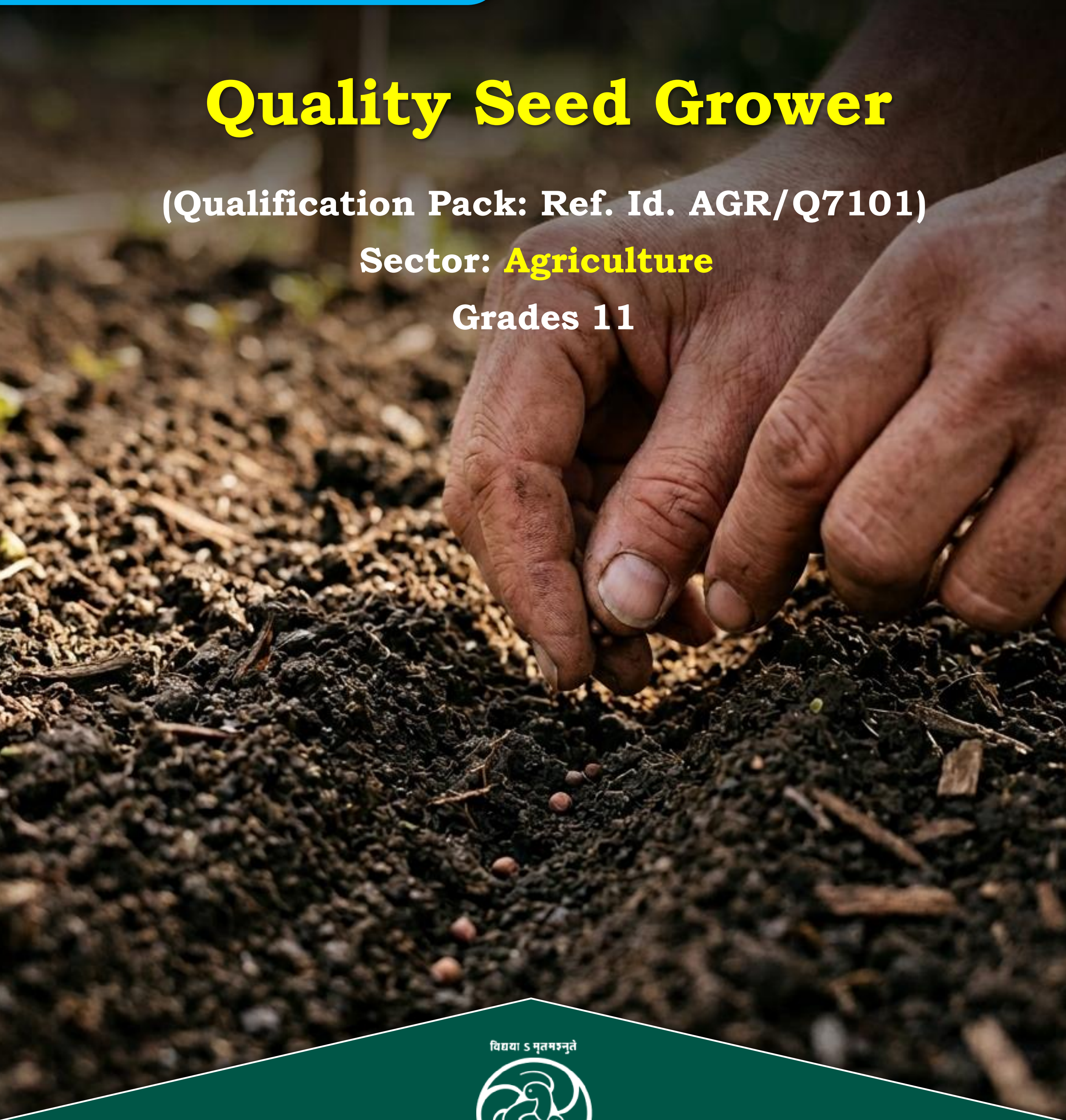
Draft Study Material

Quality Seed Grower

(Qualification Pack: Ref. Id. AGR/Q7101)

Sector: Agriculture

Grades 11



विद्यया ऽमृतमश्नुते

एनसीईआरटी
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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 Oilseed Crops

Module Overview

Agriculture is a fundamental component of human existence. From morning to evening, our lives are closely connected to agricultural products. Human society relies on agriculture for essential needs such as food, fiber, shelter, and raw materials for various industries. Without these resources, sustaining modern life would be unimaginable. Food, in particular, plays a vital role in human life as it provides the necessary nutrition and energy for survival. People obtain food from diverse sources, including grains, vegetables, fruits, milk, and other agricultural products. In agriculture, a wide variety of crops are cultivated to meet human needs, including cereals, pulses, oilseeds, fruits, vegetable crops, and many others. Each category contributes uniquely to food security and nutrition.

Oilseeds are a major group of crops, rich in oil and protein, and they play an important role in human nutrition. Oilseeds provide both edible and non-edible oils, which serve as major sources of dietary fat, energy, and are also widely used for various industrial purposes. Oilseeds are important nutritional component of human diet due to high content of high-quality protein, fat and vitamins. World Health Organization (WHO) and Food and Agriculture Organization (FAO) suggests that fats may constitutes 20-35 % of total energy intake. The Oilseed crops are primarily grown for oil extraction purpose and major source of vegetable fat. In national scenario, Oilseeds holds second position after cereals in terms of area, production, productivity and economic value. The self-sufficiency (Atma-nirbharta) in oilseeds was attained through Yellow Revolution during 1990s and achieved by concentrated efforts to enhance productivity of oilseeds by the launch of the Technology Mission on Oilseeds (TMO) in 1986. Self-sufficiency in edible oil could not sustained for longer period. India still dependent on import due to increase of per capita consumption of oil.

This module introduces students to the fundamental concepts of oilseed crops and highlights their importance in agriculture, nutrition, and the economy. In Session 1, students will learn about the importance and scope of oilseed crop cultivation, including their role in farming systems, crop diversification, and contribution to national agricultural development. Session 2 focuses on the nutritional and commercial importance of oilseeds, emphasizing their value in human diets, edible oil production, industrial applications, and income generation for farmers.

Learning Outcomes

After completing this module, you will be able to:

- Explain the importance and scope of oilseed crop cultivation in agriculture and rural development.
- Describe the nutritional value and commercial uses of major oilseed crops.

Module Structure

Session 1: Importance and scope of oilseed crops cultivation

Session 2: Nutritional and commercial importance of oilseed

Session 1: Importance and scope of oilseed crops cultivation

India is fortunate to grow nine annual oilseed crops in different agroclimatic zones. Among nine annual oilseed crops seven are edible viz. soybean, groundnut, rapeseed-mustard, sunflower, sesame, safflower and niger and two are non-edible oilseeds (Castor and linseed). In addition to nine annual oilseeds, several oil-bearing tree crops like coconut, oil palm and tree borne oilseed (TBOs) are also grown as secondary source of vegetable oil. Oilseeds are primarily grown for edible oils for cooking and oil cakes after oil extraction serves as fertilizer and a valuable protein supplement in animal and poultry feed. Byproducts of oilseed crops used as raw material in biodiesel production, industries like soaps and derergents, paints, varnishes, cosmetics, lubriants and pharmaceuticals. Thus, oilseed crops are not only contributing to nutritional security but also driving rural income generation and agro-industries. Oilseed crops also play an important role in addressing climate change and environmental challenges as they have low water requirement, low fertilizer requirement, low carbon footprint compared to grain and other commercial crops. Soybean and groundnut have added advantage of nitrogen fixation into the soil by symbiotic relationship with *Rhizobium spp.* so, intercropping or crop rotation of non-nitrogen-fixing oilseeds with biological nitrogen fixing oilseeds (soybean and groundnut) or pulses enhances soil fertility and maintain nitrogen balance in farming systems.

Importance of Oilseeds in Indian Economy

India is a leading player in global edible oil sector and occupy fourth rank behind the USA, China and Brazil. India contributes considerable share to global picture, accounting for 6-7 % in production, 15-20 % in area and 9-10 % of total consumption. Globally, India ranks first in the production of safflower, sesame and niger, second in groundnut, third in rapeseed-mustard, fourth in linseed and fifth in soybean. Globally, among the nine major oilseed crops grown, soybean ranks first with 15.18 million tonnes (35.63%) of the total oilseed production of 42.61 million tonnes, followed by rapeseed–mustard at 12.61 million tonnes (29.58%) and groundnut at 11.90 million tonnes (27.91%) *(Source: 3rd Advance* *estimate of Food Grains, Oilseeds and Commercial crops, Department of Agriculture and Farmers Welfare, 28-05-2025).*

During 2023-24, oilseeds cover the 14.3 % of the gross cropped area in the country, holds 8.7% share in Gross Value Added (GVA) and hold 8 % share in total agriculture export valued at Rs. 29,587 crores. Nearly 76 % oilseeds are grown in rainfed agriculture that contribute 80 % of total production and rainfed cultivation is major cause of poor productivity in oilseeds. In total domestic edible oil production, major contribution comes from rapeseed-mustard (45%) followed by groundnut (25%) and soybean (25%) and these three crops contributes 95 % and rest 5 % is contributed by minor oilseeds (sesame, safflower, sunflower and nigerseed.) Major oilseed producing states includes Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Haryana, Uttar Pradesh, West Bengal, Karnataka, Tamil Nadu and Telangana. Out of these states, nearly 78 % contribution in production is only from four states viz. Rajasthan (21.54 %), Madhya Pradesh (20.44 %), Gujarat (18.40 %) and Maharashtra (17.68 %). Even after remarkable oilseed production by country, dependency for edible oil on import is still 57 % worth of 20.56 billion USD. Among imported edible oil, palm oil share is 57 % followed by soybean (29 %) and sunflower (14 %).

Nationally, per capita consumption of edible oil records significant rise, increasing from 15.9 kg/person/annum in 2012-13 and 19.7 kg/person/annum in 2021-22 but National Institute of Nutrition (NIN) recommend only 14.6 kg/person/annum. (Source: Recommended Dietary Allowance, Report of Expert Group 2020, NIN). Overconsumption of edible oil increases the risks of obesity, cardiovascular diseases (CVDs), diabetes, high blood pressure, cancer and imbalance in nutrient uptake. Soybean and Groundnut fit well in cropping system as they fixes biological nitrogen at. The trend in area, production, productivity and import over last five year is presented in Table. 1.

Table: 1 Area, Production, Productivity and import of total oilseeds

Year	Area (Lakh ha)	Production (Lakh Tonnes)	Yield (Kg/Ha)	Domestic Availability of Edible Oil (Lakh tonnes)	Import of edible oil (Lakh tonnes) Foreign exchange value in crores) *
2020-21	288.337	359.462	1247	111.51	131.30 (Rs. 117,225.0)
2021-22	289.451	379.630	1312	116.50	140.30 (Rs. 156,800.0)
2022-23	302.393	413.551	1368	124.10	164.70 (Rs. 138,424.0)
2023-24	301.923	396.694	1314	116.20	159.6 (Rs. 131,967.0)

2024-25	302.65	426.09	1408	116.5 (Estimated)	160.0 (Rs. 161,000.0)

(Source: Department of Agriculture & Farmers welfare and Solvent extractors association of India)

Global Scenario of total Oilseeds

Globally, oilseed secures fourth rank after cereals, vegetables and melons and fruits and nuts. (Reference: OECD-FAO, 2020). Since 1961, global oilseed production has recorded nearly ten time increase, rising steadily from 57.02 million tonnes. According to FAOSTAT (2022), nine major oilseed crop production reached to 559 million tonnes from area of 254 million hectares. Similarly like India, soybean recorded dominance in total oilseed production and accounted for nearly 60 % of total global production with an average production of 353 million and an average productivity of 2.8 tonnes/ha. Soybean is followed by Rapeseed (75.9 MT), sunflower seed (53.2 MT), and groundnut (52.2 MT) with an average yield of 2.1 t/ha, 1.9 t/ha and 1.7 t/ha, respectively.

Oilseed Crop Scenario- Area, Production and Productivity

The diverse geographical or agroclimatic distributions enables the country to cultivate nine oilseeds across different seasons and climatic conditions. The distributions of oilseed crops are majorly determined by rainfall patterns, soil types and temperature regimes and also influenced by consumption pattern also. Mustard oil is preferred in north and east India followed by sunflower oil. In the west zone, soybean and mustard oil is preferred but southern people prefer sunflower followed by groundnut oil. In contrast, urban public prefer refined oil (sunflower and soybean) whereas, rural public prefer mustard oil. Crops wise area, production and productivity along with major producing states are presented in Table 2.

Area, Production, Productivity and Major Production state of Oilseed Crops

Crop	Area (Lakh ha)	Production (Lakh Tonnes)	Yield (Kg/Ha)	Major producing states
Soybean	128.72	130.62	1069	Maharashtra, Madhya Pradesh, Rajasthan
Groundnut	54.28	101.50	1957	Gujarat, Rajasthan, Madhya Pradesh
Rapeseed-Mustard	82.71	132.59	1471	Rajasthan, Uttar Pradesh, Madhya Pradesh
Sunflower	1.74	1.73	1041	Karnataka, Haryana, Telangana

Safflower	0.73	0.55	753	Maharashtra, Karnataka, Telangana
Sesame	15.87	8.17	516	West Bengal, Madhya Pradesh, Gujarat
Niger	0.91	0.15	319	Chhattisgarh, Assam, Madhya Pradesh
Linseed	1.93	1.13	651	Madhya Pradesh, Uttar Pradesh, Jharkhand
Castor	9.42	118.96	1897	Gujarat, Rajasthan, Andhrapradesh
Total Oilseeds	**302.65**	**429.89**	**1408**	**Rajasthan, Madhya Pradesh, Maharashtra**

Classification of oilseed crops

Oilseeds is a group of crops and can be classified based on season of cultivation as *Kharif, Rabi*, and *Summer (Zaid)* and nature of oil or uses as Edible Oilseeds and Non-Edible Oil Seed crops.

1- Classification of Oilseeds based on season of cultivation

Oilseed crops are categorized in three crop seasons i.e.

i) ***Kharif:*** crops which are mainly grown in kharif season (June- October) and their contribution in total oilseed is nearly 65 %. These crops can withstand with high temperature and high humidity and faces more biotic and abiotic stresses. Eg. Soybean, Groundnut, Sesame, Castor, Niger, Sunflower

ii) ***Rabi:*** crops which are mainly grown in rabi season (October- March) and require lower temperature/cool climate during sowing and medium to high temperature/ warm climate during maturity. The contribution to total oilseed production is around 32 %. Eg. Rapeseed-Mustard, Linseed, Safflower, Sunflower, Groundnut and Sesame

iii) **Summer:** crops which can be grown in summer season (February – June) and summer season contribute only 3 % in total oilseed. Eg. Groundnut, Sesame, Sunflower

2- Classification based on nature of Oils

i) **Edible Oilseed crops:** most important group of oilseeds that supply the edible oil and seeds are crushed to extract oil for vegetable oil purpose and this category is known as edible oilseed crops. Eg. Soybean, Groundnut, Rapeseed-Mustard, Sesame, Niger, Sunflower and safflower

ii) Non-Edible Oilseed Crops/Industrial Oilseed Crops: the oil extracted from these crops are not suitable for consumption purpose but useful for industrial purpose. Eg. Castor and Linseed.

Description of Oilseed Crops

Sr. No.	**Name of Crop**	**Scientific Name (Family)**	**Chromosome No.**	**Synonyms**	**Oil Content (% by weight)**
1	Soybean	*Glycine max* (L.) Merr. (Fabaceae)	2n= 36	Soya bean	15- 25
2	Groundnut	*Arachis hypogea* L. (Fabaceae)	2n= 40	Peanut, Earthnut, Moongphali	35- 50
3	Rapeseed-Mustard	*Brassica spp.* (Brassicaceae)	2n= 36 (*B. juncea*)	Sarson, Raya, Laha	35- 42
4	Sesame	*Sesamum indicum* L. (Pedaliaceae)	2n= 26	Til, Gingelly	45- 52
5	Sunflower	*Helianthus annus* L. (Asteraceae)	2n= 40	Surajmukhi	40- 50
6	Safflower	*Carthamus tinctorius* L. (Asteraceae)	2n= 24	Kusum, False saffron	30- 35
7	Niger	*Guizotia abyssinicia* (Lf.) Cass. (Asteraceae)	2n= 36	Ramtil, Nigerseed	38- 40
8	Linseed/ Flax	*Linum usitatissimum* (Linaceae)	2n= 30	Alsi, Flaxseed,	35- 40
9	Castor	*Ricinus communis* L. (Euphorbiaceae)	2n= 36	Arandi	45- 50

Activities

Activity 1: Prepare a pie chart/ bar diagram, depicting the production of Oilseed producing States in India

Material required: Pen, pencil, Scale, Eraser, Notebook, Colours, etc.

Procedure:

- Collect data of oilseed production for different states.
- Note the values in your notebook.
- Make pie chart or bar diagram and mark value for each state.
- Colour and label each part or bar.

Activity 2: Identification of different Oilseed crops

Material Required:

Samples/pictures of oilseed crops (Groundnut, Mustard, Sesame, Sunflower, Soybean, Castor, Linseed, etc.), Notebook, Pen/Pencil, Glue, Colours (optional).

Procedure:

- Collect samples of various oilseed crops.
- Observe each seed carefully and note down following observation:
    - Shape of seed
    - Colour of seed
    - size of seeds.
- Write the name of each oilseed crop in your notebook.
- Paste the picture or draw the seed and plant structure next to the name.
- Mention one key identifying feature for each crop.

Check Your Progress

Fill in the Blanks

1. _____ and _____examples of non-edible oilseed crops.
2. India ranks _____in the production of safflower, sesame.
3. Nearly _____oilseeds are grown in rainfed areas.
4. Major oilseed-producing state with highest share is _____.
5. Soybean belongs to the _____family.

Multiple Choice Questions

1. Which oilseed crop has the highest oil content?
    a. Soybean
    b. Sesame
    c. Sunflower

d. Safflower

2. Which oilseed ranks first in global production?
   a. Groundnut
   b. Soybean
   c. Sunflower
   d. Linseed
3. Which of the following is a non-edible oilseed?
   a. Niger
   b. Sesame
   c. Sunflower
   d. Castor
4. Rapeseed–mustard belongs to which family?
   a. Fabaceae
   b. Asteraceae
   c. Brassicaceae
   d. Pedaliaceae
5. Sunflower has a chromosome number of:
   a. 2n = 24
   b. 2n = 30
   c. 2n = 40
   d. 2n = 26

Match the Column

Column A	Column B
1. Soybean	a. Brassicaceae
2. Groundnut	b. Asteraceae
3. Rapeseed-Mustard	c. Fabaceae
4. Sunflower	d. Fabaceae

5. Safflower e. Asteraceae

Subjective Questions

1. What is Yellow Revolution and describe importance of yellow revolution.
2. Describe role of oilseed crops in Indian Economy.
3. Describe classification of oilseed crops

Session 2: Nutritional and commercial importance of oilseed

Nutritional Value of Oilseed Crops

Oilseed crops are an inevitable part of human diet and these are vital sources of essential nutrients. Oilseed crops provide balanced composition of oils, proteins, vitamins and minerals. Oilseed crops are mainly grown as a source of vegetable oil and the ratio of saturated and unsaturated fatty acids determines the oil quality. Vegetable oil is the major source of essential fatty acids linolenic acid, eicosapentaenoic acid, docosahexaenoic acid, oleic acid and linoleic acid and arachidonic acid. Unsaturated fatty acid contributes majorly for cardiovascular health. Without an adequate intake of these essential fatty acids can lead to thrombocytopenia, dermatitis, increased infections, and delayed growth. Oilseeds are also source of fibre, vitamins (E, B complex, niacin and folate) and minerals (Phosphorous, Iron, Magnesium and Selenium). The nutritional value of different oilseed crops are presented in Table 3. Soybean and groundnut seeds are rich in protein (20-30 %) of high biological value, making them important in human and animal nutrition. Sesame and sunflower are rich in vitamin E (tocopherols) and selenium, acting as potential antioxidants while linseed (flaxseed) is a rich source of omega-3 fatty acids and lignans which help in metabolic and immune functions. Rapeseed-mustard contains bioactive phytochemicals such as glucosinolates that exhibit potential health advantages and preventive effects against cancer if consumed in limited quantity. Overall, the nutritional worth of oilseed crops are beyond their oil yield, they offer multifaceted contribution in diet, health benefits and nutritional security.

Nutritional composition of oilseed crops (per 100 gm seed basis)

Sr. No.	Name of Crop	Protein (%)	Oil (%)	Carbohydrate (%)	Fibre (%)	Major Fatty Acids	Major Bioactive compound	Minerals & Vitamins
1	Soybean	38–42	15-25	25–30	4.0	Linoleic, Linolenic	Isoflavones	P, Zn, Vit. B1, B2
2	Groundnut	25–28	35–50	15–18	3.0	Oleic, Linoleic	Resveratrol, Phytosterols	Ca, Mg, Fe, Vit. E

3	Rapeseed-mustard	22–25	35–42	20–25	4.5	Erucic, Oleic, Linoleic	Glucosinolates, Phenolics	Ca, P, Vit. E
4	Sesame	18–25	45–52	20–25	3.5	Oleic, Linoleic	Sesamin, Sesamolin, Lignans	Ca, Fe, Vit. E
5	Sunflower	20–22	40-50	18–20	2.0	Oleic, Linoleic	Chlorogenic acid	Mg, Se, Vit. E
6	Safflower	18–20	30–35	28–32	2.0	Linoleic, Oleic	Serotonin derivatives, Flavonoids	Ca, Fe
7	Niger	18–20	38–40	20–25	2.5	Linoleic, Oleic	Polyphenols, Tocopherols	Ca, Mg
8	Linseed	20–25	35–40	28–30	4.0	α-Linolenic (ALA, omega 3)	Lignans (SDG), Omega-3 fatty acids	Mg, K, Vit. B3
9	Castor	18–20	45–50	12–15	3.5	Ricinoleic	Ricinoleic acid, Ricin (toxic protein)	Ca, P

Looking at the exceptional nutritional worth, oil quality and agronomic versatiliy of groundnut, groundnut is also known as ***“King of Oilseeds”*** whereas, sesame is also known as ***“Queen of Oilseeds”*** due to highest oil content among all oilseeds, nutritional value, uses in ayurveda and oxidative stability of oil.

Biofortification concept and need for oilseed crops

In 2015, United Nations General Assembly set 17 Sustainable Development Goals (SDG) and among the 17 SDGs, SDG 2, “Zero Hunger” and SDG 3, “Good health and Well- Being”, aim to transform the world by facilitating food and nutritional security. Hence, fighting with malnutrition requires a multi-faceted approach, including dietary diversification, supplementation, fortification and bio-fortification, where biofortification is the one-time, cost-effective investment and sustainable strategy for nutritional security. Bio-fortification is a process of enriching the nutrient profile either by increasing nutrient content or reducing anti-nutritional factors in crops through genetic interventions. Approaches such as conventional plant breeding, molecular breeding, transgenic techniques or genome editing provide avenues for the development of nutrient-rich oilseed crops. In oilseeds, biofortification is possible in two dimensions, *i) increasing* *desirable micronutrients/vitamins* (Fe, Zn, Ca, Mg, P, S, K, vitamin E, K etc.) *and fatty acids composition* (high oleic/linoleic acid ratio, high omega 6 and omega-3 fatty acid ratio etc.) *ii) removal of anti-nutritional factors which restricts the bioavailability of nutrients* (lectins, phytic acid, Kunitz trysin inhibitors (KTI), saponins, lipoxygenase (lox), lathyrogens, protease inhibitors, α- amylase inhibitors, erucic acid, glucosinolates and tannins etc.). The list of the targeted traits for biofortification in oilseed crops has been presented in Table.

Important nutritional parameters and their levels for biofortification

Crop	Targeted Trait	Effects on Human Health
Brassica species	Erucic acid (< 2.0 %)	Myocardial lipidosis
	Glucosinolate (< 30 ppm)	Goitrogenic effect
Linseed	Linoleic acid (>58 %)	Reduces Blood Cholesterol
Groundnut	Oleic acid (>70 %)	Decrease in LDL, cholesterol, prevents cardiac stroke
Soybean	Kunitz trypsin inhibitor (KTI) – Free from KTI	Poor protein digestibility, pancreatic diseases
	Lipoxygenase 2 (lox-2)- low beany flavour	Beany flavour and poor oil stability
	Oleic acid (> 40 %)	Decrease in LDL, cholesterol, prevents cardiac stroke
Safflower	Oleic acid (>70 %)	Decrease in LDL, cholesterol, prevents cardiac stroke

Missions for promotion of oilseed crops:

To enhance the production oilseed to achieve self-sufficiency (*Atma-nirbharata*) in edible oil of oilseed, government of India implemented the several schemes after green revolution. Some of major schemes with major objectives are as follows:

Name of scheme	Implementing Year	Purpose/objective
Technology Mission on Oilseeds (TMO)	1986-87	Revised version of NODP, for enhancement of domestic production of edible to avoid huge loss of import of edible oil. TMO was launched under supervision of Indian Council of

		Agricultural Research (ICAR) for technological back up to harness the best of production, processing, management technologies, harmonizing the interests of farmers, consumers and to accelerate self-reliance in oilseeds and edible oils. In 1988-89, TMO implementation was transferred to Department of Agriculture & Cooperation, Ministry of Agriculture, and Government of India.
National Food Security Mission (NFSM)	2018-19	NMOOP was merged with NFSM and comprises oilseeds as sub components NFSM- Oilseeds, NFSM-Oil Palm and NFSM- TBOs.
National Missoon Edible Oils- Oil Palm (NMEO-OP)	2021	Launched with aim to enhance the edible oilseeds production and oil availability by Oil palm area expansion (from 3.70 to 10.0 lakh hectares by 2025-26) and reduce burden on edible oils.
National Mission on Edible Oils- Oilseeds (NMEO-Oilseeds)	2024-25 to 2030-31	Misson aims to increase primary oilseed production from 39 million tonnes (2022-23) to 69.7 million tonnes by 2030-31 to meet 72 % of our projected domestic requirement together with NMEO-OP by inclusion of high yielding high oil content seed varieties, horizontal expansion in rice fallow areas, hiqh quality seeds and cutting-edge technologies like genome editing.

Commercial Value of post-harvest products of oilseed:

Oilseed crops are not only a source of edible oils but defatted cakes also provide protein-rich (35–50%), seed cakes, used as animal feed, organic manure and soil conditioner. Oilseeds also possess high commercial value due to wide range of post-harvest products that contributes significantly to agro-industries based economy. The refined oil extract from major oilseed crops are used in culinary, confectionary and processed food industries. Non-edible oils find application in biodiesel production, lubricants, paints, soaps and cosmetics. Linseed offers dual benefit of oil and fibre. Fibre processed into linen fabric, which is natural textile extracted from flax stem through retting and fetches premium price as linen cloth. Major products derived from oilseeds are catergorized in Table.

Major oilseed Product and their Use

Category	**Product name**	**Oilseed Crops**	**Applications / Uses**
Edible Products	Edible oils	Groundnut, Rapeseed-mustard, Soybean, Sesame, Safflower, Sunflower,	Cooking, frying, salad dressing, and margarine
	Hydrogenated oils (Vanaspati ghee)	Soybean, Rapeseed-mustard	Bakery, confectionery, processed foods
	Roasted seeds & snacks	Groundnut, Sunflower, Sesame	Snack foods, confectionery
	Nut butters & spreads	Peanut butter, Sesame paste (tahini)	Health foods, bakery
	Protein products (Soy milk, tofu, soy flour, vegetable protein, Peanut protein bars, Gajak/Chikkis)	Soybean, Groundnut	Dairy alternatives, protein supplements
Industrial Products	Biodiesel	Soybean, Rapeseed-mustard, castor	Renewable fuel
	Bio-lubricants	Castor, Rapeseed, Linseed	Machinery, automotive lubricants
	Paints and varnishes	Linseed, Safflower, Castor	Surface coatings, drying oils
	Soaps and detergents	Castor, Linseed, Rapeseed-Mustard	Cleaning, cosmetics

	Printing ink	Soybean, Linseed	Eco-friendly printing
	Plasticizers & resins	Castor, Linseed	Paints, adhesives, plastics
	Linen fabric	Linseed	Woven cloth, textiles
Cosmetic and Pharmaceutical Products	Hair oils & skin creams	Castor, Rapeseed-mustard	Cosmetics, skincare
	Lecithin, tocopherol, phytosterols	Soybean, Sunflower	Nutraceuticals, antioxidants
	Essential & aromatic oils	Sesame, Rapeseed-mustard	Massage oils, aromatherapy
Agricultural By-products	Oilseed cakes / meals	Groundnut, Rapeseed-mustard, Soybean, Linseed	Livestock feed, organic manure
	Seed husks / shells	Groundnut, Sunflower	Fuel, compost, coir industry
Value-added and special products	Virgin and cold-pressed oils	Sesame, Sunflower, Rapessed-mustard	Premium edible oil, cosmetics
	Omega-rich oils/ Capsules	Linseed	Functional foods, supplements
	Biochar and briquettes	Husk, shells, residues	Renewable energy, soil amendment

Research Network for Oilseeds:

Under National Agricultural Research System, a research network for oilseeds includes national institutes, state or central agricultural universities (SAUs/CAUs), krishi vigyan kendras (KVKs), state agriculture departments, private sector partners and international institute. These organizations are working in co-ordiantion for promotion and productivity enhancement of oilseed through research and capacity building. The major research organizations working on oilseed crops are as follows:

Name of Institute	**Location**	**Mandate Crops**
National Institutes		

ICAR- Indian Institute of Oilseeds Research (ICAR-IIOR)	Hyderabad (Telangana)	Sunflower, Castor, Sesame, Niger, Safflower, Linseed
ICAR– Indian Institute of Rapeseed-Mustard Research (ICAR-IIRMR)	Bharatpur (Rajasthan)	Rapeseed–mustard
ICAR – Indian Institute of Groundnut Research (ICAR-IIGR)	Junagadh (Gujarat)	Groundnut
ICAR - National Soybean Research Institute (ICAR-NSRI)	Indore (Madhya Pradesh)	Soybean
ICAR - Indian Agricultural Research Institute (ICAR-IARI)	New Delhi	Rapeseed-mustard, Soybean
ICAR - National Bureau of Plant Genetic Resources (ICAR-NBPGR)	New Delhi	Oilseeds germplasm conservation and evaluation
ICAR - All India Coordinated Research Project (AICRP) on Oilseeds crops	Across India through SAUs/CAUs	All nine major oilseed crops
International Institute		
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Patancheru, Hyderabad (Telangana), India	Groundnut, Sesame

Career Opportunities for Oilseed Cultivators

Trained oilseed cultivators possess specialized knowledge and skills in crop production, crop protection, seed production, post-harvest processing and value addition. Therefore, oilseed cultivator may have following career opportunities:

- **Agripreneur/ Progressive farmer:** knowledge of oilseed cultivation and management will be useful to achieve higher productivity and profitability by oilseed crops
- **Farm manager:** provides opportunity to manage large scale oilseed farms/ seed production field of oilseed crops
- **Oilseed industry:** provides opportunity to start oil or animal feed industry at small or large scale and also provides scope to work in oil, animal feed industry, biofuel, organic oil production and other byproduct industries
- **Seed growers:** scope to become seed businessmen or may be engage in seed industry

- **Farmer producer organization (FPOs):** provides opportunity to establish oilseed specific farmer producer organization or may engaged in local manufacture of byproducts of oilseeds such as soymilk, tofu, gajak etc.
- **Higher Education and Research Opportunities –** higher education (B.Sc.-Agriculture and PG) may be availed in specific area like agronomy, plant breeding, seed science, or pathology to opt research as career or join government job.

Activities

Activity 1: Prepare a Chart to Show the Nutritional Value of Oilseed Crops

Material Required: Chart paper, Sketch pens/Colours, Pencil, Scale, Eraser, Notebook.

Procedure:

- Collect information about the nutritional value of major oilseed crops.
- Note down key nutrients for each crop in your notebook.
- Draw a neat table or chart on chart paper to present the nutritional values clearly.
- Write the name of each oilseed crop and list its main nutrients in separate columns or blocks.
- Display your completed chart in the classroom or keep it in your project file.

Check Your Progress

Fill in the blanks

1. Indian Institute of Oilseeds Research is located at.......................
2. .... is known as king of oilseeds.
3. .... is the rich source of Omega-3 fatty acid.
4. Soybean and groundnut contain ______and _____ protein.

Multiple Choice Questions:

1. Which oilseed crop is known as *Queen of Oilseeds*:
   a. Groundnut
   b. Sesame
   c. Soybean
   d. Castor
2. Technology Mission on Oilseeds (TMO) was launched in the year
   a. 1990-91

b. 1983-85

c. 1986-87

d. 2024-25

3. Linen fibre is extracted from which crop

   a. Cotton

   b. Sunflower

   c. Safflower

   d. Linseed

4. Oilseed crop with highest production in the India is

   a. Safflower

   b. Sunflower

   c. Soybean

   d. Castor

Match the Column

	Column A		Column B
i.	Sunflower	a.	Kunitz trypsin inhibitor (KTI)
ii.	Rapeseed-mustard	b.	Ricinoleic acid
iii.	Soybean	c.	*Guizotia abyssinicia*
iv.	Castor	d.	Erucic acid
v.	Niger	e.	*Helianthus annus* L.

Subjective Questions

1. Describe the nutritional importance of oilseed crops.
2. What is biofortification? Describe the need for biofortification in oilseed crops.
3. Explain the major government initiatives to boost oilseed production.

Module 2
Nutrient Management in Oilseed Crops

Module Overview

The elements necessary for normal metabolic activities in the body of plants 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.

This module introduces students to the principles and practices of nutrient management in oilseed crops, focusing on maintaining soil fertility and enhancing crop productivity. In Session 1, students will learn about essential plant nutrients, their classification (macro and micronutrients), functions, and the symptoms of nutrient deficiencies in oilseed crops. Session 2 covers the application of manures and fertilizers, including types, methods, timing, and balanced nutrient management practices to achieve sustainable yields and soil health.

Learning Outcomes

After completing this module, you will be able to:

- Describe essential plant nutrients and explain their functions in oilseed crop growth and development.

- Identification of common nutrient deficiency symptoms in major oilseed crops.

Module Structure

Session 1: Plant Nutrients

Session 2: Application of Manures and Fertilizers

Criteria of essentiality

The idea of criteria of essentiality was first proposed by Arnon and Stout in 1939. These criteria define the essentiality of nutrients and those nutrients follows these principles are categorised under Essential nutrients.

The 3 following criteria of essentiality are:

1. The element should be directly involved in the metabolic activities.
2. The element should be irreplaceable through any other element and the deficiency of that particular nutrient must be fulfilled by applying the deficient nutrient.
3. The deficiency leads to incomplete life cycle of the plants.

Session 1: Plant Nutrients

Role of nutrients in plants

Plant nutrients can be classified according to their function or importance in plant life growth, development and production. In this classification nutrients are 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:** Accessory structural elements also called 'macro-elements', 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) act as catalyst and activators in various chemical processes 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.

1- 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.

2-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).

3- 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.

Table: Nutrients, their functions and deficiency symptoms

Nitrogen (N)	
Functions	**Deficiency symptoms**
a. Promotes the growth and development of leaves and stems.	a. Loss of vigour and yellowing of green parts especially the new (meristematic) growth

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. e. Promotes vegetative growth and overall plant Vigor.	b- Shortening of the stem, leaves become paler and remain small in size c- Slow growth and plant become dwarf d- Older leaves turn yellow and stem becomes thin in Mustard e- Delayed flowering, stunted growth, stem becomes thin, poor branching in Mustard, groundnut and sesame
Phosphorus (P)	
Functions	**Deficiency symptoms**
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 e. Enhances energy transfer and supports pod formation.	a. Growth of a plant is retarded at the early stage b. Older leaves curl up and margin becomes purplish in colour c. Scorching of leaf margin is observed sometimes d. Slow maturity and vegetative growth continue beyond normal time e. Poor root development and fewer seeds development
Potassium (K)	
Functions	**Deficiency symptoms**
a. Helps in carbohydrates and protein synthesis b. Helps in the transfer of carbohydrates from leaves to roots called the transporter of elements c. (c)Regulates water balance and maintains stomata opening and closing d. Increases disease resistance, vigour and hardiness to drought and frost e. Improve the quality of produce.	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 e. Stems appears weak and seed filling is poor

Sulphur (S)	
Functions	**Deficiency symptoms**
a. Helps in carbohydrates and protein synthesis b. Helps in the transfer of carbohydrates from leaves to roots called the transporter of elements c. (c)Regulates water balance and maintains stomata opening and closing d. Increases disease resistance, vigour and hardiness to drought and frost e. Improve the quality of produce.	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 e. Stems appears weak and seed filling is poor
Calcium (Ca)	
Functions	**Deficiency symptoms**
a. Improves plant vigour b. Influences the intake and synthesis of other plant nutrients c. Important constituent of cell wall and strengthens it d. Increases the yield of large and medium-sized tubers e. Improves specific gravity of tubers, and thus, enhances tuber quality for processing	a. Failure of development of terminal buds at apical tips b. Smaller 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	**Deficiency symptoms**
a. Influences the intake of other essential nutrients b. Helps in the assimilation of fats c. Assists in the translocation of phosphorus and fats d. Activates enzyme and aids in carbohydrate translocation	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. Interveinal chlorosis of older leaves

Zinc (Zn)	
Functions	**Deficiency symptoms**
a. Synthesis of tryptophan b. Helps in enzyme action c. Essential for protein synthesis and seed production d. Fastens the rate of maturity e. Involved in hormone	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	**Deficiency symptoms**
a. Essential in the enzyme system of plant metabolism b. Essential for the synthesis of enzymes which are responsible for chlorophyll synthesis in plants	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	**Deficiency symptoms**
a. Helps in the oxidation-reduction process during photosynthesis b. It plays major role in splitting of water c. Essential element in respiration	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 d. Yellow mottling in oilseeds
Copper (Cu)	
Functions	**Deficiency symptoms**
a. Essential for the synthesis of chlorophyll and other plant pigments b. Enzyme activation and redox reactions c. Helps improve the flavour and the content of sugar in vegetables	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

d. Increases the dark green colour of leaves and also the crop yield	d. Delayed maturity in soybean and reduced peg formation in groundnut
Molybdenum (Mo)	
Functions	**Deficiency symptoms**
a. Involved in nitrogen fixation and nitrate assimilation b. Required by some microorganisms for nitrogen fixation in soils	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
Boron (B)	
Functions	**Deficiency symptoms**
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	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	**Deficiency symptoms**
a. It has a direct role in photosynthesis b. It is necessary for shoot apex and root growth	a. Chlorosis and wilting of young leaves Chlorosis of the inter-veinal area of leaf blade b. In severe deficiency, bronzing of the mature leaves on upper surface

Nutrient deficiency and Corrective measures

It is always recommended to prevent the diseases rather than curing it after appearance. This is particularly important for oilseed crop true for 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 Oilseed crop:

For Oilseed @ 12-15 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.

Table 4.2: Nutrient management of different Oilseed

S. No.	Oilseed Crop	Nutrient Management
1	**Soybean**	**Rainfed/Irrigated:** Apply 20 kg N and 80 kg P2O5 and 40 kg K2O and 40 kg of S as gypsum (220 kg/ha) /ha as basal dressing. Soil application of 25 kg ZnSO4/ha under irrigated condition. Treat the seeds with Carbendazim or Thiram @

		2g/kg of seed 24hrs before sowing or with talc formulation of *Trichoderma viride* @ 4 g/kg seed or *Pseudomonas fluorescens* @ 10 g/kg seed.
2	**Groundnut**	**Rainfed/Irrigated:** 25 kg N/ha, 50 kg P_2O_5/ha as basal. K_2O: 50 kg/ha if soil deficient. Sulphur: 20 kg/ha. Foliar micronutrients (Zn, B) as needed. FYM 5–10 t/ha recommended.
3	**Rapeseed & Mustard**	**Rainfed/Irrigated:** 80 kg N/ha, 40 kg P_2O_5/ha,40 kg K_2O/ha. Sulphur: 20 kg/ha. Boron: 1 kg/ha as foliar spray for better flowering and seed set. FYM 5 t/ha recommended.
4	**Sunflower**	**Irrigated/Rainfed:** 60 kg N/ha, 40 kg P_2O_5/ha, K_2O: 40 kg/ha if soil test indicates. Sulphur: 20 kg/ha. Zinc: 5 kg/ha. Application in split doses recommended for N.
5	**Sesame**	**Rainfed:** 50 kg N/ha, 25 kg P_2O_5/ha, 25 kg K_2O/ha FYM 5 t/ha. Micronutrients like Zn or Fe applied as per soil test. Seed treatment with biofertilizer enhances nodulation.
6	**Castor**	80 kg N/ha, 60 kg P_2O_5/ha, 40 kg K_2O/ha. FYM 5 t/ha. Sulphur and micronutrients applied as required by soil test.
7	**Safflower**	60 kg N/ha, 40 kg P_2O_5/ha, 40 kg K_2O/ha, K applied if deficient. FYM 5 t/ha. Zinc and boron sprays enhance yield in marginal soils.
8	**Linseed**	50 kg N/ha, 25 kg P_2O_5/ha, 25 kg K_2O/ha. FYM 5 t/ha. Sulphur: 20 kg/ha if deficient. Micronutrients applied as needed.
9	**Niger**	50 kg N/ha, 25 kg P_2O_5/ha, 25 kg K_2O/ha. K applied as per soil test. FYM 5 t/ha recommended. Zinc foliar spray in deficient soils.

Activities

Activity 1: Identify deficiency in the given samples of Oilseed crops.

Material required: Sample of Oilseed 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

Activity 2: Enlist the Macro and Micro Nutrients

Material required: Chart paper, Pencil, Scale, Sketch pens/Colours, Eraser, Notebook.

Procedure:

- Collect information about macro and micro nutrients required by plants.
- Enlist the names of macro nutrients and micro nutrients in your notebook.
- Draw a neat chart on paper and divide it into two sections.
- In one section, enlist macro nutrients and in the other section, enlist micro nutrients.
- Display the completed chart in the classroom.

Check Your Progress

Fill in the Blanks

1. Micro nutrients also known as ____________elements.
2. Enhances the dark green colour in plants and improves the quality of foliage are the functions of____________.
3. Stimulates root formation and its growth are the functions of ____________.
4. Calcium is an important constituent of the __________.
5. Failure of development of terminal buds at apical tips is deficiency symptoms of__________.
6. 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. The dose of well-decomposed FYM applied to oilseed crops is:
    a. 12-15 t/ha
    b. 1-2 t/ha
    c. 20-25 t/ha
    d. 30-40 t/ha

Match the Column

Nutrients	**Function/Deficiency causes**
1. Calcium	a. Defoliation
2. Potassium	b. Failure of terminal bud development
3. Boron	c. Dark bluish green leaves
4. Copper	d. Cracking of fruits

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?

Session 2: Application of 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.

B) 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

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
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)
- Prill's (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 sulphate, Potassium nitrate and Potassium sulphate

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 [$(NH_4)_6Mo_7O_{24}$]

Nano-fertilizers

Nano-fertilizers are the fertilizers which are developed through the nano-technology in which nutrients are delivered to the plants in the form of nano particles (1-100 nm). There are few types of nano-fertilizers available in the market: Nano urea plus (16% N), Nano DAP (16% P and 8% N), Nano zinc (12% Zn). These fertilizers enhance nutrient use efficiency, reduces loses and reduces environmental pollution.

Application of manures and fertilizer's

Timely application of fertilizers and manures in adequate quantity is important for the growth of plants. The manner and method of manure application depend 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 fertilizers 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 Oilseed crops.

Bio-fertilizers

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, whereas 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 Bio Fertilizers (PSB)

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

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

iii)- Cellulolytic or Organic matter Decomposer (OMD)

a) Cellulolytic Organism: *Cellulomonas, Trichoderma* spore

b) Lignolytic organism: *Arthobacter, Agariccus*

Nitrogen fixing bio fertilizers for Oilseed

Rhizobium biofertilizers play a crucial role in enhancing nitrogen fixation in leguminous crops, including oilseeds. While oilseeds are not legumes, certain crops like groundnut (peanut) and soybean benefit from Rhizobium inoculation due to their leguminous nature. Below is a table detailing the specific Rhizobium species associated with these oilseed crops:

- **Groundnut (Peanut):** As a leguminous crop, groundnut benefits from inoculation with *Rhizobium* species, which form nodules on the roots and fix atmospheric nitrogen, enhancing soil fertility and reducing the need for chemical fertilizers.
- **Soybean:** *Rhizobium japonicum* is the specific species that forms a symbiotic relationship with soybean roots, facilitating nitrogen fixation and promoting healthy plant growth.

Nodule Formation:

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

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.

Phosphate Solubilizing Biofertilizers (PSB)

A group of heterotrophies 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 oilseed crops.

Bacteria: *Bacillus spp. Pseudomonas spp.*

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

Yeast: *Pchwamiomyces accidentalis*

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, Burkholderia, Enterobacter, Erwinia, Mycobacterium* etc.

Application of Bio-fertilizers

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

- **Soil Treatment**: For any crop
- **Seed Treatment**: Pulses, oilseeds, 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 bio-fertilizer 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 bio-fertilizer 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 litre 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 bio-fertilizer 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.

i) Seedling Treatment: This method is used for transplanted crops. In this method 1 kg biofertilizer is mixed with 10 litre 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 Oilseed crop-specific bio-fertilizers.

ii) Application of bio-fertilizer 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 bio-fertilizer 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 unfavourable 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 Groundnut crop is 20:40:0 kg/ha, then calculate the required quantity of urea, single super phosphate (SSP) for one ha of Groundnut 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 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 kg SSP kg

For supplying 20:40:0 kg N:P: K/ ha to the Groundnut 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 groundnut crop is 20:40:0 kg N: P: K/ ha, then calculate the required quantity of DAP and urea for one ha area of Groundnut 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 kg DAP/ha

Quantity of DAP nitrogen through DAP (kg) =

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

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

= 16.11 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:

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

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

= 8.45 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 Oilseed 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__________ fertilizers.
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. which one is not Green manuring crop?
   a. Pigeon Pea

b. Mustard

c. Dhaincha

d. Groundnut

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

Descriptive Questions

1. Define fertilizer's and classify on the basis of their physical form.
2. What are manures? How they can be classified?
3. Define and classify bio-fertilizers.
4. Describe nutrient management of mustard?

Module 3
Weed Management in Oilseed Crops

Module Overview

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

This module provides an understanding of weed management practices in oilseed crops, emphasizing the importance of controlling weeds to enhance crop productivity and maintain field health. In Session 1, students will learn about the common weeds associated with major oilseed crops, their identification, characteristics, and the impact of weed competition on crop growth and yield. Session 2 focuses on Integrated Weed Management (IWM) strategies, including cultural, mechanical, biological, and chemical control methods to effectively manage weeds in a sustainable and eco-friendly manner.

Learning Outcomes

After completing this module, you will be able to:

- Identification of common weeds of oilseed crops.
- Describe harmful effects of weed infestation on oilseed crop growth and yield.
- Describe various weed control methods used in oilseed cultivation.
- Demonstrate Integrated Weed Management Methods for sustainable weed control in oilseed crop.

Module Structure

Session 1: Common weeds of Oilseed crops

Session 2: Integrated Weed Management in Oilseed Crops

Importance of Weed Management

Weeds pose a major threat to oilseed crops in India, causing substantial yield losses if not managed properly. The extent of these losses varies by crop, intensity of infestation, and environmental conditions. For instance, groundnut (peanut) can experience yield reductions of about 35.8% due to competition for nutrients and water during early growth stages, while soybean suffers losses ranging from 10% to 100%, averaging around 31.4%, depending on the timing and intensity of weed interference. Sesame is highly susceptible, with potential yield losses between 50% and 75%, particularly during slow early growth phases. Sunflower and other oilseed crops can also face losses from 20% up to 77%, depending on conditions. The critical period for weed control is generally 15–45 days after sowing, when weeds compete most aggressively with crops for essential resources such as nutrients, water, and light. Timely and integrated weed management is therefore essential to minimize yield losses and ensure optimal productivity of oilseed crops in India. Countries like India, where farm size is small or medium, farmers remove weeds manually, which is labour intensive. The practice of removal of weeds manually has become unaffordable for small farmers due to the increasing wages and unavailability of farm labour due to migration from rural to urban.

The farmers are aware of the crop weeds since time immemorial. All unwanted plants, other than the targeted crops plants, are categorized as weed. The weeds and its wild relatives are useful resources for crop improvement programs. Most of the todays cultivated species back traces their evolution from their weedy and wild relatives. Weedy and its wild relatives of crops are rich reservoir of useful genes. The researchers are utilizing these wild and weedy relatives of the crops in developing new varieties. There are more than 30,000 weed species and out of these about 18,000 species damage crops. Researchers considered that many weeds principally originated from two important and major arbitrarily defined groups. The term "weed" was coined and used in 1931 by Jethro Tull for the first time in his book "Horse Hoeing Husbandry". For his thoughts, Jethro Tull has been recognized as "Father of Weed Science".

Session 1: Common Weeds of Oilseed Crops

Weeds

Weeds are undesirable and unwanted plants growing with any crop in the same place and at the same time. Jethro Tull defined weed as "a plant growing where it is not desired". These are naturally growing plants with the crops known to cause yield losses. Researchers had recognized the importance of weed species very well. It is also a fact that all weed species are unwanted but all unwanted plant species may not be necessarily weeds.

Characteristics of Weeds

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

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

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

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

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

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

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

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

viii. **Early Seed Setting and Early Maturity:** Besides various disadvantages weed also have some importance for various purposes and these are as follows:

Importance	**Species**
Maintain soil fertility	• *Convolvulus arvens* • *Typha spp.* (adds 1 to 35 per cent nitrogen)
Controls soil erosion	• *Cynodon dactylon*
Fodder use	• *Cichorium intybus*

Medicinal value	• *Argemone maxicana* is used in skin disease • *Striga spp.* is used in diabetes • *Phyllanthus niruri* is used in Jaundice • *Leucas aspera* is used in snake bite
Economic importance	• Roots of *Cichorium intybus* is used in adding flavour to coffee • *Cyperus rotundus* is used in making Agarbatti • *Saccharum spontaneum* is used in roof making
Ornamental plants	• *Lantana camara* • *Eichhornia crassipes*
Maintains pH	• *Rumex acetocella* is used for making acidic soil to alkaline • *Argemone maxicana* is used for making alkaline soil to acidic
Used in cleaning water	• *Eichhornia crassipes*
Adds organic matter to soil	• *Amaranthus viridis* • *Convolvulus arvensis*
Used as vegetables	• *Chenopodium album* • *Amaranthus viridis*
Religious purpose	• *Cynodon dactylon*
Useful for cottage industries	• *Saccharum spontaneum* • *Typha spp.*
Donating genes to crop plants (crop breeding)	• *Saccharum spontaneum* (used in sugarcane)
Used as nematicides	• *Crotolaria* • *Parthenium*

Classification of Weeds

Researchers divide weeds into various types based on:

A. Life cycle

B. Parasitic nature

C. Morphology

D. Another basis

A. On the basis of life cycle

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

a. **Annual Weeds:** Weeds that complete their life cycle in one season, i.e. in kharif or rabi season, are known as annual weeds.
   - **Kharif Weeds**: *Eleusine*, *Echinochloa* sp.
   - **Rabi Weeds**: *Argemone Mexicana, Phalaris minor*

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

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

B. On the basis of parasitic nature

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

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

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

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

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

C. On the basis of morphology

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

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

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

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

D. On another basis

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

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

Common Weeds of Oilseed Crops

Fig. 3.1: Medicago polymorpha

Fig. 3.2: Eragrostis spp

Fig. 3.3: Boerhavia erecta

Fig. 3.4: Echinochloa colona

Fig. 3.5: Sonchus asper

Fig. 3.6: Lactuca virosa

Fig. 3.7: Portulaca oleracea

Fig. 3.8: Commelina bengalensis

Fig. 3.9: Vicia hirsuta

Fig. 3.10: Tridax procumbens

Fig. 3.11: *Dactyloctenium aegyptium*

Fig. 3.12: *Parthenium hysterophorus*

Fig. 3.13: *Euphorbia hirta*

Fig. 3.14: *Rumex spinosus*

Fig. 3.15: *Chenopodium album*

Fig. 3.16: *Orobanche aegyptiaca*

Common weeds of Oilseeds crops

Crops	Scientific name
Mustard	*Chenopodium album*
	Orobanche aegyptiaca
	Melilotus indica
	Anagallis arvensis

	Cynodon dactylon
Groundnut	*Cyperus rotundus*
	Echinocloa colona
	Digeria arvensis
	Commelina bengalensis
Sesame	*Trianthema Protulacastrum*
	Euphorbia hirta
	Celosia argentia
	Amaranthus sp.

Activities

Activity: Collection and identification of weeds in Oilseed crops and preparing a herbarium.

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

Procedure

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

Check Your Progress

Fill in the blanks

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

Multiple choice questions

1. The seeds of *Phalaris minor* can be dormant up to ?

   a. 1 year
   b. 2 years
   c. 3 years
   d. 4-5 years

2. Which weeds are used for controlling soil erosion?

   a. *Cynodon dactylon*
   b. *Phalaris minor*
   c. *Cyperus rotundus*
   d. *Convolvulus arvensis*

3. Which one is the total root parasitic weed?

   a. *Striga sp.*
   b. *Loranthus sp.*
   c. *Orobanchae sp.*
   d. *Cuscuta sp.*

4. The weeds found in water is called is known as weeds?

   a. Aquatic
   b. Annual
   c. Parasitic
   d. Broad leaved weeds

5. Weed which is used as ornamental plants, known as?

   a. *Saccharum spontaneum*
   b. *Lantana camara*
   c. *Eichhornia crassipes*
   d. Both b and c

Match the following

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

Subjective questions

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

Session 2: Integrated Weed Management in Oilseed Crops

Integrated Weed Management

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

Concepts of Integrated Weed Management

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

Methods of Integrated Weed Management (IWM)

1. **Cultural methods**: The cultural methods of weed control include proper tillage operations, planting methods, fertilizer application, irrigation techniques, crop rotations, intercropping systems etc., which ensure good growth of the crop so that the crop can fight against the weeds by themselves.
2. **Mechanical methods**: The mechanical method of weed control include the use of machines, like power weeder, kono weeder etc., for removal of weeds from the crops.

3. **Physical methods**: The physical methods of weed control include removal of weeds by the labours from the crops at an appropriate stage.
4. **Chemical methods**: The chemical methods of weed control use chemicals like herbicides/weedicides to kill weeds. For the purpose of managing weed losses and the control of weeds in diverse crops, a sizable number of herbicides have been developed and recommended. Some of the most popular herbicides are Glyphosate, Pendimethalin, Imazethapyr, Metribuzin etc.
5. **Biological methods**: The biological methods of weed control include insects that feed on leaves of weeds thereby helping in controlling their growth. For example, *Zygogramma bicolorata* provide control of *Parthenium hysterophorus.*

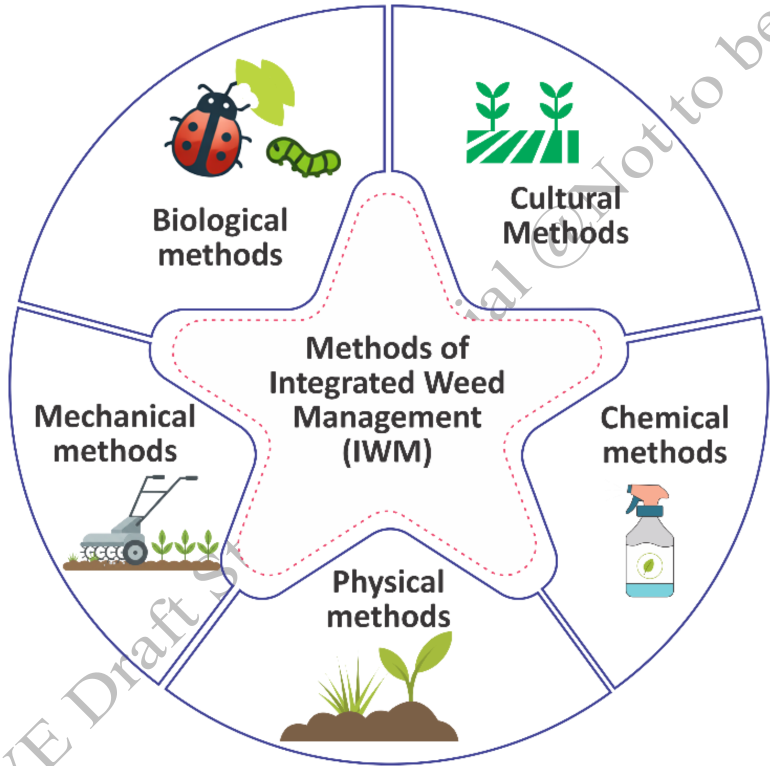

Fig.3.17: Methods of Integrated Weed Management (IWM)

Principles of Integrated Weed Management (IWM)

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

Advantages of Integrated Weed Management (IWM)

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

Necessary precautions during the application of weedicides

- The quality of herbicides should be checked before purchase.
- Weedicides should be sprayed under proper technical guidance.
- Right time, right quantity and right herbicide should be used for weedicides application.
- Dissolve appropriate quantity of weedicides in water to get the proper concentration.
- Weedicides should be sprayed in the morning and evening hours to avoid evaporation and can be absorbed easily.
- It should be kept away from eatables and animals.
- Wash the sprayer with soap and detergent after spraying.
- The instructions written on the herbicide packet should be followed.
- One should not taste, touch and smell the chemical.
- The weedicides should be kept away from children.
- Use gloves and mask during application of herbicide

Activities

Activity : Demonstrate the Integrated Weed Management of Oilseed crops.

Material required- Pen, pencil, notebook etc.

Procedure:

1. Visit the nearby field of Oilseed crops.
2. Observe and note down the following observations given below.
   a. Name of the crop
   b. Sowing time
   c. Weeding schedule

d. Growing of inter crops, if any
e. Tools and equipment's used for weed management
f. Name of the chemicals used for weed control
g. Any other information such as cultural, mechanical and biological methods of weed control adopted/used.

Check Your Progress

Fill in the blanks

1. ……………….is an approach to manage weeds in the sustainable way.
2. ……………. means complete removal of weeds from an area.
3. Machines like………………… are used for removal of weeds in the crops.
4. The insects which feed on leaves of weeds are used for……… control.
5. Right ………, right………and right………should be used for weedicides application.

Multiple Choice Questions

1. The Integrated weed management approach uses……. methods.
   a. Cultural, Chemical
   b. Mechanical
   c. Biological
   d. All
2. Cultural methods are
   a. Fertilizer use
   b. Glyphosate use
   c. *Zygogramma sp.* use
   d. Power weeder use
3. The management practices should be
   a. Feasible
   b. Not eco-friendly
   c. Not economical
   d. Disturbs soil
4. Dissolve appropriate quantity of weedicides in to get the proper concentration.
   a. Oil
   b. Water

c. Any liquid

d. None

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

a. Weed control

b. Weed eradication

c. Weed prevention

d. Weed management

Match the following

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

Subjective questions

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

2. Define Integrated Weed Management and their components.

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

Module 4
Irrigation Management in Oilseed Crops

Module Overview

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

The main aim of irrigation management is to apply and use water in the most profitable way at sustainable production levels. In the context of production agriculture, this generally means that one has to adopt artificial means for supplementing precipitation with water. An efficient water conservation, its management, and use of irrigation water are key for successful oilseed crops production, especially when field are under moisture deficit condition. Oilseed crops required irrigation at its critical stages for its better growth and development. Irrigation requirement may vary from crop to crop. If water is a limiting factor, then a proper management and conservation practices can be fruitful to cultivate crops round the year.

This module introduces students to the principles of irrigation management in oilseed crops, highlighting the importance of efficient water use for improving crop growth, yield, and sustainability. In this module, students will learn about the importance of irrigation in oilseed cultivation, critical stages of water requirement, and various irrigation methods such as surface, sprinkler, and drip irrigation systems suitable for different oilseed crops and agro-climatic conditions.

Learning Outcomes

After completing this module, you will be able to:

- Describe the importance of irrigation and critical growth stages of oilseed crops for Irrigation.
- Demonstrate different irrigation methods in oilseed cultivation.

Module Structure

Session 1: Importance and methods of the irrigation

Function of water in Crop plant

- Water is an essential element for plant life.
- It helps plants to absorb and transport minerals from soils.
- It is essential to regulate biochemical reactions in plant.
- It is an integral part of photosynthesis process in plant.
- It helps plants to manage high & low temperature stresses.

- It is essential for seed germination and seedling establishment in the field.

Sources of water for plants

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

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

Irrigation requirement of crop plants depends on:

- **Type of crop**: Shallow rooted crops need light but frequent irrigation than deep-rooted oilseed crops.
- **Growing season**: summer season oilseed crops require more frequent irrigation as compare to winter season Oilseed crops.
- **Climate:** Under cold climatic conditions, irrigation frequency is less. In tropical or hot climatic conditions, irrigation frequency is more. High wind velocity also increases evaporation and transpiration, leading to more water requirement.
- **Soil type**: Sandy soils require frequent but light irrigation whereas clay soils require less frequent but deep irrigation.
- **Type of Irrigation System**: Regular irrigation is needed in drip system and less frequently in case of surface, sub-surface and sprinkler irrigation system.

Session 1: Importance and methods of the irrigation

Importance of Irrigation

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

Sources of Irrigation Water

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

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

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

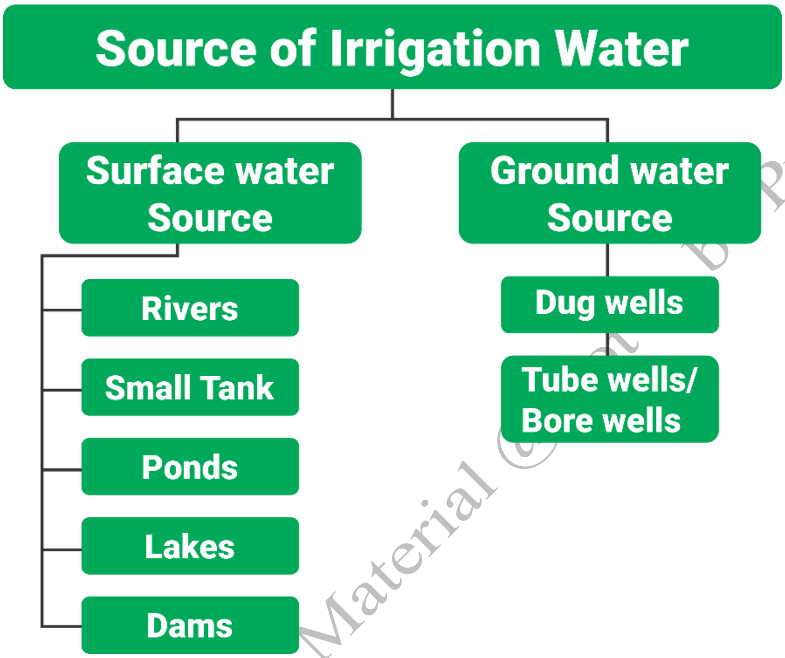

Fig. 4.1: Sources of Irrigation Water

Do you know?

- Water resources are too short in India and groundwater level is also depleting at alarming rate. So, it is essential we need to conserve the rainwater.
- In some areas, poor quality water, full of toxic, heavy metals and microbes, is in use in crop cultivation. It is necessary that only after proper treatment it can be used for irrigation.

The quality and quantity of water is very important for successful oilseed cultivation. Earlier in India, water quality concerns were less due to the availability of good quality water but presently this situation is changing in many areas. Poor quality water from industrial areas and saline ground water requires proper treatment before their use in irrigation purpose.

Quality of Water

- Good quality of water is a crucial factor for soils to remain productive for long-term.

- Good quality water allows growing any kind of oilseed crop.
- Good quality water favours high yield and oil quality.
- Various regions in the country have poor quality water to irrigate the crops.
- Untreated water from urban industrial areas is of poor quality.
- In some areas, ground water is very deep and is poor in quality.

Need of water quality test

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

Don't use poor quality water for irrigation, otherwise

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

Criteria of Water Suitability for Irrigation

- **pH** of irrigation water ranges in between 6.5 to 8.5.
- **Water Salinity**: It is an indicator of total dissolved salts present in water. It is of prime concern for both soil structure and crop yield. One can measure Salt concentration by Electrical Conductivity (EC) in milli Siemens per meter (mS m^{-1}) or micromhos per cm (µmhos cm^{-1}). Water having EC below 1500 micromhos/cm is good for irrigation.
- **Sodium Adsorption Ratio (SAR):** It is a measure of relative proportion of sodium (Na^{+}) to calcium (Ca^{+2}) and magnesium (Mg^{+2}) in water. High sodium causes breaking of soil aggregates and sealing the soil pores. Sodium weakens binding capacity of soil. High SAR value indicates high sodium content in water. It should be below 10 for irrigation water.
- **Residual Sodium Carbonate and Bicarbonate Concentration**: High carbonate and bicarbonate content in water increases the pH. This will cause an alkalizing effect and high SAR index. Residual sodium carbonate below 1.5 meq/litre is safe of irrigation water. For the management of such water quality, following measures can be adopted **-**

  i. Addition of gypsum in low calcium soil + Leaching

  ii. Addition of sulphur + Lime + Leaching

  iii. More frequent irrigation

  iv. Avoid sprinkler method of irrigation

v. Avoid use of chloride and boron containing fertilizers

vi. Select tolerant crops

- **Boron**: It is the most common element found in toxic concentrations in water. Boron cannot be easily removed from water. The only remedy is to dilute high boron water with low boron water. Irrigation water which contains more than 3 ppm boron is harmful to crops, especially on light soils.

Water Quality Testing Instruments:

It is important to test the suitability of water quality for its intended purpose. Water testing will help to know whether the quality of water is fit for irrigation or not, and if not then what is the specific reason for its poor quality. In general, the pH and electrical conductivity (EC) are two most important parameters for water quality analysis. Fig 4.2 shows change in pH colour strip when dip into the alkaline/acidic water.

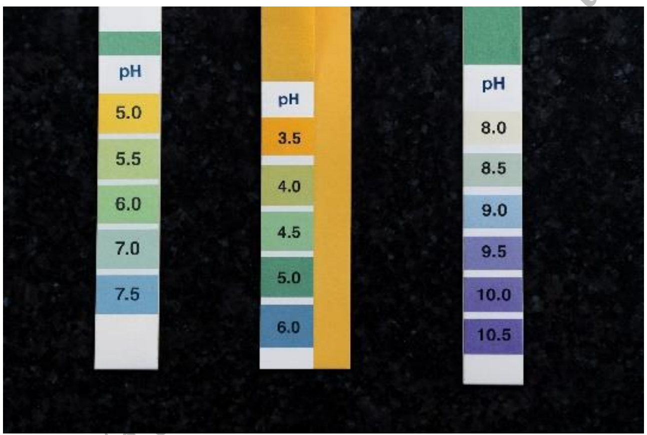

Fig. 4.2. pH colour strip

pH meter: It is an equipment by which we can measure the pH of any solution. It consists of a display unit and electrode (Fig 4.3). When the electrode is insert in to solution, the display unit shows the pH value. Ideally, the pH of the soil and water has to be 6.5–7.5. The pH meter, like all other equipment, should be calibrate before taking reading. It is more accurate than pH colour strip.

Fig.4.3: Digital pH meter

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

Fig.4.4: Digital Electrical Conductivity (EC) meter

Water Requirement

Water Requirement (WR) of a crop is the total quantity of water needed, either supplied through rainfall or irrigation or both, for crop growth and yield (Table 4.1). Water Requirement varies crop to crop and soil profile. It is different from Irrigation Requirement (IR) which is the total quantity of water applied to a cropped field to supplement rainfall and soil profile contribution.

When irrigation supplies the entire water requirement, the Water Requirement (WR) and Irrigation Requirement (IR) are the same.

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

Where,

Evapotranspiration (ET) = Total losses of water by transpiration from crop and evaporation from soil

Application losses = Water losses during the application of irrigation water e.g. deep percolation, runoff

Special needs = Water required for land preparation, transplanting, leaching *etc.*

Table 4.1 Water requirement of oilseed crops

Crop	Water Requirement (mm)
Groundnut	500–600
Mustard	300–400
Soybean	450–550
Sunflower	400–500
Sesame	350–450
Safflower	400–500
Linseed	350–450
Castor	600–700

Do you know?

- Indian Institute of Water Management is situated at Bhubaneswar, Odisha.
- Only 37.5% of the total area under oilseed crops is irrigated.

Scheduling Irrigation

An ideal irrigation schedule must indicate when irrigation water is to be applied and the quantity of water to be applied. The principle aim is to obtain maximum crop yield by making the most efficient and economic use of water. Several approaches of scheduling irrigation have been used, each one with its own advantages and disadvantages.

When to irrigate?

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

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

How much to irrigate?

The amount to irrigation water depends on factors like crop type, soil texture, and weather, and can be determined through methods like soil moisture measurement or water balance calculations.

> Irrigation scheduling is the process of determining when to irrigate and how much water to apply based on needs of the crop and nature of the soil.

Criteria for Scheduling Irrigation or Approaches for Scheduling Irrigation

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

1) Soil Moisture Depletion Approach:

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

For practical purpose, start the irrigation when the available moisture in the soil root zone reduced to 50 percent. The available water is the soil moisture, which lies between field capacity and wilting point.

2) Plant Indices:

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

3) Climatological Approach:

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

In IW/CPE ratio method, a known amount of Irrigation Water (IW) is applied when Cumulative Pan Evaporation (CPE) reaches a predetermined level. The amount of water given at each irrigation ranges from 4 to 6 cm. A Pan Evaporimeter or the Sunken Screen Pan Evaporimeter may be used for measurement of consumption use.

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

Solution:

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

$$= \frac{IW}{CPE} = 0.5; \ \frac{5}{CPE} = 0.5; \ CPE = \frac{5}{0.5} = \frac{50}{5} = 10 \text{ cm}$$

Irrigation of 5 cm is given when CPE is 10 cm

CPE at 0.6 ratio = 5/0.6 = 8.33 cm

CPE at 0.75 ratio = 5/0.75 = 6.66 cm

CPE at 0.8 ratio = 5/0.8 = 6.25 cm

4) Critical growth approach:

Moisture stress causes irreversible yield loss in each crop at certain growth stages. These stages are known as critical periods or moisture sensitive periods. If irrigation water is available in sufficient quantities, then one can schedule irrigation whenever soil moisture depletes to critical moisture level. For example, 25 or 50 percent of available soil moisture. Under limited water supply conditions, one can schedule irrigation at moisture sensitive stages and skip the irrigation at non-sensitive stages. The critical stage for irrigation of oilseed crops is given below:

Critical stages of oilseed crops for irrigation

Crop	**Critical stages**
Groundnut	Pegging, pod setting and pod filling
Mustard	Branching, flowering, and pod development
Soybean	Flowering and pod development
Sunflower	Bud initiation and seed filling
Sesame	Flowering and capsule formation
Safflower	Flowering and seed filling
Linseed	Flowering and capsule filling
Castor	Spike initiation and capsule formation

Source: Majumdar (2013)

5) Plant water status

This is the latest approach to irrigation scheduling. The plant itself serves as a good indicator of soil moisture and climatic conditions. In this method, the water content within the plant is considered for determining irrigation schedules.

However, it is not yet commonly practiced due to the lack of standardized and low-cost techniques for measuring plant water status or potential.

Methods of Irrigation

The way of application of irrigation water into the crop field refer as method of irrigation. Selection of suitable irrigation method mainly depends on the soil characteristics, cropping system, land topography, quantity and quality of irrigation water, and the nature and availability of inputs like labour and energy. For different oilseed crops, suitability of irrigation methods can be mentioned as per their sowing practice. There are four principle systems of irrigation viz. Surface, Sub Surface, Aerial or Overhead or Sprinkler Irrigation and Drip Irrigation (Fig 4.5).

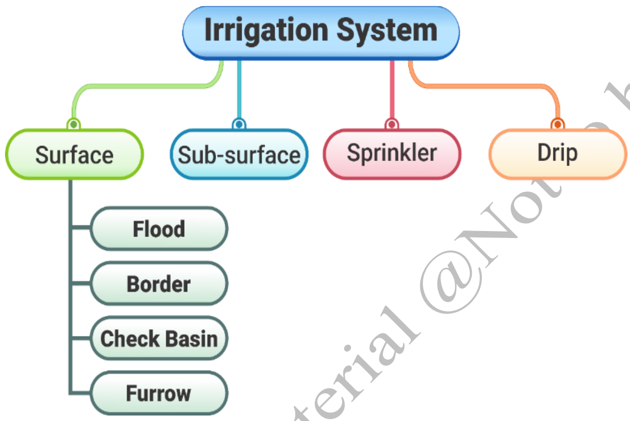

Fig.4.5: Irrigation systems and methods

A. Surface Irrigation

Surface irrigation system, also known as gravity irrigation method, is the most common and cheapest method of irrigation. In this method, one applies water to the field by introducing a stream of water through channels, pipes or ditches at the head of a field and allowing gravity and hydrostatic pressure to spread the flow over the surface of throughout the field. Land levelling and smoothing are essential operations. Crops in India are mostly irrigated by surface irrigation. This includes methods such as flood, border strip, check basin, furrow, and ring and basin methods. Flooding

1. **Flood Method:** Being an ancient practice of irrigation, it consists of opening water channel in a field and allowing it to flow freely in all directions to cover the land surface as a sheet. This practice is suitable for areas where water is abundant and have levelled topography, as shown in Fig. 4.6.

Fig.4.6: Flood Irrigation Method

Advantages

1. It is applicable to properly levelled soils.
2. Low cost of operation due to use of gravity and hydrostatic pressure.
3. Skilled human resource is not required.
4. No specialized equipment is required.

Disadvantages

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

2. Border strip Method: In this method, land is levelled and divided into different strips of appropriate size by making the borders of 30 cm height in between each strip. Strips of 3-10 m width and 30-90 m length with up to 0.5% slope are formed. This is suitable for a variety of close and row growing crops like wheat, mustard, soybean etc. (Fig. 4.7).

Advantages

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

Disadvantages

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

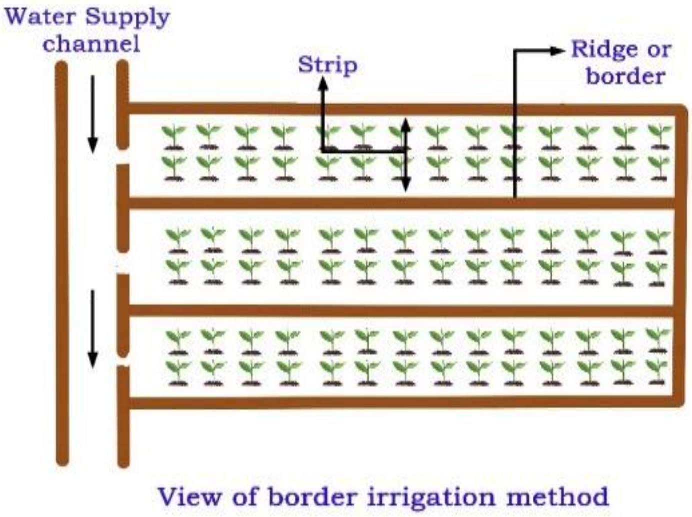

Fig.4.7: Border irrigation method

3. Check Basin Method: In this method, field is divided into square or rectangular checks or plots surrounded by ridges for irrigation as shown in Fig. 4.8. The plots are generally levelled or have a very mild slope. It is used successfully for both field and row crops.

Advantages

1. High water application efficiency.
2. No water loss through runoff.
3. Both rainwater and irrigation water are effectively utilized to wet the root zone soil.
4. Suitable for creating waterlogged conditions required for rice cultivation.

Disadvantages

1. Requires precise land leveling.
2. Considerable land area is lost due to the construction of bunds and channels.
3. High labor demand for preparing bunds and managing irrigation.
4. Movement of farm implements and machinery is often hindered by bunds and channels.

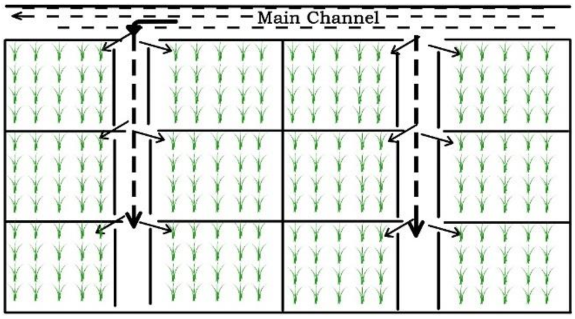

Fig.4.8: Line diagram of Check Basin Method

4. Furrow Irrigation Method: In this method, water moves into the field through furrows between two ridges. These furrows are lined among rows of the crop according to slope of land as shown in Fig. 4.9. Furrows are channels with continuous and nearly uniform slope in the direction of irrigation. Furrows run 3-6 m in length in such a way that water reaches to every nook and corner of the field. Planting is done on the side of ridges or raised beds (about 15-22 cm high) and water is given in 15-20 cm deep furrows of 30-50 cm width. Soybean is grown in ridge and furrow method.

Advantages

1. Water use efficiency is high due to minimal wastage, as irrigation is confined to the furrows only.
2. Since water does not cover the entire field, weed growth is significantly reduced.
3. Furrows act as a drainage channels in high rainfall areas

Fig. 4.9: Furrow Irrigation Method

Disadvantages

1. Labour requirement is more for making ridges and furrows and streaming irrigation water.

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

5. Ring and Basin method: Fruit trees in orchards are irrigated by constructing basins or rings around the trees. Basins are generally used for small trees, while rings are preferred for larger, widely spaced trees.

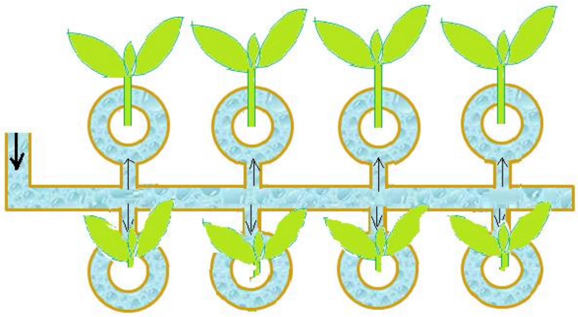

Fig. 4.10: Ring and Basin Irrigation Method

B. Sub-surface irrigation:

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

Advantages

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

Disadvantages

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

C. Sprinkler or Overhead Irrigation:

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

Advantages

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

Disadvantages

1. The installation and maintenance cost are very high.
2. High wind velocity influenced the distribution pattern of water.
3. It is not suitable if water contain appreciable amount of dissolved salts.
4. Skilled labours are required for operation and maintenance of this system.
5. It is not useful in case of tall growing crops with more spacing.

Fig.4.11: View of sprinkler or overhead irrigation system

D. Drip Irrigation System:

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

Components of Drip Irrigation System

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

Advantages

1. It is highly efficient system with 80 to 90% water use efficiency.
2. It saves water up to 40 to 60%.
3. This system also facilitates the supply of liquid fertilizers directly to the root zone.
4. It increases the plant yield up to 10-25%.
5. It minimizes the problem of weeds and cost of labour**.**
6. It is ideal for undulated land or slopes, and especially on hills.

Disadvantages

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

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

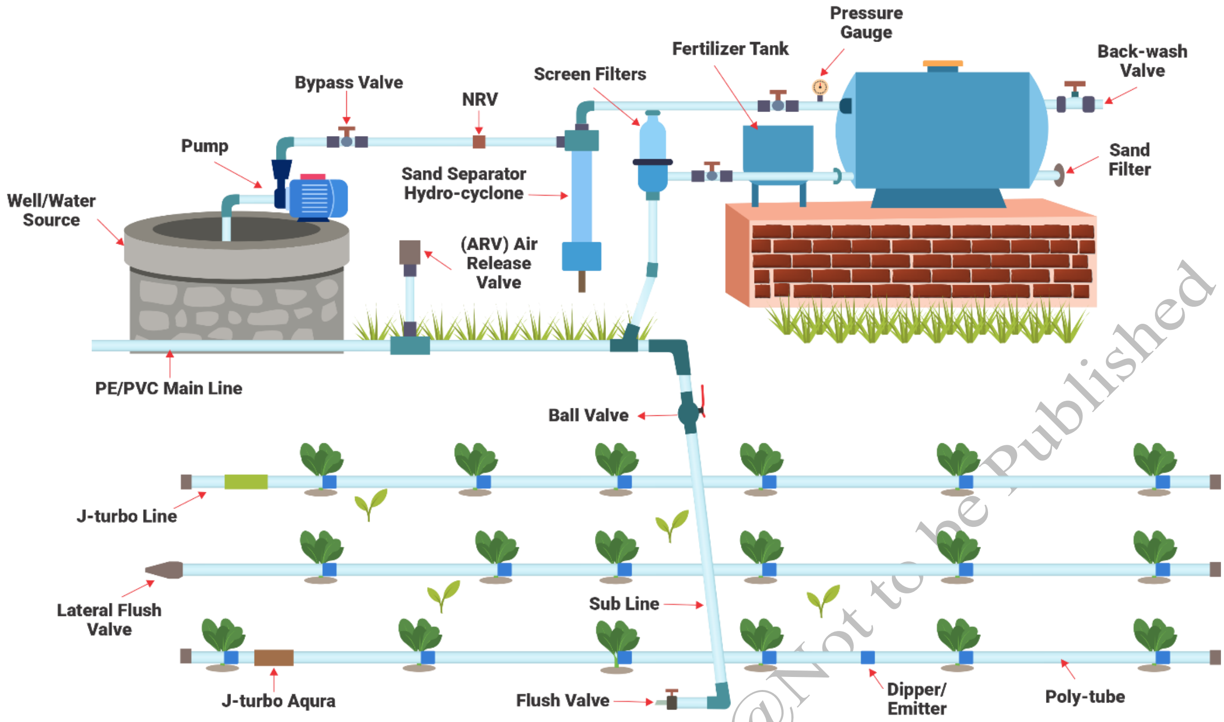

Fig. 4.12: Component and layout of drip irrigation system

Activities

Activity : Visit nearby oilseed growing field and observe method of irrigation

Material required-Pen, pencil, notebook etc.

Procedure:

1. Visit nearby oilseed growing field of farmer
2. Discuss the following with the farmer -
   - Observe and note down different components of drip irrigation system.
   - Discuss with the farmers about care and maintenance of drip system.
   - Discuss with the farmers about fertigation through drip system.
3. Note down your observations and present them before class.

Check Your Progress

Fill in the Blanks

1. The artificial application of water to the soil in order to maintain proper soil moisture regime for plant growth is known as.........
2. pH of irrigation water ranges in between.........
3. .... is a measure of relative proportion of sodium (Na^+) to calcium (Ca^{+2}) and magnesium (Mg^{+2}) in water.

4. ……………….is the most common element found in toxic concentrations in water.
5. ………………………… is the process of determining when and how much water to apply to crops for optimum growth and yield.
6. Water with pressure is forced through revolving nozzles is …………… system of irrigation.

Multiple Choice Questions

1. Drip irrigation system is known as ________________.
   a. Trickle irrigation
   b. Micro irrigation
   c. Both (a) and (b)
   d. None of the above
2. Surface irrigation systems are ________________.
   a. Flood Irrigation method
   b. Check basin method
   c. Furrow irrigation method
   d. All of the above
3. Which of the following statement/s is/are true about the sprinkler system of irrigation?
   a. It saves water up to 30–35 per cent.
   b. It is useful in irrigating undulated lands.
   c. Both a and b
   d. None of the above
4. Which method of irrigation supplies water in the form of discrete, continuous drops at slow rate through emitters, either onto the soil surface or directly on to the root zone?
   a. Drip irrigation method
   b. Sprinkler irrigation method
   c. Furrow irrigation method
   d. Check basin method

Match the Columns

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

Subjective Questions

1. Why is irrigation important for plant life?
2. Write short note on critical stages of irrigation for oilseed crops.
3. What are the different methods of irrigation? Describe drip irrigation system.
4. Give the merits and demerits of sprinkler irrigation system.
5. Describe furrow irrigation method.

Glossary

Abiotic stress: The adverse effect on plant growth and development caused by non-living environmental factors such as drought, salinity, extreme temperatures, or nutrient deficiency.

Agro-climatic zones: Geographical regions classified on the basis of climate, soil characteristics, rainfall pattern, and suitability for specific crops.

Anti-nutritional factors: Naturally occurring chemical substances in food that interfere with the digestion, absorption, or utilization of nutrients.

Basal application: The application of fertilizers to soil before or at the time of sowing to meet initial nutrient requirements of crops.

Biodiesel: A renewable and biodegradable fuel produced from vegetable oils or animal fats and used as an alternative to conventional diesel.

Biodiversity: The variety and variability of plant, animal, and microbial life within an ecosystem, including crop species and their wild relatives.

Biofertilizers: Preparations containing living microorganisms that enhance nutrient availability and uptake by plants through biological processes.

Biotic stress: Stress imposed on crops by living organisms such as insects, pathogens, weeds, and pests.

Broadcasting: The uniform spreading of fertilizers or manures over the soil surface.

Canopy: The above-ground portion of crop or weed plants that forms a cover over the soil surface.

Carbon footprint: The total amount of greenhouse gases emitted directly or indirectly as a result of agricultural activities or crop production.

Chelates: Organic compounds that bind micronutrients, enhancing their availability and preventing fixation in soil.

Composting: The biological decomposition of organic residues into stable humus-like material by microorganisms.

Concentrated organic manure: Organic manures rich in nutrients and applied in smaller quantities, such as oil cakes and animal by-products.

Crop rotation: The practice of growing different crops sequentially on the same land to improve soil fertility and reduce pest incidence.

Cropping system: The pattern and sequence of crops grown and managed on a particular field over time.

Crop–weed competition: The interaction between crops and weeds for limited growth resources resulting in reduced crop yield.

Evapotranspiration (ET): The combined loss of water from the soil surface by evaporation and from plants by transpiration.

Field capacity: The amount of soil moisture remaining in the soil after excess water has drained away and downward movement has substantially decreased.

Foliar application: Application of nutrient solutions directly to plant leaves for rapid nutrient absorption.

Fortification: The deliberate addition of essential nutrients to food products to improve their nutritional value.

Herbicidal resistance: The ability of weed species to survive and reproduce despite repeated application of a particular herbicide.

Intercropping: The agricultural practice of growing two or more crops simultaneously on the same field.

Leaching: The downward movement and loss of soluble nutrients from soil due to excessive rainfall or irrigation.

Moisture stress: A condition in which plants experience reduced growth and yield due to insufficient soil moisture.

Nitrogen balance: The maintenance of optimal nitrogen levels in soil to sustain crop productivity.

pH: A measure of acidity or alkalinity of water or soil, expressed on a scale from 0 to 14, influencing nutrient availability and crop performance.

Placement: The method of applying fertilizers close to seeds or roots to enhance nutrient use efficiency.

Rainfed agriculture: A farming system that relies primarily on rainfall rather than irrigation for crop water supply.

Seed dormancy: A condition in which viable seeds fail to germinate even under favorable conditions.

Seed treatment: Application of chemicals or biofertilizers to seeds before sowing to enhance germination and protection.

Soil health: The capacity of soil to function as a living ecosystem supporting plant growth.

Soil moisture regime: The pattern and availability of water within the soil profile that

Surface water: Water obtained from natural or man-made sources such as rivers, canals, lakes, tanks, and reservoirs used for irrigation.

Top dressing: Application of fertilizers to a standing crop during growth stages.

Value addition: The process of increasing the economic value of agricultural produce through processing or diversification.

Vegetative propagation: A method of plant reproduction using vegetative parts such as rhizomes, tubers, bulbs, stolons, or suckers instead of seeds.

Water requirement (WR): The total quantity of water needed by a crop throughout its growing period for optimum growth and yield.

Wilting point: The soil moisture level at which plants can no longer extract water and begin to wilt permanently.

Yield loss: Reduction in crop production caused by biotic or abiotic stresses.

Answer Keys

Unit 1: Introduction to Oilseed Crops

Session 1

Fill in the Blanks

1- Castor, linseed, 2-First, 3-76%, 4-Rajasthan, 5-Fabaceae

Multiple Choice Questions

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

Match the Column

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

Session 2

Fill in the blanks

1. Hyderabad (Telangana)
2. Groundnut
3. Linseed/ Flaxseed
4. 20–30%

Multiple Choice Questions

1. b 2. c, 3. d, 5. a

Match the Column

i- e, ii- d, iii- a, iv-b, v- c

Unit 2: Nutrient Management in Oilseed Crops

Fill in the blanks

1- Minor or trace, 2- Nitrogen, 3- Phosphorus, 4- Cell wall, 5- Calcium, 6-Calcium ammonium nitrate

Multiple Choice Questions

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

Match the Column

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

Session 2

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

Unit 3: Weed Management in Oilseed Crops

Session 1

Fill in the Blanks

1. Weed
2. 72,000
3. *Eichhornia crassipes*
4. Noxious weed
5. deep to very deep

Multiple Choice Questions

1.d, 2. a, 3. c, 4. a, 5. d

Match the columns

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

Session 2

Fill in the Blanks

1. Integrated weed management
2. Weed eradication
3. power weeder and kono weeder
4. biological methods
5. time, quantity and herbicide

Multiple Choice Questions

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

Match the columns

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

Unit 4: Irrigation Management in Oilseed Crops

Session 1

Fill in the Blanks

1. Irrigation
2. 6.5 to 8.5
3. Sodium Adsorption Ratio (SAR)
4. Boron

5. Sprinkler

Multiple Choice Questions

1.c, 2. d 3. c 4. a

Match the columns

1.d 2. c 3. a 4. f 5. e 6. b

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