen containing fertilizers like ammonium sulphate, calcium nitrate, urea etc. are applied. **Foliar spray of urea** Use of 1-2% urea solution as foliar spray is a quick method of correcting N deficiency

P	**Application of phosphatic fertilizer in the soil** Use of phosphorus containing fertilizers such as DAP, single super phosphate etc. Foliar spray of DAP @ 2% DAP
K	**Use of potassic fertilizer** in the soil e.g., muriate of potash. **Foliar Spray** 1% potassium chloride solution foliar spray is commonly used to overcome K deficiency
Ca	**Soil Application** In Indian soils, Ca deficiency is not a serious problem. Application of calcium carbonate or calcium hydroxide in the soil. Calcium ammonium nitrate (CAN) or super phosphate or gypsum is applied in deficient soils.
Mg	**Soil or foliar application of magnesium sulphate** Best to apply foliar spray @ 2% of $MgSO_4$
S	**Soil or foliar application of sulphur (**sulphate**)** In case severe deficiency, gypsum is added to the soil @ 500 kg/ha.
Fe	**Soil or foliar spray of ferrous sulphate** Apply 0.5% ferrous sulphate along with lime as foliar spray will remove the Fe deficiency. Chelated iron compounds such as Fe-EDTA, are very effective in quick recovery through foliar application.
Mn	**Soil or foliar spray of manganese sulphate** Foliar spray of 0.5% manganese sulfate along with lime is quite effective and it should be applied in the early stage of the crop. Or,

	Use 15-20 kg $MnSO_4$ per ha (mixed with sand) as soil application.
Zn	**Soil or foliar application of zinc sulphate** Foliar spray of 0.5% $ZnSO_4$ twice at 7-10 days interval during early stages of growth is advisable. Soil application of 20-25 kg $ZnSO_4$ per ha is also effective.
B	**Soil or foliar spray of boric acid or borax** Foliar spray of 0.2% borax acid is quite effective. Ca & B do not go together. So, do not apply simultaneously
Cu	**Soil or foliar spray of copper sulphate** Foliar spray of 0.5% of $CuSO_4$ is recommended.
Mo	**Soil or foliar application** Soil application of 0.5 to 1.0 kg/ha sodium or ammonium molybdate or by its foliar spray @ 0.01-0.02% concentration should be adopted

Nutrient recommendation in pulse crop:

For pulses 10-15 t/ha well decomposed FYM has to be well mixed in soil with last ploughing of field preparation. It improves physical as well chemical properties of soil. These properties help to enhance yield of the crop. For pulse cultivation nitrogen, phosphorus and potash (If recommended on soil test basis) should be given as basal dose.

Table 4.2: Nutrient management of different pulses

S. No.	Name of Pulse crop	Nutrient management
1-	Pigeon pea	**Under Irrigated**: Pigeon pea is a deep-rooted crop and gave good response to bio-fertilizers. The 25 kg nitrogen as

		starter dose (basal dose), phosphorus 50 kg are necessary. K is needed only if soil test indicates the need. Need based application of 20 kg sulphur per hectare as gypsum under saline soil, and 20-25 kg zinc sulphate per hectare may be applied. **Under Rainfed:** 20 kg nitrogen, 25 kg phosphorus per hectare should be given as basal dose.
2-	Black gram	**Irrigated** 25 kg nitrogen, 50kg phosphorus as basal dose. **Rainfed**: 20 kg nitrogen and 25 kg phosphorus as basal application
3-	Green gram	**Rainfed**: 20 kg nitrogen 25 kg phosphorus per hectare as basal application **Irrigated:** 25 kg nitrogen 50 kg phosphorus per hectare as basal application.
4-	Moth	Moth plant has wonderful capacity to absorb less soluble form of phosphorus, hence 20 kg nitrogen, 40 kg phosphorus as basal dose is recommended. Because it is a crop grown in light soils, application of FYM is a must.
5-	Lobia (cowpea)	15-20 kg N/ha as starter dose in poor soils (organic carbon), add 40 kg phosphorus on per hectare basis. All doses are recommended as basal application.
6-	Chickpea	**Under Rainfed**: For timely sown chick pea crop 20 kg nitrogen, 40 kg phosphorus and 20 kg sulphur **Irrigated timely sown** 20 kg nitrogen, 60 kg phosphorus, 20 kg potash and 20 kg sulphur. **Late sown** 40 kg N, 40 kg P, 20 kg K and 20 kg sulphur/ha is recommended
7-	Rajma	Rhizobia necessary for nodulation in Rajmash are deficient in Indian soils. Hence, its N requirement is high. Apply 90-120 kg N per hectare, half of it as basal & rest top dressed in two applications at pre-flowering and fruiting. Phosphorus application up to a level of 60-80 kg P_2O_5 per ha as basal application is required.

8-	Pea	Apply 20-30 kg/ha nitrogen in tall types and 40 kg/ha nitrogen in dwarf types varieties at sowing time. P and K should also be applied as basal dose on soil test basis. Generally, 40 kg/ha and 40-60 kg/ha P_2O_5 in tall and dwarf, respectively with 20-30 kg K_2O and 20 kg sulphur per hectare are required. Better to apply basal dose of fertilizer as band placement 4-5 centimetre away from the rows and deeper than seed. In acid soils, rhizobium inoculated seed for one hectare should be dusted with 1.5 kg of finally powdered lime ($CaCO_3$).
9-	Lentil	**Normal sowing time under rainfed condition** 20 kg nitrogen, 40 kg phosphorus and 20 kg sulphur per hectare **Normal Sowing time under Irrigated condition** 20 kg. nitrogen, 40 kg phosphorus and 20 kg sulphur per hectare **In case of late sowing** 30 kg nitrogen, 40 kg. phosphorus and 20 kg sulphur on the per hectare basis

Activities

Identify deficiency in the given samples of pulse crops.

Material required: Sample of pulse crop, picture showing symptoms, herbarium file, pen, pad, pencil *etc.*

Procedure:

- Observe the given sample care fully
- Identify the crop
- Identify the symptoms
- Match with the pictorial chart and confirm it
- Write down name of deficiency symptoms
- Write down the corrective measures of deficiency symptoms
- Prepare herbarium file of different deficiency symptoms

Check Your Progress

Fill in the Blanks

1. Carbon, hydrogen and oxygen are ___________nutrients.
2. Plants obtained carbon, hydrogen, and___________ from the air and water.
3. Micro nutrients also known as ____________elements.

4. Enhances the dark green colour in plants and improves the quality of foliage are the functions of___________.
5. Stimulates root formation and its growth are the functions of ___________.
6. Calcium is an important constituent of the _________.
7. ___________ helps in the oxidation-reduction process during photosynthesis.
8. Zinc fastens rate of________ in the plants.
9. Failure of development of terminal buds at apical tips is deficiency symptoms of_________.
10. The nitrogen fixation and nitrate assimilation are the functions of _____________.
11. Calcium (Ca), Magnesium (Mg) and __________ are secondary nutrients.
12. Increases disease resistance, vigour and hardiness to drought and frost are the functions of ___________.
13. Full form CAN is __________.

Multiple Choice Questions

1. -----------essential elements are required for plant growth and development.
   a) 15
   b) 6
   c) 17
   d) 18
2. Micro nutrients are ------------
   a) Ca, Mg, S
   b) N, P, K
   c) C, H, O
   d) Zn, Cu, B
3. Foliar spray of -------------% DAP is commonly used to overcome P deficiency.
   a) 1
   b) 4
   c) 2
   d) 3
4. Deficiency of boron result in-----------
   a) Loss of apical dominance
   b) Rosette appearance
   c) Syrupy exudation from the leaf blade

d) All of these

Descriptive Questions

1. What are micro and macro nutrients? Give examples?

____
____
____
____

2. Describe important functions of phosphorus and its deficiency symptoms?

____
____
____
____

3. What are the corrective measures of nitrogen deficiency?

____
____
____
____

Match the Column

Nutrients	Function/Deficiency causes
1.Phosphorus	**a.** Synthesis of the bases of RNA.
2.Potassium	**b.** Nitrogen fixation and nitrate assimilation
3.Sulphur	**c.** Synthesis of chlorophyll
4Calcium	**d.** Fats assimilation
5. Magnesium	**e.** Defoliation
6. Copper	**f.** Failure of terminal bud development
7. Iron	**g.** Reddening of stems and curling of leaves inward
8. Molybdenum	**h.** Dark bluish green leaves
9. Boron	**i.** Curled and purplish in colour

Session: 2 Soil Sampling

Importance of Soil testing

Soil testing is helpful to know the status of various nutrients, soil fertility level, pH, etc. It is important to know the fertility status and physical properties of a soil for maximum production and rational soil management. A complete soil test programme essentially consists of three basic steps.

(i) Soil sampling

(ii) Soil testing/analysis

(iii) Soil test data interpretation

Purposes of soil testing

- It helps to evaluate and improve soil productivity.
- It helps to determine the nature of the soil, i.e., alkaline, saline or acidic.
- Soil testing helps to know about the use of fertilizers and manures, and their dosage in order to improve the fertility of the soil.
- With the help of soil test one can know the actual condition of the soil so that it can be improved with the application of nutrients and other management practices.

Soil sampling Procedure

Soil sampling is the most important activity to know about soil of a particular field or area through soil analysis. Nutrients present in soil are known to vary even at micro-level in the field. It is therefore, necessary to take soil sample in such a way that it is fully representative of the field**.**

Materials required for soil sampling

1. Spade
2. Khurpi
3. Auger (screw or tube or post hole type)
4. Scale
5. Sieve
6. Label
7. Aluminum box

Figure 4.1: Aluminum box

8. Core sampler

Fig.4.2: Core

Fig. 4.3: Sampler without core

9. Sampling bags (Plastic/Cloth)

10. Plastic tray or bucket

Fig. 4.4: Plastic tray

Points to be considered before sampling

1. Collect the soil sample during fallow period: It is the period between harvesting of one crop and sowing of successive crop in the same field
2. In case of standing crop, soil samples should be collected from inter row space (space between rows).
3. Samples should be collected separately from different field units normally not exceeding 1 ha.
4. Fields that are not alike in colour, slope, drainage, pest management practices or at different elevations, should be treated as different sampling units.
5. Soil sampling depth depends on crops to be grown, for shallow rooted crops (pulses other than Pigeon pea) sampling depth should be up to 15 cm. However, for deep rooted crops it should be at 15 cm as well as at 30 cm deep.

How to select Sampling Unit at the farm

1- Before the actual sampling of a field, a visual survey of the field should be done in consultation with the farm owner, because he knows the kind of variation as visible in the crop grown in the field earlier. Also note down information regarding slope, pits, management practices, cropping systems, soil colour and its texture

2- Prepare a map of that field on paper and demarcate the field covering the identified variation, and divide into uniform portions showing boundaries depending on their uniformity in slope, management, cropping pattern and colour etc.

3- If whole field appears as uniform in all aspect, then it can be considered as single sampling unit. Normally one field unit should not cover more than one hectare.

4- Now demarcate the field unit on the basis of map and each unit should be sampled separately. These sampling units are mapped and are assigned an identification number for each (A, B, C etc. or 1, 2, 3 etc.).

Sampling Procedure

1- For each assigned unit fix the sampling spot in a random and zig zag pattern in a sampling unit. Each sampling unit will have separate and different (random) pattern.

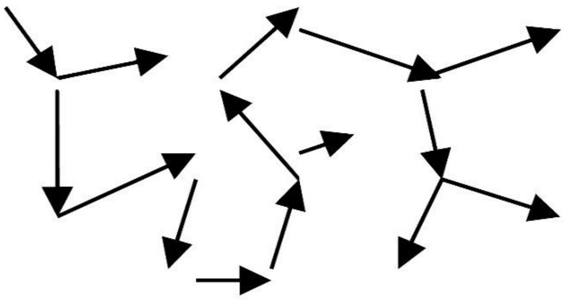


Fig. 4.5: Sampling unit with sampling spot

2- Make Sampling spot clean by removing surface litter if any.

3- Collection of 10-15 soil samples from representative spots is sufficient from each sampling unit with the help of auger.

4- Insert the auger up to a plough depth of 15 cm and draw the soil sample from a sampling spot and place the sample in a tray.

5- If the soil is too hard for use of auger, use spade or khurpi. Using spade/ khurpi make a "V" shape cut (as shown in figure) to a depth of 15 cm in the sampling spot by slicing a 2.0-2.5 cm thick piece of soil at the slope of v-cut right up to the bottom.

6- Repeat the process at each selected spot as per diagram above.

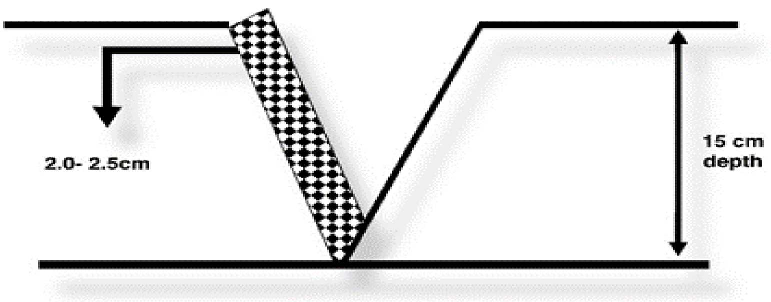


Fig. 4.6: "V" Shape cut for soil sampling

7- Drop the collected soil from each spot on a clean cloth or paper sheet and mix well. Spread the soil evenly and divide it into 4 quarters (see figure below). Reject two opposite quarters as shown in Figure and mix the rest of the soil again. Keep repeating the process till left with about 500 g of soil. This is the sample for soil test. Bag it properly with identification of farmer, village, field number, date of collection, last crop grown, etc.

Fig. 4.7: Quarter method of soil sample preparation

Processing and storage of sample

1. Assign the number to sample and keep its record in soil sample register.
2. Break large lumps of collected soil sample with the help of wooden mallet and dry the sample in shade by spreading on a clean sheet of paper.

Fig. 4.8: Mallet

3. Sieve dry soil powder through 2 mm sieve.
4. Repeat powdering and sieving process until only materials of > 2 mm (no soil or clod) is left on the sieve.
5. Soil passing through 2 mm sieve should be collected and store in a clean glass or plastic container or polythene bag with proper labelling for further analysis in the laboratory.
6. Soil samples should not be stored along with fertilizer materials and detergents to avoid contamination.
7. Information sheet of soil sample should be clearly written with permanent ink.

Information Sheet of soil sample:

I. Sample number
II. Name and address of the farmers
III. Details of the field and site, Local name of field, Khasra number etc.

IV. Date of sampling
V. Name of crop and variety to be sown/grown
VI. Source of irrigation
VII. Whether the crop in subsequent season irrigated and unirrigated
VIII. Name and type of crop and fertilizer used in previous year
IX. Date of harvest of the previous crop
X. Any other common

Interpretation of Data

Soil tests and their interpretations are based on the collection of soil samples and their analysis. Therefore, soil samples that are taken to represent the whole field. To obtain information about the nutrient status of a soil, it is essential to follow the correct procedure of soil sampling.

The collected sample is analyzed for physical and chemical properties by using standard methods in a laboratory for the following parameters.

- Size of soil separates or texture of soil
- Colour of soil
- pH (indicates whether the soil is acidic, alkaline or neutral in nature)
- Presence of total soluble salts (determined by EC, which indicates whether the soil poses any constraint to seed germination and subsequent crop growth)
- Lime and gypsum, if needed
- Organic carbon, which is an indirect measure of nitrogen content in the soil
- Phosphorus content in the soil
- Potassium content in the soil

Soil test interpretations based on the soil analysis; data can be interpreted with the help of ratings as given in the following tables.

Soil Physical properties:

Table 4.3: Soil texture classes

Name of soil separate	**Size of particle (Diameter in mm)**	**Interpretation**
Boulders	> 256 mm	Stones and gravels may affect the utility and management of land by creating tillage difficulties. These larger particles have no significant role in soil properties such as water holding capacity and capacity to store plant nutrients and their supply
Cobbles	64 – 256 mm	
Pebbles	4 – 64 mm	
Gravels	2 – 4 mm	
	Particles less than 2 mm is called fine earth, normally considered in chemical and mechanical analysis	
Coarse sand	0.2 – 2.0 mm	These particles are represented by spherical in shape due to uniform dimension, usually contains quartz with fragments of feldspar, mica and heavy minerals such as zircon, tourmaline and hornblende.
Fine sand	0.02 – 0.2 mm	
Silt	0.002 – 0.02 mm	*Particle size of silt is in between sand and clay silt particle has more surface area due to its small size. *It contributes physio-chemical properties as that of clay to a limited extent because sand and silt give a skeleton to soil.
Clay	< 0.002 mm	Clay particles represented by plate like or needle like in shape. It also called as flesh of the soil.
S. No.	**Soil Colour**	**Interpretation**
1.	Black to dark brown	Soils with high content of organic matter

2.	Red, brown and yellow tinge colour.	Soil with high content of iron compounds
3.	White or light coloured	Large quantity of silica, lime and other salts
4.	Brown	Presence of mixture of organic matter and iron oxides
5-	Mottled colour	Presence of iron and manganese compounds such colour developed due to alternate wetting and drying condition
6-	Bluish and greenish colour	Due to reduction of ferrous compound in waterlogged condition

Table 4.4: Rating of soil on the basis of pH

S. No.	**Type of soil**	**Soil reaction (pH)**
1.	Acidic	<6.0
2.	Normal to saline	6.0-8.5
3.	Tending to become alkaline	8.6-9.0
4.	Alkaline	>9.0

Table 4.5: Rating of soil on the basis of EC (1:2)

S. No.	**Category**	EC (ds/m)
1.	Normal	< 1.0
2.	Critical for germination	< 1.0-2.0
3.	Critical salt levels for growth of sensitive crops	2.0-4.0
4.	Injurious to most crops	> 4.0

Table 4.6: Rating on the basis of nutrient availability (1:2)

S. No.	Nutrient	Low	Medium	High
1.	Organic carbon	<0.5%	0.5-0.75%	>0.75%
2.	Available nitrogen (N)	<280 kg/ha	280-560 kg/ha	>560 kg/ha
3.	Available phosphorus (P)	<12 kg/ha	12-25 kg/ha	>25 kg/ha
4.	Available potassium (K)	<110 kg/ha	110-280 kg/ha	>280 kg/ha

Activities

Collect and prepare soil sample

Material required: Soil auger, scale, spade, khurpi, sieve, label, core sampler, sampling bags, plastic tray, pen, pencil and practical record.

Procedure:

- Select the field for soil sample
- Mark the places where samples to be collected
- Dug out the pits of 10-20 cm depth
- Collect the sample for testing
- Similarly collect samples from all identified locations
- Mix the all collected samples thoroughly
- Divide the collected samples to four equal parts
- Mix the two opposite parts and discard the remaining two
- Repeat the procedure till you have 500 g sample
- Put it in paper bag with a label inside
- Put the sample in polythene bag
- Label it and send to soil testing laboratory for testing

Check Your Progress

Fill in the Blanks

1. A complete soil testing essentially consists of three basic steps are soil sampling, soil testing and _________.

2. Soil sample is collected at a depth of _________.
3. Soil sample should be collected at several locations in ____________ pattern.
4. pH indicates whether the soil is acidic or neutral or _________.

Multiple Choice Questions

1. Soil with high content of organic matter is indicate which soil colour.
    a. White or light
    b. Mottled colour
    c. Black to dark brown
    d. Brown
2. Particle size of slit is
    a. 0.02-0.2 mm
    b. 0.002-.02 mm
    c. 0.2-2.0 mm
    d. 2.0-20.0 mm
3. Acidic soil pH range is.
    a. More than 9.0
    b. 8.6-9.0
    c. 5.0-6.0
    d. Below 6.0
4. Less than 280 kg/ha of available nitrogen is coming under
    a. Medium ratting
    b. Low ratting
    c. High ratting
    d. None of these

Descriptive Questions

1. Explain importance of soil testing.

2. Describe the purposes of soil testing.

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2. Explain soil sampling procedure?

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3. What are points to be considered for sampling?

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Session 3: Manures and Fertilizers

A balanced application of nutrients in soil is essential to improve the crop yield and its quality and maintain the soil health. There are two primary sources of soil nutrients which are in universal use — organic source, generally, called 'manure', and chemical or inorganic source called 'fertilizer'.

Organic Manures

A) Bulky manure

1) Farm Yard Manure (FYM): It is composed of cattle dung, urine, litter or bedding material, portion of fodder and feed refusal, wastes like ashes etc., collected and dumped into a pit or a heap in the corner or safe space in the backyard. It is allowed to remain there and allow to rot for a few months till it is taken out and applied to fields. Well decomposed Farm yard manure contains roughly, O.5. % N, 0.2 % P_2O_5 and 0.5 % K_2O.

2) Compost: Well decomposed plant and animal residue is called compost. The composting process requires air, moisture, optimum temperature and a small quantity of nitrogen for conversion in to final product. It is an activity of micro-organisms. NADEP method of composting is a standard compost making procedure. Addition of suitably prepared inoculums (micro-organisms) for decomposing the constituent material is now being undertaken, especially to expedite the process in winter season when it is slow. Fortification of well decomposed (mature) compost with crop-friendly bio-agents is also popular now.

3) Green Manuring: The in situ incorporation and decomposition of a green crop biomass in a field is called green manuring. Green manure crops, mostly legumes, are grown in the field itself and buried in the same field. The most common green manure crops are legumes like Sunn hemp, Dhaincha and guar, cowpea, etc. This improves the soil's organic matter content and is highly desirable for sustainable soil health management

Ex-situ application of tender green-twigs and leaves collected from wastelands or forests, spread in the field and incorporated into the soil is also practiced. Greens of shrubs and trees like Gliricidia, Sesbania and karanj are also applied and turned into the soil.

4) Vermicompost: Vermicompost is prepared using earthworms. The earthworms consume partially decomposed organic matter and excrete it as cast. This cast is used as vermicompost. It is rich in plant nutrients and beneficial bacteria and vesicular arbuscular mycorrhiza (VAM) fungi. Depending upon types of base material used, vermicompost, on an average contain 3% nitrogen, 1% phosphorus and 1.5% potassium.

Vermi wash is the drained-out extract of vermicompost. To prepare Vermi wash, vermicomposting unit is arranged with water trickling arrangement. Vermi wash contains more nutrients than vermicompost and finds favour for use as liquid manure.

4. **Concentrated Organic manure:** Oil cakes, fish manure and blood meal are known as 'concentrated organic manures. Some of the cakes from non-edible oil are also given in Table below

Table 4.7: Per cent nutrient contents of manure and other organic raw materials

Materials	**Nitrogen % (N)**	**Phosphorus % (P_2O_5)**	**Potash% (K_2O)**
Animal refuse			
Cattle dung and urine mixed	0.60	0.15	0.45
Horse dung	0.70	0.25	0.55
Sheep dung	0.95	0.35	1.00
Night soil	1.2-1.3	0.8-1.0	0.4-0.5
Poultry manure (fresh)	1.0-1.8	1.4-1.8	0.8-0.9
Raw sewage (fresh)	2.0-3.0	-	-

Sewage sludge, dry	2.0-2.5	1.0-1.2	0.4-0.5
Sewage sludge, activated dry	5.0-6.5	3.0-3.5	0.5-0.7
Cattle urine	0.9-1.2	Tr.	0.5-1.0
Horse urine	1.2-1.5	Tr.	1.3-1.5
Human urine	1.1-1.2	0.1-0.2	0.2-0.3
Sheep urine	1.5-1.7	Tr.	1.8-2.0
Wood ashes of			
Coal	0.73	0.45	0.53
Household	0.5-1.9	1.6-4.2	2.3-12.0
Gurhat	0.1-0.2	0.8-1.3	1.5-3.1
Babul wood	0.1-0.2	2.5-3.0	3.5-4.5
Casuarina wood	Tr.	1.4	14.0
Eucalyptus wood	Tr.	5.9	23.8
Tobacco stem	Tr.	2.6	36.0
Manures, compost etc.			
Rural compost (dry)	0.5-1.0	0.4-0.8	0.8-12
Urban compost (dry)	1.0-2.0	0.9-3.0	1.0-2.0
Farmyard manure (dry)	0.5-1.5	0.4-0.8	0.5-1.9
Filter press cake	1.0-1.5	14.0-15.0	2.0-7.0
Plant residues			
Rice hulls	0.3-0.5	0.2-0.5	0.3-0.5
Groundnut husks	1.6-1.8	0.3-0.5	1.0-1.7
Straw and Stalks			
Bajra	0.65	0.75	2.50

Banana, dry	0.61	0.12	1.00
Cotton	0.44	0.10	0.66
Jowar	0.40	0.23	2.17
Maize	0.42	1.57	1.65
Paddy	0.36	0.08	0.71
Tobacco	1.12	0.84	0.80
Arhar	1.10	0.58	1.28
Wheat	0.53	0.10	1.10
Sugarcane trash	0.35	0.10	0.60
Tobacco dust	1.10	0.30	0.93
Green manure, fresh			
Cowpea	0.70	0.10-0.20	0.60
Dhaincha	0.60	-	-
Guar	0.34	-	-
Horse gram	0.33	-	-
Moth bean	0.80	-	-
Green gram	0.72	0.18	0.53
Sunn hemp	0.80	0.10	0.50
Black gram	0.85	0.18	0.53

Source: Fertilizer Statistics. 2007-08, and Handbook on Fertilizer Usages.1994, Fertilizer Association of India, New Delhi

Tr. = Trace.

To obtain kg nutrient/t multiply per cent nutrients in the material by a factor of ten.

These cakes are hard and compact as they come after oil extraction in a compressed form. These have to be crushed and powdered and extended by mixing with sand before they can be spread in the field. Normal quantities recommended for application are about 200-250kg/ha.

Fertilizers

Fertilizers are factory prepared products based on organic, non-organic or synthetic materials, which provide identified single or multiple nutrients to the plants when applied to soil or sprayed on the plants.

Fertilizers are classified both on the basis of their physical and chemical characteristics

Physical classification

a)-Solid fertilizers: This category includes the following

- In powder form (e.g., single superphosphate)
- Crystal's form (e.g., ammonium sulphate)
- Prills (e.g., urea, diammonium phosphate, superphosphate),
- Granular (e.g., Holland granules)
- Super granules (e.g., urea super granules)
- Briquettes (e.g., urea briquettes)

b)- Liquid Fertilizers: Liquid fertilizers are applied with irrigation water or as foliar application. Liquid fertilizers require less labour in their application and these can be mixed with other formulations of herbicides and pesticides. Handling of liquid fertilizer is easy and they are popular with farmers

Chemical classification

1. Straight fertilizers: Straight fertilizers contain only one primary plant nutrient and able to supply only one primary plant nutrient, namely nitrogen or phosphorus or potassium. For example, urea (N only), single super phosphate (P only), muriate of potash (K only),

2. Complex fertilizers: At least two primary nutrients are found in chemical combination in complex fertilizers. In general, complex fertilizers are manufactured in granular form e.g., Diammonium phosphate (N and P), nitro-phosphates and ammonium phosphate.

3. Mixed fertilizers: These fertilizers are produced by mixing either mechanically or manually physical forms of straight fertilizers. Mixed fertilizers are able to supply two or three primary plant nutrients.

Fertilizers Types: Following types of fertilizers are commonly marketed in India

i)- Nitrogenous fertilizers: Among nitrogenous fertilizers nitrate nitrogen fertilizers are source of readily available nitrogen to plants. Ammoniacal fertilizers are slow release and longer lasting source of nitrogen. But because they easily volatilize, better to place them into seed bed. Don't broadcast them.

These further divided in four on the basis of their chemicals.

a)- Ammoniacal: Ammonium sulphate, Ammonium chloride and Anhydrous ammonia

b)- Nitrate: Sodium nitrate, Calcium nitrate and Potassium nitrate

c)- Ammoniacal and Nitrate: Ammonium nitrate, Calcium ammonium nitrate and Ammonium sulphate nitrate

d)- Amide: Urea and Calcium cyanamide

ii)-Phosphatic Fertilizers: Super phosphate [Ca (H_2PO_4)2], Triple super phosphate:

iii)-Potassic fertilizers: Potassium chloride, Potassium-magnesium sulfate, Potassium nitrate and Potassium sulfate

iv)- Complex fertilizers

Secondary major-nutrient fertilizers:

a)- Magnesium fertilizers: Magnesium sulphate ($MgSO_4$)

b)-Calcium fertilizers: Calcium chloride ($CaCl_2 .6H_2O$)

c)-Sulphate Fertilizers: substances containing the nutrient Sulphur in the form of absorbable sulphate anions (SO_4^{2-}).

v)-Micro-Nutrient Fertilizers:

a. Iron fertilizers: Ferrous sulphate ($FeSO_4. 7H_2O$),

Fe – Chelates
Fe-EDTA
Fe-EDDPA

b. Manganese fertilizers: Manganous sulphate ($MnSO_4. 7H_2O$),

Mn – chelates (Mn – DTA)

c. Copper fertilizers: Copper sulphate ($CuSO_4. 5H_2O$) containing 25 % Cu.

d. Boron Fertilizer's: Borax ($Na_2 [B_4O_5 (OH)_4].8H_2O$) and Boric acid ($H_3BO_3$)

e). Zinc fertilizer: Zinc sulphate ($ZnSO_4. 7H_2O$) and Zinc-oxide (ZnO)

f).Molybdenum Fertilizers: Sodium molybdate ($Na_2MoO_4.2H_2O$) and Ammonium molybdate [$(NH_4)_6Mo_7O_{24}$]

Application of manures and fertilizer's

Timely application of fertilizer's and manures in adequate quantity is important for the growth of plants. The manner and method of manure application depends on the type of the plants.

Bulky manures

Bulky manures must be spread over the desired field surface and incorporated into the soil by harrowing. The application of manures depends on the season to avoid leaching of nutrients. In areas receiving light rainfall, the manures may be applied during monsoon, whereas, it must be done after the monsoon in areas receiving heavy rainfall.

Concentrated manures

Oil cakes, fish manure etc., must be applied well in advance as their nutrients are not immediately available to the plants. They become available only after the concentrates have been broken down by soil microbes into available form which takes time. Also, their application must be done after converting compact cakes into powdered or granular state. Their application is not too bulky so they are to be extended by mixing with sand for uniform spreading.

Fertilizer application

Time of application

Generally, organic manures are applied and incorporated while preparing the land so that they improve the structure and water-holding capacity of the soil. Fertilizers are, normally, applied just before or soon after planting. The frequency and amount of fertilizer application depend on the demand and recommended package of practices for specific crop production. Adjustments have to be made in case of inadequate rain or heavy downpours.

Application of solid fertilizers

Broadcasting

Basal application: Depending on the crop, application (bed-placement or broadcasting) of fertilizer is carried out prior to sowing.

Top dressing: When fertilizers are applied in a standing crop or as part of periodic stage-specific nutrient supply, it is known as 'top dressing'. In this method, usually, nitrogenous fertilizers and micronutrients are applied, taking care to avoid injury to crop canopy by solid fertilizers or high concentration of fertilizer solutions

Placement

Place the fertilizer in prepared soil before or preferably alongside the seed placement. The placement may be done by plough furrow or single band placement. Placement reduces volatilization loss of fertilizer.

Double band placement happens when the fertilizer is applied in two bands, i.e., on both sides of the planted rows. Deep placement is commonly recommended in dry land agriculture.

Application of liquid fertilizers

Foliar application

Foliar application, is mostly used only to apply minor elements or to supplement the major elements. It is difficult to supply sufficient amounts of major elements. Nutrient concentration of 1−2 % can be applied using readily soluble fertilizer in water. Care must be taken not to cause injury to the foliage.

Fertigation

This refers to the application of fertilizer's through irrigation water. Nitrogen is the principal nutrient that is commonly used. Potassium and highly soluble forms of zinc and iron can also be readily applied in this technique. Phosphorus and anhydrous ammonia may form a precipitate in water with high calcium and magnesium content. So, they are not used in fertigation. At present fertigation is not practiced with pulse crops.

Biofertilizers

These are laboratory products, containing a critical mass of specific or specified beneficial microbes of agriculture importance. Biofertilizers help in making available to crop plants, various nutrients by their unique activity or interaction in the rhizosphere. Many species of beneficial microbes have the capacity to stimulate the growth of plants. The main difference chemical fertilizer and bio fertilizer is chemical fertilizer directly increase the nutrient content in to the soil, where as bio-fertilizers are helpful in nutrient uptake as part of their basic function. Biofertilizers can be soil-applied or seed- or seedling- applied at sowing or transplanting.

Classification of Bio-fertilizers

i)- N- Fixing Biofertilizers (NFB)

a) NFB For legumes: *Rhizobium*
b) NFB for Cereals: *Azotobacter, Azospirillum, Azolla, Anabaena* (Blue Green Algae)

ii)- Phosphorous Mobilizing Biofertilizers (PSB)

a) Phosphorous Solubilizer: *Bacillus*, *Pseudomonas*, *Aspergillus*

b) Phosphorous Absorber: *Vasicular Arbuscular mycorrhiza*, VAM like *Glomus*

iii)- Cellulolytic or Organic matter Decomposer (OMD)

a) Cellulolytic Organism: *Cellulomonas, Trichoderma* spore

b) Lignolytic organism: *Arthobacter, Agariccus*

Common Biofertilizers for Pulses

1- Nitrogen Fixing Biofertilizers e.g., *Rhizobium*

2- Phosphorus solubilizing Bacteria (PSB)

3- Vesicular Arbuscular Mycorrhiza (VAM)

4- Plant Growth Promoting Rhizobacteria (PGPR)

Nitrogen fixing Biofertilizers for pulses

Bacteria *of Rhizobium spp.* are a group of soil bacteria that are well known for their symbiotic relationship with all leguminous plants including all pulses. There are different types of *Rhizobium* that are categorized on the basis of rate of growth and the type of plant they are associated with. Many of them are crop specific but many are able to use more than one plant species as host. *Rhizobium spp.* are accordingly grouped into cross-inoculation types viz., the legume or the group of legumes that each of them can nodulate upon.

The cross-inoculation groups include:

Clover groups - *R. trifolii* infects and nodulates plants of genus *Trifolium* (clovers/trefoil)

Alfalfa groups - *R. meliloti* infects and nodulates the roots of medicago, melilotus and medicago

Bean group - *R. phaseoli* infects and nodulates plants of genus *Phaseolus* (e.g., beans)

Lupine group - *R. lupine* nodulates lupines and serradella (Ornithopus)

Pea group - *R. leguminosarum* infects and nodulates pea, sweetpea, lentil, and vetch

Soybean group - *R. japonicum* nodulates *Glycine* such as soybean

Cowpea group - *Rhizobium sp.* nodulates cowpea, Pigeon pea, lespedza, groundnut and kudz among a few others

Nodule Formation:

Rhizobium species like *R. leguminosarum* can be found in soil. However, the root of leguminous plants (lentil, sweet pea etc.) is their primary habitat. In the soil, various leguminous plants release various exudates (dicarboxylic acids etc.) that attract *Rhizobium* species.

Flavonoids have also been shown to play an important role in attracting the bacteria. Once the bacteria detect these chemicals, they actively swim towards and attach to the legume root.

In addition to attracting the bacteria, these chemicals (flavonoids in particular) also play an important role of activating genes involved in producing Nod factors. Here, then, attraction to the legume roots is followed by transcription of nod genes in preparation of the symbiotic relationship. Having attracted the bacteria through the exudates, the changes in the plant roots make it easy for the organism to enter the cells of the root hair for symbiosis.

When the bacteria comes into contact with the root hair, they cause the plasma membrane of the cells to invaginate. As the bacteria penetrates the cell, the plant produces new cell wall material at the site to not only cover the bacteria, but also allowing them to enter deeper into the root hairs.

Symbiotic Nitrogen Fixation

Nitrogen fixation is the conversion of atmospheric nitrogen into organic compounds (particularly ammonia) that can be used by plant for its development. The relationship between leguminous plants and *Rhizobium* bacteria is referred to as a symbiotic relationship because the bacteria and the plant benefit each other. Nitrogen fixation in the nodules begins when the nodules fully mature. While the plant's rhizosphere provides shelter and a source of energy for the bacteria, the bacteria convert atmospheric nitrogen to ammonia in which form it can be used by plant for proper growth and development of the plant.

This process requires two important genes (nif and fix). These genes play an important role of producing several crucial enzymes that are involved in the nitrogen fixation.

Phosphate Solubilizing Biofertilizers (PSB)

A group of heterotrophy have the ability to convert insoluble phosphorus source to solubilize inorganic phosphorus. Phosphate solubilizers also produce growth promoting substance for plants. Phosphate solubilizing bio-fertilizers can be used in wide range of other crops apart from pulse crops.

Bacteria: *Bacillus spp. Pseudomonas spp.*

Fungi: *Aspergillus spp.*, *Penicillium spp.* and *Trichoderma spp.*

Yeast: *Pchwamiomyces occidentails*

Phosphate absorber Biofertilizers

Vesicular Arbuscular Mycorrhiza: it a fungus which colonize in plant root system and promote growth as well as yield of crops. It enhances phosphorus uptake particularly by the plants, apart from this it also increases the uptake of Zn and other micronutrients

Plant growth promoting Rhizobacteria (PGPR):

Plant growth promoting Rhizobacteria colonize root or rhizosphere soil. This group of bacteria referred as bio stimulant due to phytohormone production. Example *Pseudomonas, Burkhodaria, Enterobacter, Erwinia, Mycobacterium* etc.

Application of Biofertilizers

There are two methods which are very common for the application of Biofertilizers in crops i.e.

Soil Treatment: For any crop

Seed Treatment: Pulses cereals and millets

Seedling treatment: Crop seedlings which are raised in nurseries i.e., vegetable crops, Paddy etc.

i) Soil Treatment

In this method the bacteria are introduced into soil. This can also be an enhancement or supplementary process when the presence of beneficial bacteria is less than optimum. Under this method for one-hectare land area 4 kg of recommended Biofertilizer for a particular crop is mixed with 200 kg of compost/FYM/ vermicompost and keep it overnight. At the time of sowing this mixture is incorporated in the field through broadcasting or band placement.

ii) Seed Treatment

In this kind of treatment, just before sowing, the seeds are provided with a layer of bacterial coating. Normally, for treating every 10 kg seed, 200 g of desired biofertilizer culture is sufficient. Practically speaking, approximately 900 g. soil base cultures are sufficient to inoculate the seeds for one hectare. A 10% jaggery (gur) solution is taken, sufficient to lightly moisten the seed surface of seeds (1 liter per 10 kg seed). Gur or jaggery serves two purposes – one, it helps bacterial to survive and multiply on its sugar content, two, it serves as a sticking medium too, this solution is spread over the seeds and mixed to build up a thin moist coat over the seeds. Then the inoculant is sprinkled over the seeds and mixed thoroughly. Then the mixed content is dried in the shade overnight if necessary. Treated seed must be sown within 24 hours or else, a retreatment will be necessary.

In case liquid Biofertilizer is to be used, it should be diluted @ 3 ml/liter water and requisite seed should be dipped in the solution. The treated seed should be shade dried and sown within 24 hours of treatment.

iii) Seedling Treatment

This method is used for transplanted crops. In this method 1 kg biofertilizer is mixed with 10 liter water and root portion of seedling is dipped into it for a period of 20-30 minute just before planting.

Precautions in using biofertilizers

i) Always use right combination of pulse crop-specific bio-fertilizers.

ii) Application of Biofertilizer bacterial cultures is the last item of seed treatment. No other seed treatment should follow after culture treatment

iii) Any type of chemical should not be mixed with bio-fertilizer, because it will harm the living microbes of bio-fertilizer.

iv) Bio fertilizer packet has to be stored in cool and dry place.

v) Avoid direct exposure to sunlight and heat.

vi) The Biofertilizer packet needs to be used before its expiry date.

vii) Bio-fertilizers are not the substitute of chemical fertilizer or organic manure, but these play a supplement role in nutrient uptake.

Limitations in using Bio-fertilizers

i)- Inadequate availability of good quality and crop specific Bio-fertilizer.

ii)- Shelf life is very short

iii)-Highly susceptible to unfavorable climatic conditions like water logging, low and high soil pH, hot days

iv)- Faulty methods of application might make it ineffective

Example, For the calculation of fertilizer quantity:

Example 1: If the recommended N: P: K fertilizer dose for Pigeon pea crop is 20:40:0 kg/ha, then calculate the required quantity of urea, single super phosphate (SSP) for one ha of Pigeon pea crop.

Solution

Nitrogen content in urea = 46%

Phosphorus content in urea = 16%

$$\text{Quantity of urea required (kg)} = \frac{\text{Recommended dose of nitrogen X 100}}{\text{Nitrogen content in urea (\%)}}$$

$$= \frac{20 \text{ X } 100}{46}$$

$$= 46.\ 47 \text{ kg urea}$$

$$\text{Quantity of SSP required (kg)} = \frac{\text{Recommended dose of phosphorus X 100}}{\text{Phosphorus content in SSP (\%)}}$$

$$= \frac{40 \text{ X } 100}{16}$$

$$= 250 \text{ kg SSP kg}$$

For supplying 20:40:0 kg N:P: K/ ha to the Pigeon pea crop we need to apply 43.47 kg of urea and 250 kg of single super phosphate.

Example 2: If the recommended dose of fertilizer of N: P: K for chickpea crop is 20:40:0 kg N: P: K/ ha, then calculate the required quantity of DAP and urea for one ha area of chickpea crop.

Solution

Phosphorus content in DAP = 46%

Nitrogen content in DAP = 18%

Quantity of DAP required for supplying phosphorus (kg)

$$= \frac{\text{Recommended dose of phosphorus X 100}}{\text{Phosphorus content in DAP (\%)}}$$

$$= \frac{40 \text{ X } 100}{46}$$

$$= 86.95 \text{ kg DAP/ha}$$

Quantity of DAP nitrogen through DAP (kg) =

$$\frac{\text{Quantity of DAP Applied X Nitrogen content in (DAP \%)}}{100}$$

$$= \frac{89.5 \text{ X } 18}{100}$$

$$= 16.11 \text{ kg nitrogen}$$

Quantity of nitrogen to be added through urea =

The recommended dose of nitrogen-quantity of nitrogen addend through DAP

= 20-16.11

= 3.89 kg

For adding 3.89 nitrogen from urea, the following quantity of urea will be required:

$$\text{Quantity of urea required (kg)} = \frac{\text{Nitrogen to be added (kg) X 100}}{\text{Nitrogen content in urea (\%)}}$$

$$= \frac{3.89 \text{ X } 100}{46}$$

$$= 8.45 \text{ kg urea}$$

For supplying 20:40:0 kg N: P: K/ha to Pigeon pea crop, we need to apply 89.95 kg DAP and 8.45 kg of urea.

Activities

Activity 1: Identify various types of manures and fertilizer's.

Materials required: Samples of different manures and fertilizer's

Procedure:

- Observe the given sample carefully
- Identify and write the name of the manure/fertilizer
- Write its characteristics in short.
- Note down % nutrient content of manure/fertilizer.

Activity 2: Demonstrate application of fertilizer's in pulse crops

Materials required: Different types of fertilizers

Procedure:

- Select crop/plot for application of fertilizer
- Identify and select the fertilizer's
- Calculate the amount of fertilizer
- Demonstrate fertilizer's application i.e. broadcasting, placement methods
- Follow the precautions during application of fertilizer

Check Your Progress

Fill in the blank

1. Diammonium phosphate and ammonium phosphate are__________ fertilizer's.
2. Well decomposed plant and animal residue is called_________.
3. Full form of PGPR is ____________.
4. Diammonium phosphate contain _________ % N and ______ % P_2O_5.
5. The ____________fixes nitrogen symbiotically with leguminous crop.

Multiple Choice Questions

1. Nitrogen fixing biofertilizer is
    a) Bacillus
    b) Pseudomonas
    c) Rhizobium
    d) Aspergillus
2. Which of the following is a straight fertilizer?
    a) Calcium ammonium nitrate
    b) Potassium chloride
    c) Nitro phosphate
    d) Di-ammonium phosphate
3. Fertilizer's that supply more than single nutrients are called
    a) Sole fertilizer's
    b) Manures
    c) Bio-fertilizer
    d) Mix fertilizer's
4. When fertilizers are broadcast in a standing crop is known as
    a) Broadcasting
    b) Top dressing
    c) Placement
    d) None
5. Green manuring crop is
    a) Guar
    b) Sunn hemp
    c) Dhaincha
    d) All of these

Descriptive Questions

1. Define fertilizer's and classify on the basis of their physical form.

____
____
____
____

2. Write a brief note on types on fertilizer's.

____
____
____
____

3. Explain nodule formation in pulse crops?

____
____
____
____

4. What are manures? How they can be classified?

____
____
____
____

5. Define and classify bio-fertilizer's.

____
____
____
____

6. Describe nutrient management of chickpea and Pigeon pea?

____
____
____
____

Match the Column

Column A	Column B
1. Calcium fertilizer's	a. Calcium nitrate
2. Nitrate fertilizer's	b. Zinc sulphate
3. Boron fertilizer's	c. Calcium chloride
4. Zinc fertilizer's	d. Potassium sulfate
5. Potash fertilizer's	e. Borax

Module 5
Maintain Health and Safety Measures at the Workplace

Module Overview

Occupational health relates to controlling health hazards that may arise while doing an agricultural work in a farm or laboratory. It deals with recognizing, anticipating, evaluating and controlling such environmental factors at workplace, which may lead to health issues. Despite taking all precautions, accidents occur often while handling chemicals. Therefore, it is essential for students to know about the first aid measures that they need to take immediately, in case a chemical or mechanical accident occurs in a farm or lab. Besides, they need to learn about the safety measures that they may be required to follow in order to prevent such hazards.

Learning Outcomes

After completing this module, you will be able to:

- Identify and describe potential hazardous conditions in the workplace, and implement effective strategies to prevent accidents and ensure a safe working environment.
- Explain the principles and practices of first aid, including the recognition and initial treatment of common workplace injuries and medical emergencies.
- Demonstrate the proper use and maintenance of safety equipment, and understand the importance of safety protocols and personal protective equipment (PPE) in preventing workplace injuries and illnesses.

Module Structure

- Session 1: Prevent Hazardous Conditions at Workplace
- Session 2: First Aid, Treatment and Safety Equipment

Session 1: Preventing Hazardous Conditions at the Workplace

Hazard

It is a condition that has the potential to cause injury or sickness to human beings and animals, and adversely affect the environment. A hazardous substance can cause adverse health problems and physical damage at workplace. Fig. 5.1 shows the different types of hazard that may occur at the workplace.

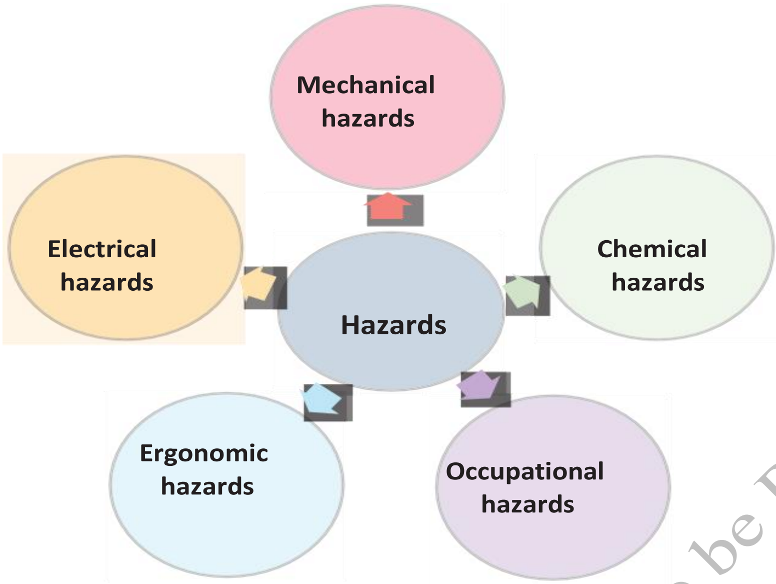

Fig. 5.1: Types of hazards

Mechanical hazards

These are related to poorly designed and ill-maintained agricultural machinery and equipment.

Chemical hazards

These comprise pesticide solutions meant for destroying, mitigating and controlling insects–pests. Accidental death from pesticides is rarely occurred but skin allergies or infections, and other health ailments may occur, if appropriate and timely precautions are not taken (Fig. 7.2). Careless handling or use of pesticides can cause harmful effects to the environment, handler and other living beings. Precautions must be taken while selecting a pesticide, its transportation, loading, mixing, application, storage and container disposal (Fig. 5.2, 5.3 and 5.4).

Fig. 5.2: Always wear personal protective equipment while preparing pesticide spray solutions pesticide application in a field

Fig. 5.3: Caution signage

Fig.5.4: Signage indicating

Precautions

Toxicity labels marked on the pesticide package, as shown in Table 5.1 and Fig. 5.5 must be taken into account while using pesticides. Some of the points that must be taken care of prior to pesticide application are as follows.

- Chemicals must not be sprayed in foggy and windy weather conditions.
- A person spraying chemicals must not have an open injury or wound on the body.

Table 5.1: Toxicity label of pesticides

Name of the label	**Level of toxicity**	**Listed chemicals**
Red	Extremely toxic	Monocrotophos, Zinc phosphide, Ethyl mercury acetate, etc.
Yellow	Highly toxic	Carbaryl, quinalphos, etc.
Blue	Moderately toxic	Malathion, thiram, glyphosate, etc.
Green	Slightly toxic	Mancozeb, oxyfluorfen, mosquito repellant oils and liquids, and other household insecticides

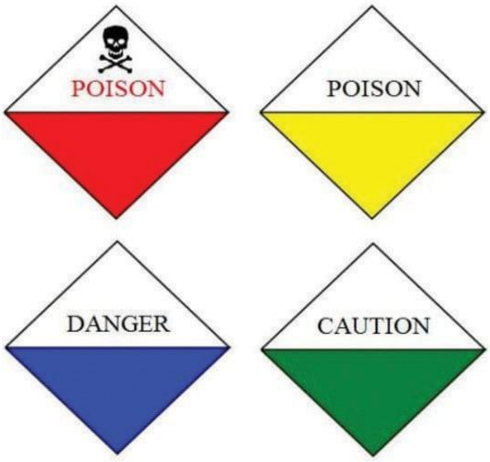

Figure 5.5: Colour labels showing the toxicity of pesticides

Occupational hazards

Farmers and workers, while working in an agricultural farm, may suffer from a number of occupational hazards. These hazards may include those related to farm machinery, biological and chemical substances, and stress. These may cause injuries, health disorders or diseases.

Hazards related to animals

Injuries inflicted by animals include bites, kicks, crushing and transmission of infectious diseases. If a farmer or person, working in a field, is injured by a farm animal, immediate first aid must be administered to the person and timely medical treatment be provided. Injuries from cattle relate to a number of factors, including lack of trained workers, unsafe work practices, weight of the animal, stress, and sometimes, behaviour of the animal.

Ergonomic hazards

These are caused by inappropriate and cumbersome postures, leading to damage or pain in the muscles and tendons. These are mainly caused while working on or with inappropriate or faulty tools.

Electrical hazards

An electrical hazard arises due to faulty switches and machines, poor quality cords, overhead power lines, etc. Faulty electrical installations and use of cheap quality equipment can even cause fires (Fig. 5.6). When an equipment or machinery gets close to a high-tension line, it can lead to electric shocks, causing injury to the driver or the person handling it. In severe cases, it may even lead to electrocution, causing permanent disability or death of the person.

Risk

This may be defined as the danger of loss from unforeseen situations. It is associated with a potential danger as regards to an activity. Understanding the kind of harm machinery may cause to a farm worker or assessing the risk helps one design and implements strategic and operational plans for the mitigation of hazards. For example, the main hazard of a power-driven machine is of its getting trapped or entangled in power cables, ropes, etc. The following measures can help avert an accident on a farm.

- Identification of dangers in every aspect of a work
- Identification of people who may get exposed to some particular risks
- The reliability and adequacy of existing precautionary or preventive measures.
- Decision on new measures that need to be introduced to eliminate or reduce risks.

Fig. 5.6: Electricity hazard sign

Activities

Make a flow chart on types of hazards, usually, witnessed at a workplace.

Material required: Chart paper and writing material

Procedure

- Take a chart paper and draw a flow chart, depicting the different types of hazards, usually, witnessed at a workplace.
- Make a presentation in your class.
- Discuss the hazards that you have identified with your classmates and allow feedback on the topic.

Check Your Progress

Fill in the Blanks

1. A condition that has the potential to cause an injury to human beings and animals, and adversely affect the environment is known as a-______________.
2. Substances intended for preventing and mitigating insects–pests are called___________.
3. If a farmer working in a field gets injured by a farm animal, then immediate must be administered________________.
4. Risk is defined as the danger of loss from____________________ situations.

Multiple Choice Questions

1. Ergonomic hazards are caused by______________.
   (a) Inappropriate or faulty tools
   (b) Machinery
   (c) Chemicals
   (d) Electricity
2. The use of dangerous substances comes under__________.
   (a) Ergonomic hazards
   (b) Extreme weather hazards
   (c) Chemical hazards
   (d) Natural hazards
3. Hazards caused due to agricultural machinery are called__________________.
   (a) Electrical
   (b) Mechanical
   (c) Chemical
   (d) None of the above
4. Electrical hazards arise due to_________________.
   (a) Faulty switches
   (b) Spray chemicals
   (c) Farm animals
   (d) All of the above

Subjective Questions

1. Define hazards.
2. List the various types of hazards related to agriculture and discuss them in brief.

Match the Columns

A	B
1. Green label	(a) Extremely toxic
2. Red label	(b) Highly toxic
3. Yellow label	(c) Moderately toxic
4. Blue label	(d) Slightly toxic

Session 2: First Aid, Treatment and Safety Equipment

Despite all precautions and care, accidents often take place while handling and applying chemicals. Therefore, it is important for students to know about the immediate medical aid that needs to be administered, in case of a chemical accident and learn about the safety and precautionary measures that need to be adopted in order to prevent them. Besides, they must learn about the Personal Protective Equipment (PPE) that they need to wear at all times while handling chemicals in order to be safe.

Chemical poisoning and first aid measures

Chemical poisoning may result from continuous contact with a chemical, absorption of a chemical through the skin, inhalation of toxic vapour or swallowing a chemical directly during handling or application. The common symptoms of pesticide poisoning are headache, vomiting, nausea, tremors, convulsion, difficulty in breathing, etc. A first aid kit with necessary antidotes must be made available at a workplace in order to treat all types of poisoning.

Fig.5.7: First aid box

Personal Protective Equipment

Always wear Personal Protective Equipment (PPE) in order to prevent hazards due to pesticide poisoning. The various kinds of pesticide poisoning and their first aid treatment have already been discussed. PPE mainly consist of gas mask, gloves, shoes, eye shields, headgear, protective clothing, respiratory devices, etc. (Fig. 5.8 and 5.9).

Gas mask

It is used to protect the handler's eyes and respiratory tract from toxic gases and aerosols. It filters the air by removing contamination and impurities, and makes it fit for breathing or inhalation (Fig. 5.8).

Fig. 5.8: Hand gloves and gas mask

Gloves

Never use gloves made of leather, cotton or other fluid absorbent material while handling chemicals. Always use rubber gloves.

Shoes

Shoes made of rubber or any other synthetic material must be used instead of leather or canvas ones.

Eye shields

These must be worn to prevent irritation and infection in the eyes due to gases and pesticides.

Protective clothing

An apron must be worn while working with treated crops or chemicals. The skin must be protected entirely. The clothing needs to be washed before re-use (Fig. 5.9).

Figure 5.9: Protective clothing

General health and safety measures

- Identify what is unsafe or unhealthy.
- Take required action to solve unsafe or unhygienic issues at the workplace.
- Ensure that the problems are resolved and do not recur.
- Train workers on how to work safely.
- Design safe work procedures and supervise the workers.
- Provide a first aid kit and have personnel, who can administer first aid at the workplace.
- Arrange appropriate safety gear (for example, hats, gloves, reflective vests, etc.) for the workers.

Amenities and environment

- Ensure that the workers have access to civic utilities like toilets.
- They must have access to potable and clean drinking water.
- The worksite must have a first aid kit and workers, who can administer first aid in case of an accident or emergency.
- Ensure that the surrounding or building is safe. Look out for the presence of dangerous creatures (for example, snakes, spiders, scorpions, etc.) and reduce fire fuel loads.
- Provide a hand wash and face wash to the workers.

Emergency response

- The workers must be aware about the procedures that need to be followed in case of an emergency situation.
- Install emergency response equipment at the workplace.

- In case of an emergency, trained workers must be involved in administering first aid to patients.

Manual tasks

- Maintain appropriate restraint, wherever needed.
- Avoid crush injuries on hands.
- Pay attention to the risk of slips, trips and falls in yards.

Chemical and hazardous substances

- Safety Data Sheets (SDS) must be made available for all hazardous substances.
- Read the label and SDS carefully, and follow the instructions.
- Store the chemicals at a safe place and keep them away from ignition sources.
- Minimize exposure to the workers by adopting appropriate and recommended preventive measures and train them in safe handling techniques as regards to chemicals.
- Never store toxic chemicals in food and water containers. Always keep the chemicals in their original containers and make sure that they are labeled correctly with necessary instructions.

Electricity

- Keep all electrical equipment's, appliances and naked power cables away from water and fire.
- Protect all electrical equipment with a residual current device (safety switch).
- Ensure that extension leads are not defective or damaged and are uncoiled when plugged into the main socket.
- It must be ensured that all electrical equipment and appliances are maintained and functional.
- All electrical equipment must be tested and tagged before use.
- Areas having overheads power cables must be identified with ground markers.
- Apply and mark appropriate exclusion zones while working near power lines.

Precautions to be taken in a farm

- While preparing a solution, one's face must never be just above the container, in which it is being prepared.
- While working with a chemical, one must always wear rubber gloves and face mask or shield to avoid direct physical contact with the chemical and check inhalation of chemical fumes.
- Clean the sprayer with a detergent immediately after spraying is completed.
- Follow the instructions mentioned on the pesticide bottle before using it.
- Take a bath and wash your clothes after spraying.
- Do not smell, taste or touch a chemical.
- Keep pesticides and other chemicals away from children's reach.

Activities

Demonstrate the use of Personal Protective Equipment while handling chemicals. Prepare a chart, depicting how you can use first aid to handle an emergency situation at the workplace.

Material required: Chart paper, pictures of PPEs and first aid items, and writing material

Procedure

- Take a chart paper and paste the pictures of PPEs that one needs to wear while handling chemicals at the workplace.
- Label the PPEs and discuss the usage of each PPE item with your classmates.
- On another chart paper, paste the pictures of first aid items that you will use at the workplace.
- Label the first aid items and discuss the importance of each item with your classmates.
- Invite feedback from your classmates and ask if they can suggest some more precautionary measures while handling chemicals at the workplace.

Check Your Progress

Fill in the Blanks

1. During pesticide spraying, ________________must be worn to prevent eye infections and irritation.
2. A gas mask is used to protect the eyes and respiratory tract from

___________.

3. Gloves made of __________must be used while handling chemicals.
4. While working with treated crops, ______________ must be worn to protect the skin.

Multiple Choice Questions

1. Common symptoms of pesticide poisoning are
   a) Headache
   b) Vomiting and nausea
   c) Difficulty in breathing
   d) All of the above
2. To prevent hazards at workplace, the following material need to be put in place ____________.
   a) SDS
   b) First aid kit
   c) Protective clothing
   d) All of the above
3. Protective and safety equipment comprise _______________.
   a) Gas mask
   b) Gloves
   c) Both (a) and (b)
   d) None of the above
4. Potentially dangerous creatures around house and office buildings include
   a) Chameleon
   b) Snakes and scorpions
   c) Honey bees
   d) All of the above

Subjective Questions

1. What are the first aid treatment measures that need to be adopted in case of chemical poisoning?

____
____
____

2. List the Personal Protective Equipment that one needs to wear while working in an agriculture field.

____
____
____

Answer Keys

Module 1 Introduction to Pulse Crops

Session 1: Importance and Scope of Pulse Crops Cultivation

Fill in the Blanks

1. 18-25 2 Rabi season 3. Kanpur 4. India 5 King of pulses 6. Oct.-Nov. 7. Green manure 8. Green fodder

Multiple Choice Questions

1. c 2. b 3. c 4.d

Match the Column

1. c 2.d 3. a 4.e 5.b

Module 2 Field Preparation for Pulse Crops Cultivation

Session 1: Field Preparation for Pulses Cultivation

Fill in the Blanks

1- Tillage, 2- Harrowing, 3- Undulations of land,4- Plough, 5- Mouldboard, 6- Discs, 7- Sowing, 8- Ploughing and Harrowing.

Multiple Choices Questions

1-b, 2-a, 3-d 4-a

Session 2: Soil and Climate Requirement for Pulses Cultivation

Fill in the Blanks

1-Weathering, 2- Essential nutrients, 3- June and September, 4- Bureau of Indian Standards, 5- June and September, 6- Mean Sea Level, 7- Summer

Multiple Choice Questions

1-b, 2-a, 3-c, 4-a

Module 3 Seed Production of Pulses

Session 1: Selection of Seed and Varieties

A. Fill in the Blanks

1. Dormant embryo 2. Pigeon pea 3. Breeder 4. 1:30

B. Multiple Choice Questions

1. (a) 2. (b) 3. (a) 4. (c)

C. Match the Columns

1. (c) 2. (d) 3. (b) 4. (a)

Session 2: Seed Production

A. Fill in the Blanks

1. Seed 2. Roguing 3. Physiological maturity 4. Pigeon pea

B. Multiple Choice Questions

1. (b) 2. (d) 3. (a) 4. (c)

Module 4 Integrated Nutrient Management in Pulse Crops

Session 1: Plant Nutrients

Fill in the Blanks

1- Structural, 2- Oxygen, 3- Minor or trace, 4- Nitrogen, 5- Phosphorus, 6- Cell wall, 7- Manganese, 8- Maturity, 9- Calcium, 10- Molybdenum 11- Sulphur (S), 12- Potassium, 13- Calcium ammonium nitrate

Multiple Choice Questions

1- c, 2- d, 3-c, 4- d

Match the Column

1- i, 2- h, 3- g, 4- f, 5- d, 6- e, 7- c, 8- b, 9-a

Session 2: Soil Sampling

Fill in the Blanks

1- Data interpretation, 2- 15-20 cm, 3- zig-zag , 4- alkaline

Multiple Choice Questions

1- c, 2- b, 3- d, 4-b,

Session 3: Manures and Fertilizers

Fill in the Blanks

1-Complex, 2- Compost, 3- Plant growth promoting Rhizobacteria, 4-18, 46, 5- Rhizobium.

Multiple Choice Questions

1- c, 2- b, ,3- d, 4- b, 5-d

Match the Column

1- c, 2- a, 3- e, 4- b, 5- d

Module 5 Health and Safety Measures at the Workplace

Session 1: Prevent Hazardous Conditions at Workplace

A. Fill in the Blanks

1. hazard, 2. Pesticides, 3. first aid, 4. unforeseen

B. Multiple Choice Questions

1. (a) 2. (c) 3. (b) 4. (a)

D. Match the Columns

1. (d) 2. (a) 3. (b) 4. (c)

Session 2: First Aid, Treatment and Safety Equipment

A. Fill in the Blanks

1. eye shields, 2. toxic gases, 3. Rubber, 4. protective clothing

B. Multiple Choice Questions

1. (d) 2. (d) 3. (c) 4. (b)

Glossary

Abiotic stress: is defined as the negative organism in a specific environment.

Alkali soil: A soil that gives a pH reaction of 8.5 or above, found Esp in dry areas where the soluble salts, Esp of sodium, have not been leached away but have accumulated in the B horizon of the soil profile.

Animal drugs: drugs intended for use in the diagnosis, cure, mitigation, treatment or prevention of diseases in animals.

Antibiotic: a substance that can destroy or prevent the growth of bacteria and cure infections.

Atmospheric nitrogen: Atmospheric nitrogen is molecular dinitrogen, a relatively nonreactive molecule that is metabolically useless to all but a few microorganisms. Nitrogen fixation occurs between some termites and fungi. It occurs naturally in the air by means of NOx production by lightning.

Bio-agents: Biocontrol agents are mass-produced agent manufactured from a living microorganism for the biological control of insects, plant pathogens, and weeds.

Biotic stress: is stress that occurs as res living organism. Such as bacteria, virus, f cultivated plant.

Carbohydrates: A carbohydrate is a naturally occurring compound, or a derivative of such a compound, with the general chemical formula Cx(H2O)y, made up of molecules of carbon (C), hydrogen (H), and oxygen (O). Carbohydrates are the most widespread organic substances and play a vital role in all life.

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.

Determinate: Determinate varieties (including bush varieties) reach a certain plant height and then stop growing. Indeterminate varieties continue to grow and produce tomatoes all along the stems throughout the growing season. Indeterminate plants need extra-tall supports of at least 5 feet.

Dicot: dicotyledon, byname dicot, any member of the flowering plants, or angiosperms, that has a pair of leaves, or cotyledons, in the embryo of the seed. Most common garden plants, shrubs and trees, and broad-leafed flowering plants such as magnolias, roses, geraniums, and hollyhocks are dicots.

Dietary protein: Protein is in every cell in the body. Our bodies need protein from the foods we eat to build and maintain bones, muscles and skin.

Digestible fiber: Dietary fiber (DF) is generally defined as the macromolecules present in the diet that resist digestion by human endogenous enzymes and is essentially composed of plant cell wall remnants, such as cellulose, hemicelluloses, pectic polysaccharides and lignin.

Direct seeding: Direct seeded crops require less labor and tend to mature faster than transplanted crops. In this method, plants are not subjected to stresses such as being pulled from the soil and re-establishing fine rootlets. However, they have more competition from weeds.

Diverse cropping systems: Diversified farming systems are a set of methods and tools developed to produce food sustainably by leveraging ecological diversity at plot, field, and landscape scales. Around the field, hedgerows or live fences provide habitat for beneficial insects that control pests and provide pollination.

Dormant embryo: Dormancy is defined as the temporary inability of a viable seed to germinate under favorable environmental conditions (Simpson, 1990).

Drought tolerance: Drought tolerance is the ability to which a plant maintains its biomass production during arid or drought conditions. Other plants, specifically crops like corn, wheat, and rice, have become increasingly tolerant to drought with new varieties created via genetic engineering.

dSm-1: The most commonly used EC *units* are Deci Siemens per meter (ds/m) and millimho per centimeter (mmho/cm), numerically: *1* ds/m = *1* mmho/cm.

Elevation of soil: The elevation of a geographic location is its height above or below a fixed reference point, most commonly a reference geoid, a mathematical model of the Earth's sea level as an equipotential gravitational surface (see Geodetic datum § Vertical datum).

Essential element: A chemical nutrient that is vital for the successful growth and development of an organism. Macronutrient elements include carbon, hydrogen, oxygen, nitrogen, Sulphur, phosphorus, potassium, magnesium, and calcium.

Fertilizer: Fertilizer is a synthetic substance or an inorganic compound. Low percentage of nutrients is present. High percentage of nutrients is present. Manure provides a lot of organic matter to the soil.

First aid: medical assistance given to a person or animal, suffering a sudden accident, illness or injury.

Fungicides: Fungicides, herbicides and insecticides are all pesticides used in plant protection. A fungicide is a specific type of pesticide that controls fungal disease by specifically inhibiting or killing the fungus causing the disease.

Genetic drift: Genetic drift (allelic drift or the Sewall Wright effect) is the change in the frequency of an existing gene variant (allele) in a population due to random sampling of organisms.

Genotypic: An organism's genotype is its specific combination of alleles for a given gene. So, for example, in the pea plants above, the possible genotypes for the flower-color gene were red-red, red-white, and white-white.

Germination test: The idea of a germination test is to take a random sample of seeds from your lot or package, put them in the conditions that make them most likely to germinate, and see how many develop into healthy sprouts. Expressed as a percentage, this is the number we print above the packing date on Southern Exposure seed packets.

Grading: Sorting of the agriculture produce into different lots according to their various quality specifications is known as grading.

Hazard: any source of potential damage, harm or adverse health effects to a worker, animals and environment.

Hybrid varieties: hybrid varieties are the result of crossing two different breeding lines. They represent the first generation originating from the cross (F1).

In situ conservation: In situ conservation means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticates or cultivated species, in the surroundings where they have developed their distinctive properties.

Indeterminate: plant growth in which the main stem continues to elongate indefinitely without being limited by a terminal inflorescence or other reproductive structure also: growth characterized by sequential flowering from the lateral or basal buds to the central or uppermost buds — compare determinate growth.

Intercropping: Intercropping involves cultivating two or more crops in a field simultaneously. In addition to cash crops, cover crops are also sometimes used in intercropping.

Irrigation: Irrigation is the agricultural process of applying controlled amounts of water to land to assist in the production of crops, as well as to grow landscape plants and lawns, where it may be known as watering.

Isolation distance: Isolation distance is the minimum separation required between two or more varieties of the same species for the purpose of keeping seed pure.

Kharif crops: Kharif crops like corn, rice, cotton, pearl millets, etc. are grown in the months of July to October which is the months of South West monsoon.

Manure: Manure is a natural or an organic substance obtained by the decomposition of plant and animal wastes.

***Mean sea level* (*MSL*):** *Mean sea level* (*MSL*) is an *average* level of the surface of one or more of Earth's bodies of water from which heights such as *elevation* may be measured.

Micronutrients: Micronutrients are those nutrients needed in small amounts as opposed to macronutrients required in large amounts. For example, proteins, vitamins, and minerals are nutrients humans need; however, proteins are needed in amounts higher than vitamins, making the latter considered as micronutrient.

Micro-organisms: Microbes include fungi, bacteria and viruses. Farmers and ranchers often think of microbes as pests that are destructive to their crops or animals (as well as themselves), but 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.

Monocot: Monocotyledons, commonly referred to as monocots, (Lilianae sensu Chase & Reveal) are grass and grass-like flowering plants (angiosperms), the seeds of which typically contain only one embryonic leaf, or cotyledon.

Natural mutation: natural mutation –> spontaneous mutation. A mutation which occurs by itself without first being affected by a mutagen, for example during the process of DNA replication. Spontaneous mutations arise at a remarkably constant rate.

Necrosis: Necrosis is the death of body tissue. It occurs when too little blood flows to the tissue. This can be from injury, radiation, or chemicals. Necrosis cannot be reversed.

Occupational hazards: these comprise hazards at the workplace. There are other hazards like chemical, biological and physical as well that a person may encounter while working.

Off-type: Off-type means any seed or plant not a part of the variety in that it deviates in one or more characteristics from the variety as described and may include, seeds or plants of other varieties; seeds or plants not necessarily any variety; seed or plants resulting from cross-pollination by other kinds or varieties

Organic matters: Organic matter pertains to any of the carbon-based compounds that abound in nature. Living organisms also excrete or secrete material that is considered an organic material. The organic matter from living things becomes a part of the environment. Thus, organic matter abounds in the ecosystem, e.g. soil ecosystem.

Out-crossing or out-breeding: Out-crossing or out-breeding is the technique of crossing between different breeds. With recessive traits, outcrossing allows for the recessive traits to migrate across a population. The outcrossing breeder then may have individuals that have many deleterious genes that may be expressed by subsequent inbreeding.

Pest infestation: Pests can include weeds, plant pathogens (certain fungi, bacteria, and viruses), rodents, and nematodes in addition to the plant-feeding insects and mites described in the preceding text, and are estimated to destroy as much as one-third of all agricultural yield.

Phenotypic: The phenotype of a plant is a term used to describe observable characteristics, such as height, biomass, leaf shape and so on. We use the term phenotype in a more specific context to describe the collective expression of the genotype in conjunction with the environment on a plant's observable characteristics.

Poison: substance capable of causing illness or death.

Pollination: Pollination is the transfer of pollen from an anther (male part) of a plant to the stigma (female part) of a plant, later enabling fertilization and the production of seeds, most often by an animal or by wind. This process would result in the production of a seed made of both nutritious tissues and embryo.

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. When productivity fails to grow significantly, it limits potential gains in wages, corporate profits, and living standards. The calculation for productivity is output by a company divided by the units used to generate that output.

Rabi crops: Rabi crops can also be known as the winter crops.

Rainfall: The primary source of water for agricultural production for most of the world is rainfall. In its simplest sense, effective rainfall means useful or utilizable rainfall. Rainfall is not necessarily useful or desirable at the time, rate or amount in which it is received.

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 (%).

Ridges and furrows method: The ridges and furrows method of cultivation is a traditional method of ploughing which helps to drain the field by allowing the excess water to flow through the furrows thus, reducing excess moisture stress on plants.

Rouging: Rouging refers to the act of identifying and removing plants with undesirable characteristics from agricultural fields. Rogues are removed from the fields to preserve the quality of the crop being grown.

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 erosion: Soil erosion is a gradual process of movement and transport of the upper layer of soil (topsoil) by different agents – particularly water, wind, and mass movement – causing its deterioration in the long term.

Soil fertility: Soil fertility is the ability of soil to sustain plant growth and optimize crop yield.

Soil testing: A soil test commonly refers to the analysis of a soil sample to determine nutrient content, composition, and other characteristics such as the acidity or pH level. ... As soil nutrients vary with depth and soil components change with time, the depth and timing of a sample may also affect results.

Soil treatment: Soil treatment is defined as the process in which you take contaminated Soil, which cannot grow any crops, and treat it in order to recycle it and make it usable for agriculture or any other purpose.

Transplanting: When we refer to "transplanting," we mean the act of moving seedlings or small plants from their pots outside into the garden soil. This applies to both: Small starter plants (called "transplants") purchased at the nursery.

Vitamins: A vitamin is an organic molecule (or a set of molecules closely related chemically, i.e. vitamers) that is an essential micronutrient which an organism needs in small quantities for the proper functioning of its metabolism.

Waterlogging: Waterlogging is the saturation of soil with water. Soil may be regarded as waterlogged when it is nearly saturated with water much of the time such that its air phase is restricted and anaerobic conditions prevail. In agriculture, various crops need air (specifically, oxygen) to a greater or lesser depth in the soil.

Weed control: Weed control is the prevention or control of unwanted and invasive plants. By effectively controlling unwanted plants, there is less competition for water, nutrients and light for beneficial and desirable vegetation.

Weedicides: chemicals sprayed over the fields to get rid of weeds. Some of the popularly used weedicides are 2, 4-d ethyl ester, neem extract, glyphosate, etc.

Weeds: Weeds are important biotic constraint to food production. Weeds compete with crops for the same resources, basically water, nutrients, light and carbon dioxide. Furthermore, they are alternate hosts for crop pests and pathogens.

Zaid crops: Zaid crops like Pumpkin, cucumbers are grown in between the months of March to July (the Indian summer season).

List of Credits

Figure 1.1: Pigeon Pea (Arahar) LB Yadav

Figure 1.2: Chickpea (Gram) LB Yadav

Figure 1.3: Urd bean LB Yadav

Figure 1.4: Moong bean LB Yadav

Figure 1.5: Moong bean Ajay Haldar, PSSCIVE, Bhopal

Figure 1.6: Moong bean Ajay Haldar, PSSCIVE, Bhopal

Figure 1.7 Black gram Ajay Haldar, PSSCIVE, Bhopal

Figure 1.8: Black gram Ajay Haldar, PSSCIVE, Bhopal

Figure 1.9: Black gram Ajay Haldar, PSSCIVE, Bhopal

Figure 1.10: Flower of Pigeon Pea (Arahar) Ajay Haldar, PSSCIVE, Bhopal

Figure 1.11: Flower of Pigeon Pea (Arahar) Ajay Haldar, PSSCIVE, Bhopal

Figure 1.12: Pod of Pigeon Pea (Arahar) Ajay Haldar, PSSCIVE, Bhopal

Figure 2.1: Mouldboard plough DAAH

Figure 2.2: Disc plough DAAH

Figure 2.3: Rotavator Akash Shukla, PSSCIVE, Bhopal

Figure 2.4: Cultivator DAAH

Figure 2.5: Disc Harrows DAAH

Figure 2.6: Seed cum Fertilizer drill DAAH

Figure 3.1 Seed DAAH

Figure 4.1: Aluminum box Prabhat Kumar, ICAR-IISS, Bhopal

Figure 4.2: Core Prabhat Kumar, ICAR-IISS, Bhopal

Figure 4.3: Sampler without core Prabhat Kumar, ICAR-IISS, Bhopal

Figure 4.4: Plastic tray Prabhat Kumar, ICAR-IISS, Bhopal

Figure 4.5: Sampling Module with sampling spot DAAH

Figure 4.6: “V” Shape cut for soil sampling DAAH

Figure 4.7: Quarter method of soil sample preparation Prabhat Kumar, ICAR-IISS, Bhopal

Figure 4.8: Mallet Prabhat Kumar, ICAR-IISS, Bhopal

Figure 5.1: DAAH

Figure *5.2: Always wear personal protective equipment while preparing pesticide spray solutions*

Figure *5.3: Caution signage*

Figure *5.4: Signage indicating* pesticide application in a field

Figure 5.5: Colour labels showing the toxicity of pesticides Courtesy: https://goo.gl/nWpfBV

Figure 5.6: Electricity hazard sign Courtesy: https://goo.gl/nUK73m

Figure 5.7: First aid box Courtesy:https://goo.gl/BLyejx

Fig. 5.8: Hand gloves and gas mas Courtesy:https://goo.gl/ZvGFsn

Fig. 5.9: Protective clothing Courtesy:https://goo.gl/mzBA2Q