Draft Study Material

Spice Crops Cultivator

(QUALIFICATION PACK: Ref. Id. AGR/Q0603)

SECTOR: AGRICULTURE

Grade 11

विद्यया ऽमृतमश्नुते

एन सी ई आर टी
NCERT

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Preface

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

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Module 1
Scope and Importance of Spice Crops

Module Overview

The history of Indian spices dates back to the beginning of human civilization and spices were mostly instrumental in the exchange of ancient culture and civilization inside and outside to the country.

The history of Indian Spices is more than seven thousand years old. Even before the discovery of Rome and Greece, India used to export, spices, perfumes and textiles to Mesopotamia, Arabia and Egypt.

India is appropriately known as the "Home of Spices or Land of Spices" because most of the spice crops are being cultivated in our country since ages. Some spice crops such as cardamom, ginger and turmeric were cultivated in India as early as 8th century BC. Susruta, an ancient surgeon/physician of India (around 4th century BC) used white mustard and other aromatic plants in bed sheets to ward off malleable soul. He used sesame seed plasters to cure post operation wounds as sesame acts as antiseptic. Indians used spices and herbs namely cinnamon, black pepper, cardamom and turmeric since thousands of years for culinary and health purpose.

In ancient history all the herbs and spice crops are used as a medicine by Charaka (1st century) and Susruta II (2nd century). Many more other spices like cinnamon, cardamom, ginger, turmeric and pepper are also used by Susruta II as curative of wounds and other problems. In our country most of the families used spices like cloves and cardamom alone or wrapped in betel-nut leaves and chewed after meals for increase the flow of saliva and help to digestion. For different types of health benefits and home remedies many spices such as cardamom, ginger, black pepper, cumin, turmeric, fenugreek, fennel, coriander, dill, nigella, ajwain mustard seed etc., were included in ancient herbal medicines and are part of today's Ayurvedic medicines too. Cultivations of suitable spice and herb crops can play a vital role in enhancement of farmer's and growers' income.

Learning Outcomes

After completing this module, you will be able to:

- Discuss the scope and importance of spice crops in agriculture and culinary practices, including their economic significance, cultural value, and health benefits.

Classify spice crops based on their botanical origins, culinary uses, and commercial value, identifying major categories such as herbs, seeds, barks, and roots.

Module Structure

- Session 1: Scope and Importance of Spice Crops
- Session 2: Classification of Spice Crops

Definition of Spice crops:

The plant parts like seed, fruit, flower, leaf, bud, stem, bark or roots used to enhance the flavour and seasoning, containing medicinal properties are known as spices. The spices are usually aromatic and pungent in taste and are used as dietary additives example. Coriander, Cumin, Fenugreek, Fennel, Ajwain, Black Cumin, Sweet Flag, Aniseed, Celery, Black Pepper, Cardamom, Cinnamon, Clove, Nutmeg, Curry Leaf, Zinger, Turmeric, Garlic, Vanilla, Saffron, Asafoetida, Paprika, Tamarind, Kokum and Juniper etc.

Session 1: Scope and Importance of Spice Crops

1. scope of spice crops

Most of the Indian states grows different types of spices and herbs with the help of agronomic practices under varied soil, climate and several agro-ecological regions and some other factors. Spices are low volume and high value crops. In Indian economy spices play an exceptional role by improving the income of the growers, marginal farmers, stakeholders, rural and urban people. Total 109 spices crops are grown in the world and 63 spices are well grown in India. Cultivation of spices generate lot of employment opportunities for the rural population because of labour intensive nature of farming operations pertaining to spices. In the world market demand of quality Indian spice is actually abundant in other countries. Hence, to a great extent, people have scope to meet the demand of spices by massive production.

Spices and herbs are very important as food and medicines. Spices and herbs are used in every kitchen since morning tea to supper, in milk, curry, paratha,

pickle and other dishes. Indian food does not full fill the taste and aroma without spices and herbs; they also enhance the unique natural taste of cuisines. Spices and herbs are mostly used to make the food tempting, add aroma and in processed food they act as food preservative.

Spices provide sustainable availability of raw material to the industry which produces products of spice or blending of spice, perfume, curry powder, juice, herbal drinks etc., value addition of spice and herbs in the form of essential oils & herbal extracts. Spices are very remunerative and high-income generating crops. Quality life assurance through cultivation of spices & herbs and utilization of barren lands. Spices and herbs help in production of active compound, Hydrosols (Scented water) and they also helps in realizing foreign exchange by exporting various spices and their products.

Importance of Spice crops

Spices play an important role in health and export sector. Major spices and their importance are as:

Garlic (Lehsun): Botanically garlic is called *Allium sativum*, it is originated in Central Asia and belongs to the family Amaryllidaceae. An organo-sulphur compound of garlic is their major active compound also called *diallyl-thio-sulfonate* (Allicin). Universal use of garlic in different cuisine is for their compound of flavouring agent. Garlic used as a traditional medicine and also control cholesterol and blood pressure and boosts immunity.

Ginger (Adrakh): Botanically ginger is called *Zingiber officinale*, belongs to family Zingiberaceae, it is a spice cum medicinal plant that has been widely used in India and other countries in the world. active compound of ginger is terpenes and oleoresin (non-volatile pungent components) also called oil of ginger. Volatile oils content is approximately 1% to 3%. In old era ginger used for treatment of many disorders like arthritis, muscular aches, pains, hypertension and helps in enhancement of immunity.

Turmeric (Haldi): Botanically turmeric is called *Curcuma longa* L. belongs to the family Zingiberaceae, is one of the used in tooth powder or paste, turmeric is traditional medicine in India. active compound of turmeric is curcumin. It can cure asthma and coughs. In ayurvedic medicines extracts of dried turmeric is very useful, it is used directly to reduce irritation. In covid-19 situation turmeric powder was used in India and other countries to boost immunity.

Black Pepper (Kali Mirch): Botanically pepper is called *Piper nigrum*, pepper is an extensively used spice both in Eastern and Western food. The major active

compound of black pepper is piperine, it has an impressive antioxidant and antibacterial effect and cure the digestive system and weight loss of the body. Black-pepper is called as the king of spices because they earn foreign exchange and demand is high in international trade and market.

Cinnamon (Dalchini): Botanically cinnamon is called *Cinnamomum verum*, belong to the family Lauraceae which is cultivated in India, Egypt, China, Srilanka and Australia. It has very high medicinal value, used as antioxidant and have antimicrobial property and have anti-diarroheal nature. Dry leaves and bark of cinnamon are used widely as spice and essential oils of cinnamon contain aroma and good medical values.

Coriander (Dhania): Botanically coriander is called *Coriandrum sativum*, belongs to the family Apiaceae, coriander is traditionally used for treatment of kidney related issues, gas, diarrhea. The active compound present in coriander is linalool (65–79%).

Fenugreek (Methi): Botanically fenugreek is called *Trigonellafoenum graecum*, belongs to the family Fabaceae also called Leguminosae. In ayurvedic medicine fenugreek is commonly used for joint pain, digestive agent, diabetes patient and obesity. Many seasonal dishes are prepared using dry seeds or fresh leaves of fenugreek to treat different health issue like joint pain and arthritis.

Dill (Sowa): Botanically dill is called *Anethum graveolens*, In India the green dill leaves are used to make a number of local dishes. Carvone is a principle ingredient. The seeds of sowa are used in various traditional medicines against jaundice, headache, stomach problems, liver problems and many other ills. Dill seeds can also be used to prepare herbal tea. Dill water used in gripe water preparation, for minor gastric issues in infant babies.

Thyme: Botanically thyme is called *Thymus vulgaris* and also commonly called as "Ajwainke Phool", belongs to the family Lamiaceae. The essential oil of thyme is called thymolis about contains 20 - 54%. It is used in many commercially products such as mouth washes, digestive agent and others and it is effective against various fungal diseases.

Rosemary: Botanically rosemary is called *Rosmarinus officinalis* belongs to family Lamiaceae. rosmarinic acid and carnosic acid is active compound of rosemary. They are used to suppress allergic responses.

State wise area and production of spices crops

Area in '000' ha

Production in '000' MT

S.No.	Name of major spice	State	Area (ha)	Production (MT)
1.	Coriander	Madhya Pradesh	296.28	401.35
		Rajasthan	102.13	129.01
		Gujarat	141.00	212.51
		Assam	60.70	35.76
		West Bengal	11.91	15.21
		Orissa	19.61	10.85
		Uttar Pradesh	6.77	4.43
		Andhra Pradesh	0.75	0.71
	Total including others		**661.77**	**831.92**
2.	Cumin	Gujarat	469.03	429.19
		Rajasthan	770.00	425.00
	Total including others		**1241.06**	**856.20**
3.	Fenugreek	Rajasthan	55.00	70.00
		Madhya Pradesh	51.75	98.99
		Gujarat	7.00	13.58
		Haryana	3.19	8.45
		Uttaranchal	0.70	3.90

		West Bengal	2.62	2.76
	Total including others		**121.33**	**202.63**
4.	Fennel	Gujarat	42.04	87.44
		Rajasthan	31.62	34.28
		Madhya Pradesh	1.32	2.38
		West Bengal	2.94	1.09
		Uttar Pradesh	0.72	0.79
	Total including others		**78.98**	**127.16**
5.	Celery	Punjab	4.57	6.51
	Total including others		**4.57**	**6.51**
6.	Dill	Rajasthan	8.18	12.80
		Gujarat	12.83	16.83
		West Bengal	0.95	1.23
	Total including others		**21.96**	**30.86**
7.	Ajwain	Rajasthan	12.68	8.18
		Telangana	1.32	1.03
		Gujarat	5.00	4.73
		Madhya Pradesh	6.64	6.98
		Andhra Pradesh	3.36	0.92

	Total including others		**29.00**	**21.84**
8.	Black pepper	Karnataka	160.77	78.58
		Kerala	83.79	34.52
		Tamil Nadu	6.58	1.44
	Total including others		**260.23**	**120.46**
9.	Cardamom	Sikkim	22.13	5.65
		West Bengal	2.99	0.84
		Kerala	39.14	20.57
		Karnataka	2.00	0.40
		Tamil Nadu	4.03	0.37
	Total including others		**88.64**	**33.81**
10.	Clove	Tamil Nadu	1.04	1.01
		Karnataka	0.10	0.09
		Kerala	1.00	0.07
	Total including others		**2.15**	**1.19**
11.	Ginger	Madhya Pradesh	28.53	161.62
		Karnataka	20.54	249.91
		Assam	19.45	185.95
		West Bengal	12.52	136.74

		Orissa	16.57	128.00
		Gujarat	4.80	105.21
		Kerala	2.75	55.01
		Sikkim	15.22	81.50
		Meghalaya	9.94	66.18
		Mizoram	8.55	60.13
		Arunachal Pradesh	3.28	13.38
		Uttaranchal	5.09	50.68
		Telangana	1.97	13.55
		Andhra Pradesh	0.46	3.87
	Total including others		**176.35**	**1886.53**
12.	Turmeric	Telangana	41.00	264.00
		Karnataka	21.50	130.93
		Tamil Nadu	20.89	86.51
		Andhra Pradesh	30.52	73.24
		West Bengal	17.75	45.70
		Orissa	27.87	43.61
		Maharashtra	59.61	230.86
		Mizoram	7.74	29.82
		Assam	17.76	24.67

		Gujarat	4.00	15.72
		Haryana	1.33	3.01
	Total including others		**291.28**	**1064.44**
13.	Nutmeg	Kerala	22.51	14.34
		Karnataka	0.42	0.54
	Total including others		**23.35**	**14.92**
14.	Garlic	Madhya Pradesh	190.04	1956.75
		Rajasthan	90.93	544.70
		Uttar Pradesh	34.75	216.71
		Gujarat	16.23	125.29
		Punjab	8.87	96.77
		Assam	10.77	68.92
		Orissa	12.06	42.99
		Haryana	3.20	31.70
		West Bengal	3.93	37.51
		Maharashtra	3.75	22.27
	Total including others		**390.64**	**3184.81**

Source- 3rd Advance Estimate (Horticultural statistic at aglance-2020-21)

Crop-wise Area and Production of Spice Crops 2020-21

Area in '000 Ha
Production in '000 MT

S. No.	Crop	Area	Production
1.	Ajwain	29	22
2.	Cardamom	84	34
3.	Chillies (Dried)	729	2092
4.	Cinnamon/Tejpatta	2	5
5.	Celery, Dill& Poppy	31	31
6.	Clove	2	1
7.	Coriander	662	832
8.	Cumin	1241	856
9.	Fenugreek	121	203
10.	Fennel	79	127
11.	Garlic	391	3185
12.	Ginger	176	1887
13.	Nutmeg	23	15
14.	Black Pepper	260	120
15.	Vanilla	0	0
16.	Tamarind	44	159
17.	Turmeric	291	1064
18.	Mint (Mentha)	359	47
	Total Spices	**4524**	**10679**

Provisional: 3rdAdvance Estimate (Horticultural Statistics at a Glance 2020-21)

Production share of leading spices producing states for 2020-21

S. No.	STATES/UTs	Production (in '000 MT)	% Share
1.	Madhya Pradesh	3308.78	30.98
2.	Rajasthan	1228.86	11.50
3.	Andhra Pradesh	885.55	8.29
4.	Gujarat	1033.18	9.67
5.	Telangana	845.31	7.92
6.	Karnataka	707.75	6.63
7.	Maharashtra	424.13	3.97
8.	West Bengal	253.87	2.38
9.	Assam	337.86	3.16
10.	Uttar Pradesh	278.69	2.61
11.	Others	1375.3	12.88
	All India Total	**10679.22**	**100**

Provisional: 3rdAdvance Estimate (Horticultural Statistics at a Glance 2020-21)

2. Economic importance of spice crops

1. India is fortunate enough to cultivate the maximum number of spices in the world.
2. Traditionally India has been one of the biggest producer, consumer and exporter of spices throughout the world. In the world India is the single largest producer and exporter of wide range of spices.
3. The Average production of spices in India is around 10.67 million MT and average covered area for cultivation of spices is approximate 4.52 million hectares. (Horticultural Statistics at a Glance 2020-21).

4. Spices Trade in India during 2020-21, despite the continuance of COVID-19 pandemic and consequent recession in global economy; spices export from India continued its upward trend and crossed the milestone of US $ 3.6 billion mark for the first time in the history of spice export. The export has been 15, 65000 tonne valued Rs. 27,193.20 crores (US $ 3624.76 million) against 12.08.400 tonnes valued Rs. 22.062.80 crores (US $ 3110.20 million) achieved during the previous financial year. (Spices Board, Ministry of Commerce & Industry, Annual Report 2020-21).
5. In marketing situation of asafoetida major producing countries are Afghanistan, Iran and Turkistan. Well established asafoetida processing industries, exudate- gum of asafoetida are imported to India, from other country like Iran and Afghanistan but a part of the imported gum is re-exported after some value addition to other country.
6. Spices plays very important role in our daily food preparations for flavouring and seasoning of food. In the daily intake of food and culinary preparations, the Indian food habits amalgamate divergent spices and exploit and utilize photochemical to add aroma.
7. Most of the spices have medicinal values. In the national and international levels many pharmaceutical industries, flavouring or colouring agent, types of preservatives in home for preparation of Pickles and Chutney, spices and products of spices are directly and indirectly used.
8. Spices have been used in cosmetic and perfumery industries. Spice oils are used in the manufacture of soaps, tooth pastes, talcum powder, after shave lotions, vanishing creams, mouth fresheners, room fresheners etc.
9. Indian spices and spice products were exported to 180 destinations globally in 2020-21. The leading destinations among them were China, the USA, Bangladesh, Thailand, the UAE, Sri Lanka, Malaysia, the UK, Indonesia, and Germany. These nine destinations contributed more than 70 per cent of the total export earnings during 2020-21. (Spices Board, Ministry of Commerce & Industry, Annual Report 2020-21).
10. In India the highest production thrust area of spice is Madhya Pradesh with an estimated production volume of over three million metric tonnes. (Horticultural Statistics at a Glance 2020-21).

Activities

Activity 1:

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

Procedure:

- Visit to nearby spice growing farm/field
- Collect available specimen of various spice crops or seed
- Identify and prepare a list of collected samples of spices or seed
- Prepare herbarium file

Activity 2: Identification of spice in medicines

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

Procedure:

- Collect bottle/packing material od medicines available at home
- Note down the names of spices mentioned on the medicines
- Prepare the list of medicinally important spices

Activity 3: Prepare a bar diagram depicting area and production of spices

Material required: Pen, pencil, practical notebook, graph paper file, etc.

Procedure:

- Collect the information about area and production of different spice producing states.
- Arrange data in table
- Draw a bar diagram and shown area and production of spices producing states

Check Your Progress

Fill in the blanks

1. India is called land of _____.
2. An ancient history all the spice crops and herbs are used as a medicinally by _____ and _____
3. Out of 109 spices crops India easily grown _____ spices.

4. _____is largest producer, consumer and exporter of spice crops in the world.

5. Spices have been used in _____, _____and _____industries.

6. For the preparation of Pickles and Chutney spices have used as _____

7. Allicin is active compound of _____

Multiple Choice Questions

1. Turmeric belongs to family

   (a) Apiaceae (c) Fabaceae

   (b) Zingiberaceae (d) Alliaceae

2. Highest Seed spices growing state in India

   (a) Uttar Pradesh (c) Madhya Pradesh

   (b) Maharashtra (d) Rajasthan

Subjective Questions

1. Describe importance and scope of spice crop

_____
_____
_____
_____

2. Describe present status of spice crops in India

_____
_____
_____
_____

3. What are medicinal uses of turmeric and ginger?

_____
_____
_____
_____

Match the Column

A	B
1- Black pepper	a- Dalchini
2- Rosemary	b- Piper nigrum
3- Lauraceae	c- Lamiaceae
4-Anethum graveolens	d- Curcumin
5- Turmeric	e- Dill

Session 2: Classification of Spice Crops

In India spices crops can be classified by different groups based on their functions and uses, plant part use, life cycle, growth behaviour, their utility, their importance etc. But all the group of classification is not completed and they overlapped each other.

Classification of spices

1. **Based on completion of life cycle**

a) **Annual:** These plants have one-year of life cycle. These are plants that germinate, flowering, set fruit(seed) and die in one season or year, e.g., Cumin, Coriander, Fennel, Fenugreek etc.

b) **Biennial:** These plants have a seed-to-seed life cycle of two –year. During the first year, only vegetative growth of the plant and the second year they produce flower, fruits /seeds and die. e.g., Onion

c) **Perennial:** A plant that lives more than two years. e.g., Cardamom, Cinnamon, Clove, Saffron and curry leaf etc.

2. **Based on growth behavior**

a) **Herbaceous spices:** A vascular plant that have no persistent woody stems above ground. **e.g.,** Cumin, Coriander, Fenugreek, Turmeric, Ginger, Onion, Garlic.

b) **Shrubaceous spices:** Black pepper, Cardamom.

c) **Tree spices:** Cinnamon, Clove, Nutmeg, Tejpatta.

3. **Based on plant part used**

a) **Seed spices:** Ajwain, Cumin, Coriander, Dill, fenugreek, Fennel.

b) **Fruit spices:** Cumin, Coriander, Fennel, Black pepper, Dill, Chilli.

c) **Flower spices:** Saffron.

d) **Bud spices:** Clove

e) **Bark spices:** Cinnamon,

f) **Leafy spices:** Mentha, Cinnamon leaf, Coriander, Fenugreek.

g) **Underground spices:** Turmeric, Ginger, Onion, Garlic.

4. Based on utility

a) **Taste imparting spices:** Cardamom, Ginger, Coriander, Cumin, Garlic, Onion, Tamarind, Black pepper, Chilli.

b) **Flavour imparting spices:** Clove, Cardamom, Coriander leaf, Curry leaf, Cinnamon, Asafoetida and Garlic.

5. Based on importance

a) **Primary spices:** Chilli, Cardamom, Ginger, Turmeric.

b) **Secondary spices:** Cumin, Fennel, Coriander, Fenugreek, Clove, Nutmeg, Mace, Cinnamon.

Figure 1.1: Coriander Seed

Figure 1.2: Garlic Bulb

Figure 1.3: Garlic plant

Figure 1.4: Ginger crop

Figure 1.5: Turmeric mother Rhizome

Figure 1.6: Nigella Crop

Figure **1.7:** Coriander crop

Figure **1.8:** Sowa flower umbel crop

Figure**1.9:** Cumin Crop

Figure 1.10: Fennel Crop

Figure 1.11: Fennel Crop

Figure 1.12: Nutmeg plant and fruit

Figure 1.13: Fruit of Nutmeg

Figure 1.14: Flower of Nigella

Figure 1.15: Sowa Crop

Figure 1.16: Black pepper

Activities

Identification of Spices based on different types

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

Procedure:

- Visit to nearby spice growing farm/field
- Collect available specimen of various spice crops
- Identify spices and note down the uses of spices.

Check Your Progress

Fill in the blanks

1. Black pepper is called as_____.
2. Cardamom, Ginger, Coriander, Garlic, Onion, Tamarind, Chilli are ..... Spices.
3. Annual plants have _____of life cycle.

4. _____is a plant that lives more than two years.

5. _____ of cinnamon plant is used as spices.

Multiple Choice Questions

1. Coriander comes under the types of spices

   (a) Tree (c) Seed

   (b) Biannual (d) All of the above

2. Bud spices plant is

   (a) Tejpatta (c) Cinnamon

   (b) Clove (d) None of these

Subjective Questions

1. Classify spice crops based on completion of life cycle.

_____

_____

_____

2. Classify of spice crops based on plant part used.

_____

_____

_____

3. Classify of spice crops based on utility and importance.

_____

_____

_____

Match the Column

A	B
1- Underground spices	a- Tejpatta
2- Tree spices	b- Dill
3- Seed spices	c- Saffron
4- Perennial	d- Cardamom
5- Shrubaceous spices	e- Mentha
6-Leafy spices	f- Turmeric

Module 2
Soil and Climatic Requirement of Spice Crops

Module Overview

Soil provides essential nutrients to the plants for growth and production. It provides support to growing plants by holding their roots and holds moisture and water for long time. It serves as habitat of many micro and macro-organism. Provides heat, air and water to growing organisms within or over it. Soil is the most important natural resource of any country. Soil combines organic matter and rock particles which are responsible for plant life and growth. Soils consist of four major components viz. (i) mineral matter, (ii) organic matter (iii) water and (iv) air. All these components cannot be separated because they are mixed intimately with each other. Mineral matter forms bulk of soil solids and very small amount of soil solid occupied by organic matter.

Soils comprises of dead plant twigs, stone, roots, leaves and other part of plant, fine sand, clay, silt and humus. Plant roots, bacteria. Earthworm, algae, fungi, nematodes, actinomycetes and many other organisms are the living part of organic matter.

Learning Outcomes

After completing this module, you will be able to:

- Explain the soil requirements for optimal growth of crops, including factors such as soil type, pH levels, nutrient availability, and drainage characteristics.
- Identify the climatic requirements for successful crop cultivation, including temperature, rainfall, humidity, and sunlight exposure considerations.
- Describe the process of collecting soil samples, including sampling techniques, depth considerations, and methods for preserving sample integrity during collection and transportation.

Module Structure

- Session 1: Soil Requirement
- Session 2: Climatic Requirement
- Session 3: Collection of Soil Sample

Session 1: Soil Requirement

Soil may be defined as a natural body developed as a result of weathering of rocks in which plants and other forms of life can grow very well. "The upper loose layer of the earth crust" very rich in minerals and nutrient on which plant can grow is termed as soil.

Types of soil in India

On the basis of colour and characteristics, different types of soil available in India are as below.

1. **Black soil –** These soils are also known as black cotton soil and are poor in nitrogen, phosphate and organic matter but rich in iron, lime, calcium, potash, magnesium, and aluminium. The black soil has high water retaining capacity. These soils are most suitable for rain fed agriculture and predominantly found in Deccan Plateau– Maharashtra, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Valleys of Krishna and Godavari rivers.
2. **Red soils -** These are porous, friable and neutral to acidic in reaction. These soils have wide variation in texture ranging from coarse sandy to loamy. The red colour of the soil is due to presence of ferric oxide. Upper most layer of the soil is red and the horizon below is yellowish. Red soils are generally deficient in phosphate, magnesium, lime, humus and nitrogen. Red soils are mainly found in Tamil Nadu, parts of Karnataka, south-east of Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Odisha, Chota Nagpur plateau, parts of south Bihar, West Bengal, Uttar Pradesh; Aravallis and the eastern half of Rajasthan (Mewar or Marwar Plateau).
3. **Lateritic soil** - These soils have vesicular structure and usually reddish or yellowish in colour. Soils have acidic character with pH of 5.0 to 6.0. These soils are porous and have low water holding capacity. Lateritic soils are poor in N, P, K, Mg and lime. These soils become hard or capable of hardening when exposed to drying after wetting and turn hard brick like material which can be used as brick for construction of houses. These soils are mainly found in Kerala, Karnataka, Orissa hills and Assam.
4. **soil -** These soils are very productive and formed due to deposition of silt carried out by the rivers in course of their massive flow during rainy season. Occurs mainly in the Sutlej- Ganga- Brahmaputra Plains and valleys of other rivers. Mostly the alluvial soils are neutral to alkaline in reaction but may be acidic in reaction in high rainfall area like Assam.

5. **Arid and Desert soil -** Arid Desert soils are sandy soils found in low rainfall areas. These soils are very deficit in organic matter content. These soils with high pH value (Alkaline) are unproductive. Western Rajasthan, north Gujarat and southern Punjab share area under desert soil in India.
6. **Forest and hilly soils**: These soils are found on higher and lower elevation on the hills. These soils are very infertile for production of crops and stony and acidic in nature. Humus content of such soils is very high but deficient in potash, phosphorus and lime.
7. **Peat and marshy soils-** These soils are highly acidic and black in colour and are deficient in potash and phosphate. These soils are mainly found in humid regions of Kerala, Odisha, Tamil Nadu, West Bengal, Bihar and Uttarakhand states. Coconut trees are found in plenty in these soils in coastal areas.

Table 2.1: Suitable soils for different spice crops cultivation

S.No.	Name of crop	Soil types	The portion in field preparation
1.	**Fenugreek**	Clayey loam soil is relatively better.	One deep ploughing followed by two cross harrowing and planking is sufficient to make a good tilth.
2.	**Cumin**	Well-drained, loamy and rich in organic matter is preferred.	Three-year crop rotation should be followed for sowing of cumin. Deep ploughing followed by 2-3 light ploughing is necessary for development of fine tilth.

3.	**Ajwain**	Loamy to sandy loam soils with good drainage are suitable for growing of Ajwain.	Good germination and establishment of ajwain require preparation of fine soil tilth with planking to conserve soil moisture.
4.	**Coriander**	Coriander grows well in well drained loamy soils.	Soil should be free from stubbles and clods.
5.	**Dill (Sowa)**	Well drained loam to sandy loam soils, rich in organic matter are most suitable.	2-3 times ploughing is necessary for bringing soil in fine tilth.
6.	**Celery**	It requires well drained sandy and silt loam soils for better production.	Well levelled beds of convenient size with fine tilth are most favourable for growth and development.
7.	**Nigella**	Black cumin thrives in sandy, loamy or medium to heavy clay soil, soil pH of 5 – 8 with adequate drainage.	The soil should be prepared to fine tilth.
8.	**Caraway**	Well drained medium to heavy loam having better water holding capacity is mostly best suited.	Soil to be prepared to fine tilth.
9.	**Fennel**	Well drained, nutrient rich loamy as well as heavy soils	Well levelled fine tilth soil is needed.
10.	**Anise**	Well drained, moderate to heavy loam soils is best suited.	Soil surface with fine tilth and well levelled is divided into convenient sized beds.

11.	**Ginger**	Well drained heavy lateritic loam, clay loam, red loam soils are ideal for its cultivation.	In order to improve porosity and soil aeration, 4-5 times ploughing is required. Remove the Weeds, stubbles, roots etc.
12.	**Turmeric**	Sandy or clayey loam soils having good drainage and rich in humus are very suitable for turmeric.	Planting is done by making ridge and furrows/which facilitates proper drainage.
13.	**Nutmeg**	Red laterite, clay loam and sandy loam soils are very congenial for cultivation of nutmeg cultivation.	At the time of field preparation farm yard manure and organic matter incorporated to enrich the soil fertility.
14.	**Cardamom**	Humus rich loamy soils of Western Ghats are best suited for cultivation.	Contour terraces with inward slope should be prepared in the sloppy area and pit should be taken along the contour.
15.	**Black pepper**	Clay loam to sandy loam soil and lateritic soils rich in organic matters are suitable for cultivation of black pepper.	In order to avoid scorching effect planting of black pepper should be done on lower half of north and north eastern slope.
16.	**Clove**	Rich loamy soils of humid tropics are most suitable.	For partial filling of pits top soil should be used.

Importance of soil testing

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

- Soil sampling
- Soil testing
- Soil test interpretation

Purposes of soil testing

- Helps to evaluate and improve soil productivity.
- It helps to determine the nature of the soil, *i.e.,* alkaline, saline or acidic.
- It helps to know the status of macro and micro nutrients presents in the soil.
- Actual condition of the soil is revealed by soil testing, thereby it can be improved with the application of nutrients and other management practices.
- The use of fertilizer and manure can be ascertained and their doses may be standardised accordingly for improvement of the fertility of the soil.
- Soil can be classified into different groups for preparing soil fertility maps

Soil sampling

Soil sampling is the most important activity to know about soil of a particular field or area through soil analysis. As we all know that soils vary from place to place, therefore efforts should be made to take the soil samples in such a way that it is fully representative of the field**.** For collecting representative soil sample due consideration must be given to the following tips

1. The sample must truly represent the field it belongs.

2. If field is appreciably uniform then it must be treated as single sampling unit.

3. The plots which have been recently fertilized, bunds, channel, marshy tracts and area near to trees must be avoided during sampling.

4. Variation in slope, colour, texture, crop growth and management practices are the important factors that should be taken into account for sampling

5. An area of about 2-3 meter along all the sides of the field should be left in large field.

Materials required for soil sampling

1. Spade
2. Khurpi
3. Auger (screw or tube or post hole type)
4. Scale
5. Sieve
6. Label
7. Aluminium box
8. Core sampler
9. Sampling bags (Plastic/Cloth)
10. Plastic tray or bucket

Figure 2.1: Aluminium box

Figure 2.2: Aluminium box

Figure 2.3: Core

Figure 2.4: Core

Figure 2.5: Sampler with core

Figure 2.6: Plastic tray

How to select sampling unit

1- Before the actual sampling of a field, a visual survey of the field should be done by the person who is responsible for sampling in the presence of farm owner. Because farm owner knows better about their fields. Note down the information regarding variation in slope, management practices, cropping systems and pattern, soil colour and its texture.

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

3- If whole field appears as uniform in all aspect, then it can be considered as single sampling unit. But it should not be larger than 1 to 2 hectares.

4- Now demarcate the field on the basis of map and each uniform portion should be sampled separately. These sampling units are identified alphabetically *i.e.,* A, B, C or Number in the map.

Soil sampling procedure

Collect small portion of soil from the desired depth of the field (0-15 cm or more) by means of suitable sampling tools. Sample should be drawn in between the rows in case of standing crop. Mix together the samples collected from all the spots within one field.

1) **Field area to sample:** The ideal area for sampling is 0.5 hectare (5000 square meter) is one soil sample.

2) **Time of sampling:** The best time to collect the soil sample is just before a crop is grown to measure level of nutrients availability in the soil and any deficiency found to cure them. Important things that do not collect the sample from any recently fertilized field, bunds, water channels, muddy areas, near or under trees shade, water wells, compost masses and border areas etc. Fix the sampling spot in a zigzag pattern in a sampling unit. Each sampling unit is traverse separately.

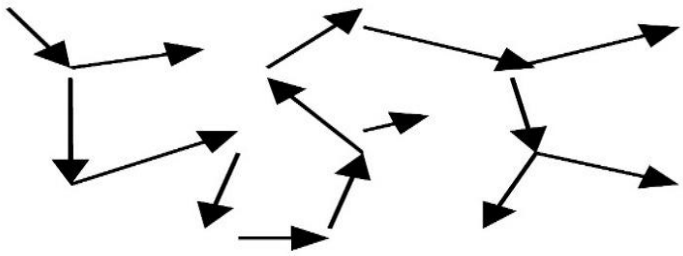

Fig. 2.7: Sampling unit with Zig-Zag sampling spot

3) **Sampling tools:**

- Tube auger, post hole or screw type auger or even a spade/Khurpi are for Soil sampling.

- In order to mix the soil and for sub sampling, clean bucket/ tray is needed
- For marking pencil is needed and for tying the cloth bags, tags are required.
- Information sheet of soil sample

4) **Sampling depth:** The depth of the soil of sampling area depends upon those crops which are to grow, for example 0-15 cm if shallow rooted crops are grown but if deep rooted and long duration crops are grown then depth of soil sampling depends accordingly.

5) **Amount of sample:** Minimum five and maximum eight soil samples should be collected. The soil sample should be mixed thoroughly before sending for analysis in the laboratory. The weight of each sample should be 500 g.

6) **Sampling process:** Before collecting the sample draw a proper map of the area to be covered in a survey showing different sampling unit boundaries. A plan of manner of composite soil sampling and number of soil sample should be entered on the map. Different field should be designated by letters A, B, C etc.

Soil sample from 10-20 spots must be taken depending on the size of the field for preparing composite soil sample.

"V" shaped cut should be made with khurpi to a depth of 15 cm at a sampling site. A 2.0-2.5 cm thick slice of the soil is removed from the slant area as shown in the following **figure**. Sampling with auger is done in zigzag manner from required soil depths.

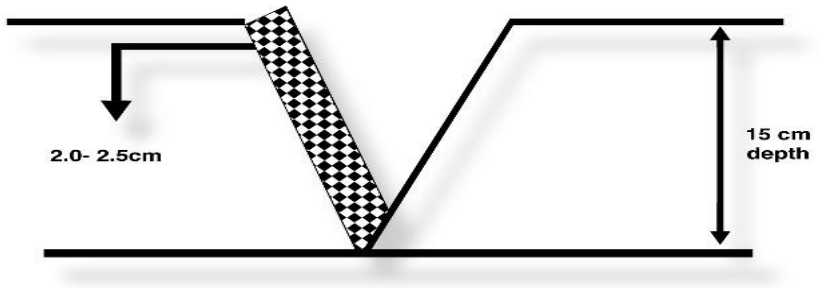

Fig. 2.8: "V" Shape cut for Soil sampling

7) **Process for mixing and preparation of sample (Quarter method).**

i. Collect sample by V method or auger method.

ii. Mix the collected samples thoroughly.

iii. Divide it in four equal parts.

iv. Remove two diagonal samples (as shown in figure 2.9)

v. Take remaining two diagonal soil samples.

vi. Mix them properly (samples from step v)

vii. Repeat the step number iv to vi till the final representative sample remains 500 gm in weight.

viii. Store final sample for further analysis.

8) **Drying samples**: In order to facilitate drying, large soil clods should be crushed. Generally, for drying the sample on the air they take approximate one-week time. During air-drying, avoid any contamination.

Information Sheet of soil sample:

i. Sample number
ii. Name and address of the farmers
iii. Details of field such as Khasra number and local name etc.
iv. Sampling date
v. Name of crop and variety to be sown
vi. Source of irrigation
vii. whether the crop in subsequent season irrigated and unirrigated
viii. Name and type of crop and fertilizer used in previous year
ix. Date of harvest of the previous crop
x. Any other information/comment:

Figure 2.9: Quarter method of soil sample preparation

Processing and storage of sample

1. Assign the sample number and make its entry in soil sample register.
2. After collection of soil sample, they must be preserved in sealed polythene bag for estimation of soil moisture content.
3. Spread the collected soil samples on a clean sheet of paper, break large clods/ lumps with the help of mallet and dry the crushed soil sample under shade.
4. Do not dry at high temperature. Generally, air drying is done under shade. It takes approximately one-week time. During air-drying, avoid any contamination.

Figure 2.10: Mallet

5. The powdered dry soil is passed through 2 mm sieve size.
6. The soil which passes through 2.0 mm sieve should be collected and stored in a clean glass or polythene bag or plastic container with proper labelling for further analysis in the laboratory.
7. Soil samples should not be stored along with fertilizer materials and detergents to avoid contamination.
8. Before putting soil samples in bags, they should be examined for cleanliness as well as for strength.
9. Information sheet of soil sample should be clearly written with permanent ink.

Points to be considered for sampling

1. Collect the soil sample during fallow period: It is the period between harvesting of one crop and sowing of successive crop in the same field
2. In case of standing crop, soil samples should be collected from inter row space (Space between rows).

3. To ensure homogeneity, sampling should be done at several locations in *zig-zag* pattern.
4. From one hectare area samples should be drawn from 10 to 15 spots in zig -zag pattern and make a composite sample.
5. Samples should be collected separately from fields that do not look alike in colour, slope, drainage, management practices like liming, gypsum application, fertilization, cropping system *etc*.
6. Soil sampling depth depends on crops to be grown, for shallow rooted crops; sampling depth should be up to 15 cm. However, for deep rooted crops it should be upto 30 cm deep.
7. The surface litter including crop /weed residues should be removed before obtaining uniform thick slice of soil from surface to plough depth from each sampling spot.
8. Instead of rusted iron khurpi, stainless steel augers should be used
9. The bags or boxes which has been previously used for storing fertilizer, salt or other chemicals should not be used.

Interpretation of data

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

The collected sample is analysed for physical and chemical properties by using standardized method in a laboratory for the following parameters.

- Size of soil particles or texture of soil
- Colour of soil
- pH (indicates whether the soil is acidic, alkaline or neutral in nature)
- Presence of total soluble salts (determined by EC, which indicates whether the soil poses any constraint to seed germination and subsequent crop growth)
- Requirements/recommendations of Lime and gypsum, if needed
- Available nitrogen content in soil
- Available phosphorus content in soil

- Available potassium content in soil

Data can be interpreted with the help of ratings as given in the following tables.

Soil physical properties:

Table 2.2: Soil texture classes:

Name of soil separate	**Size of particle (Diameter in mm)**	**Interpretation**
Boulders	> 256 mm	Stones and gravels may affect the utility and management of land by creating tillage difficulties. The water holding capacity as well as capacity of storing plant nutrient is not influence by larger size of soil particle.
Cobbles	64 – 256 mm	
Pebbles	4 – 64 mm	
Gravels	2 – 4 mm	
	Particles less than 2 mm is called fine earth, normally considered in chemical and mechanical analysis	
Coarse sand	0.2 – 2.0 mm	These particles are represented by spherical in shape due to uniform dimension, usually contains quartz with fragments of feldspar, mica and heavy minerals such as Tourmaline, hornblende and zircon.
Fine sand	0.02 – 0.2 mm	
Silt	0.02–0.02 mm	• Particle size of silt is in between sand and clay silt particle has more surface area due to its small size. • It contributes physico- chemical properties as that of clay to a limited extent because sand and silt give a skeleton to soil.
Clay	< 0.002 mm	Clay particles represented by Plate like or needle like shape. It is also called as flesh of the soil.

S. No.	Soil Colour	Interpretation
1.	Black to dark brown	Soils with high content of organic matter.
2.	Red, brown and yellow tinge colour	Soil with high content of iron compounds
3.	White or light coloured	Large quantity of silica, lime and other salts
4.	Brown	Presence of mixture of organic matter and iron oxides
5.	Mottled colour	Presence of iron and manganese compounds. Such colour developed due to alternate wetting and drying condition
6.	Bluish and greenish colour	Due to reduction of ferrous compound in water logged condition.

Table 2.3: Soil pH

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

Table 2.4: Rating of soil on the basis of EC (1:2) soil and water ratio

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

Table 2.5: Rating on the basis of nutrient availability (1:2)

S. No.	**Nutrient**	**Low**	**Medium**	**High**
1.	Organic carbon	<0.5%	0.5-0.75%	>0.75%
2.	Available nitrogen (N)	<280 kg/ha	280-560 kg/ha	>560 kg/ha
3.	Available phosphorus (P)	<10 kg/ha	10-25 kg/ha	>25 kg/ha
4.	Available potassium (K)	<110 kg/ha	110-280 kg/ha	>280 kg/ha

Activities

Activity 1: Identification of the soils

Material required: Pen, pencil, practical notebook etc.

Procedure:

- Visit to nearby spice growing field
- Collect available specimen of various soil
- Identify the collected soil samples.

Activity 2: Collect of soil samples for Soil testing

Material required: Pen, pencil, practical notebook, Soil, Cellophane bags, mallet etc.

Procedure:

- Collect small portion of soil from the desired depth of the field (0-15 cm or more) by means of suitable sampling tools.
- Sample should be drawn in between the rows in case of standing crop.
- Sample should be done in zig zag manner which represent the whole field.
- Mix together the samples collected from all the spots within one field.

Check Your Progress

Fill in the blanks

1. The upper loose layer of the earth crust" very rich in minerals and nutrient on which plant can grow is called as _____.
2. Soil provides essential nutrients to the _____for growth and production.
3. These soils are porous, friable and neutral to acidic in reaction is called _____.
4. The size of pits 45 × 45 × 30 cm is dug in April to May and filled with a mixture of topsoil and well rotten Farm Yard Manure or any compost for _____ crop.
5. For soil sample _____shaped cut should be made with Khurpi to a depth of 15 cm at a sampling.
6. The powdered dry soil is passed through _____sieve size.
7. Soils with high content of organic matter _____in colour.
8. Soil with high content of iron compounds_____ brown and yellow tinge colour.
9. Presence of mixture of organic matter and iron oxides they show _____colour.

Multiple Choice Questions

1. Soils consists of major components are

   (a) Mineral and organic matter (c) Water

   (b) Air (d) All of the above

2. The soil is poor in nitrogen, phosphate and organic matter is

   (a) Red Soil (c) Black cotton Soil

   (b) Lateritic soil (d) All of the above

3. The soils with high pH value (Alkaline) are unproductive is called as

   (a) Alluvial soil (c) Black Soil

   (b) Lateritic soil (d) Desert soil

4. The pH of alkaline soil is

   (a) 5.4-5.2 (c) > 9.0

   (b) 7.0 (d) None of these

Subjective Questions

1. Describe types of soil in India?

   _____

   _____

   _____

2. Describe the purposes of soil testing.

   _____

   _____

   _____

3. Write down the soil sampling procedure.

   _____

   _____

   _____

4. Explain the physical properties of soil.

   _____

   _____

   _____

Match the Column

A	B
1- Boulders	a- 4 – 64 mm
2- Cobbles	b- > 256 mm
3- Pebbles	c- 2 – 4 mm
4- Gravels	d- 0.2 – 2.0 mm

5- Coarse sand	e- 0.02 – 0.2 mm
6- Fine sand	f- 0.02– 0.02 mm
7- Silt	g- 64 – 256 mm
8- Clay	h. < 0.002 mm

Session 2: Climatic Requirement

Climate: Crop growth and development are primarily governed by environmental conditions *i.e.,* climate. The success or failure of spices primarily depend upon the weather conditions prevailing during the growth period of spices. Weather is a state or condition of atmosphere at given place at a given time. It is a daily variation or condition of lower layer of atmosphere.

Climate is defined as the average of commonly prevailing weather conditions like temperature, wind speed, humidity, rainfall/ precipitation, sun shine hours, atmospheric pressure, cloudiness meteorological parameters etc. of a region for a long time.

There are four major climatic zones:

1. **Temperate climate:**

   Spice of this type can withstand low temperature and frosty weather but are damaged easily in hot weather. This climate is characterized by the fall of temperature below freezing point in winter. During summer the temperature varies between 10^0C to 14^0C and relative humidity between 80% to 100%. This type of climate is observed at 1800 m to 3500 m height from mean sea level.

2. **Tropical climate:**

   Spices of this category need high temperature and abundant humidity. They are easily damaged by low temperature. This type of climate receives high rainfall and has high humidity. The temperature ranges from 22^0C to 27^0C. It is experienced at 300m to 900 m height from mean sea level.

3. **Sub- tropical climate:**

   In sub-tropical climatic zone three distinct seasons like winter, summer and monsoon prevail. Low temperature occurs in winter and high temperature during summer. During vegetative or early growth state, most of the spices require comparatively low temperatures. During their reproductive stage, they require higher temperature. The temperature

ranges from 25^{0}C to 30^{0}C and humidity to almost 100% during monsoon. It is found at 900 m to 1800 m height from mean sea level.

4. Arid zone:

A region is arid when it is characterized by excess of evaporation over precipitation leading to extreme shortage of available water to the extent of restriction in growth and development of living entities in the region. In addition, high wind velocity (35-40 km/h), less humidity and distinct temperatures lead to aridity. Thus, areas experiencing extremes of temperature (-2 to 48^{0}C) and rainfall less than 400 mm are under this zone,

Table 2.6: Climatic requirement of spices

S. No.	Name of Spice crop	Climate and Temperature
1.	Fenugreek	In southern parts it is grown as *kharif* crop and in northern conditions as rabi season crop. It can withstand frost and freezing weather and does well in places that receive moderate or low rainfall but it does not thrive in areas with heavy rainfall.
2.	Cumin	It requires sub-tropical climate having temperature of 25 – 30 °C. It is a rabi season crop. Cumin is susceptible to frost. It does not favor heavy rainfall. Hence sunny days are preferred for growth of cumin.
3.	Ajwain	It requires 15-27 °C temperature and 65% relative humidity during growth period. A moderately cool and dry climate is very congenial for proper growth and development of ajwain.
4.	Coriander	Coriander requires a frost-free, cool and comparatively dry climate.
5.	Dill (Sowa)	Dry and cool climate having temperature around 10 – 27 °C is best. It is grown in spring, summer and up to fall in warm temperate zones.

6.	Celery	It is temperate crop and requires cool climate. Optimum temperature of 15-21 °C and moderate well distributed rain fall is ideal.
7.	Nigella	It is a frost-free winter season crop of northern plains, central and peninsular region.
8.	Caraway	Dry temperate climate with more sunshine hours and temperature range of 16 to 20 °C at flowering to seed setting for biennial crop and cool short-day conditions for annual crop.
9.	Fennel	Cool season crop requiring 15-20°C temperature for growth and development and 20-29°C for germination.
10.	Anise	Warm conditions with a temperature of 20-28 °C at sowing, 18-21 °C at germination, and 40-170 cm rainfall is best suited
11.	Ginger	This crop requires warm and humid climate of up to 1500 m altitude, optimum being between 300 to 900m.
12.	Turmeric	Turmeric can be very well grown in varied tropical climatic conditions from sea level to 1500 M altitude above mean seas level. A temperature range of 20-35°C is very favourable for successful growth of turmeric.
13.	Nutmeg	Warm humid conditions are suitable. It grows well up to about 1300 m above mean sea level.
14.	Cardamom	A mean temperature of 15 °C to 35 °C
15.	Black pepper	High rainfall, humidity and hot climate is most suitable condition.
16.	Clove	It is a tropical region crop. Requires warm humid climate with temperature range of 20 to 30^0C.

Activities

Identified the temperature for growing spice crops

Material required: Pen, pencil, practical notebook etc.

Procedure:

- Visit to nearby spice growing field

Collect information about the weather conditions and crops grown

Check Your Progress

Fill in the blanks

1. Crop growth and development are primarily governed by environmental conditions is called _____.
2. _____is a state or condition of atmosphere at given place at a given time.
3. Temperate climate is characterized by the fall of temperature below freezing point in_____
4. Temperate climate relative humidity range between _____.
5. Temperate type of climate is observed at _____m height from mean sea level.
6. In _____ climate growing spices of this category need high temperature and abundant humidity.
7. _____is a frost-free winter season crop of northern plains, central and peninsular region
8. In _____ climatic zone during summer the temperature varies between 100C to 140C and relative humidity between 80% to 100%.

Multiple Choice Questions

1. It is weather conditions_____

(a) Temperature (c) Wind speed,

(b) Humidity (d) All of the above

2. In the temperate region, during summer the temperature varies between _____

(a) 100C to 140C (c) Both a and b

(b) 150C to 180C (d) All of the above

3. Tropical type of climate receives _____rainfall and humidity

(a) Low (c) High

(b) Medium (d) None of the above

4. A temperature very favourable for successful growth of turmeric is

(a) 10-15°C (c) both a and b

(b) 20-35°C (d) None of these

5. In arid zone wind velocity is

(a) 35-40 km/h (c) 15-20 km/h

(b) 20-30 km/h (d) None of these

Subjective Questions

1. Describe different climate in India?

_____

_____

_____

2. Explain the climate requirement of fenugreek, cumin coriander, nigella and anis?

_____

_____

_____

3. Explain the climate requirement of clove, cardamom, nutmeg and Black pepper?

_____

_____

_____

4. Write down the climate requirement of ginger and turmeric?

_____

_____

_____

Match the Column

A	**B**
1- Nutmeg	a- tropical region crop
2- Clove	b- Cardamom
3- annual rainfall of 1500-2500 mm	c- Dry and cool climate
4- Dill	d- Cumin
5- Sub-tropical climate	e- Warm humid conditions are suitable

Module 3
Field Preparation and Nutrient Management of Spice Crops

Module Overview

Field preparation is to create top soil structure to a fine and firm tilth that encourages the uniform and high germination percentage, quick emerge of seedlings and easy access to the nutrients, water and aeration for better seedling growth and development.

The aim of land preparation is loosening of the top soil layer, uniform incorporation of any additives such as lime, compost, farmyard manure, crop residues and chemicals for plant nutrition and pest control. Also, to facilitate irrigation, drainage and control of weed/ pests.

Learning Outcomes

After completing this module, you will be able to:

- Describe effective field preparation techniques, including land clearing, plowing, leveling, and seedbed preparation, to optimize soil conditions for crop growth.
- Explain strategies for managing soil fertility, including the use of organic and inorganic fertilizers, crop rotation, cover cropping, and soil amendment practices to enhance nutrient availability and soil health.

Module Structure

- Session 1: Field Preparation
- Session 2: Manage the Soil Fertility

Session 1: Field Preparation

Site selection criteria for spice crops

Spices crops are growing in different types of soils- ranges from sandy loam to clayey loam. For the successful cultivation of spices crops, the soil must be fertile with continuous supply of nutrients and proper drainage facility.

Methods of field preparation

The soil is dug out to a certain depth, resulting in big clods (ploughing), which are further broken down to make the soil fine and smooth with the requirement tilth. This facilitates weed management, ploughing back of crop residues, water infiltration, soil aeration and root penetration and development. Land preparation includes ploughing, crushing of clods, levelling, harrowing etc.

Tools and equipment used in field preparation:

With the advancement of science and technology, various metals have been used to develop new and modern tools and equipment for land preparation and nursery management. The various tools and equipment are

Pick Axe- Pick-Axe is a large tool consisting of curved pointed piece of metal with long handle joined in the middle. Pick axe have two edges. One edge of pick axe is broadened and other edge is pointed. The hard, compact and stony soils can be easily dug out with pick axe.

Figure 3.1: **Pick Axe**

Kodali- It can also be said as single pick axe. It is used for digging compact soil. Kodali can also use for digging and weeding operation in spice crops.

Pronged Hoes- It is having two, three or four arms. It is used for digging of hard or stony soil and also for digging rhizome crops like ginger, turmeric etc. Besides, it is useful for mixing manures.

Spade- It is used for lifting and turning the soil. Also used for digging the pit, preparing channel for irrigation and drainage.

Figure 3.2: **Spade**

Fork- It is used similar to spade but in many circumstances, it is more convenient to use. The tines allow the implement to be pushed more easily into the ground. The stone and weed can be rake out with the fork and it can break large clods very easily.

Hoe-cum-rake- It is made up of rectangular shape metal blade with fork like fore edge. It is used for digging, hoeing, earthing, levelling and collecting weeds. It is also used for hoeing, weeding and transplanting seedling.

Furrow opener- It consists of curved disc made up of hardened steel. Furrow opener have one concave disc. Narrow and shallow furrow can be easily opened with furrow opener after sowing of seeds in the nursery.

Shovel- The dugout soil from one place to another can be easily placed with the use of shovel.

Figure 3.3: **Shovel**

Garden rake- It is used for collecting stump and other residues of plants in the nursery. It also helps in breaking clods and levelling of land.

Figure 3.4: **Garden rake**

Hand leveller- It is used in small beds and nursery for levelling land and covering the seeds after sowing. It is also used for evenly distribution of the applied manure.

Crow-bar- It is used for digging soil, breaking stone or hard layer of soil.

Cultivator- It is a machine designed for tilling the soil. It is an important farm implement used for secondary tillage to prepare seed bed for sowing of spices.

Figure 3.5: **Cultivator**

Disc harrow- It is used for pulverizing the soil. It is also used for turning crop residues, weeds and other debris in the soil.

Figure 3.6: **Disc Harrows**

Thowel- It is used for uplifting nursery plants and also for transplanting seedlings manually.

Figure 3.7: **Thowel**

Axe- It is used for felling trees and cutting branches.

Figure 3.8: **Axe**

Dab- It is used for cutting small trees, shrubs and other wild plants.

Bill hook- The hardy branch of plants and other woody shrubs can be easily cut with bill hook.

Figure 3.9: **Bill hook**

Khurpi- It is used for removing weeds from the field. It is also used for digging bulb crop.

Figure 3.10: **Khurpi**

Straight blade hand hoe- It is used for removing weeds from the rows of the standing crops.

V- Blade hand hoe- It works similar to straight blade hand hoe but due to V-shaped blade it can also be used for earthing-up soil to the plant.

Karjat hoe- Due to three blades, it is useful for removing weeds and also used for pulverizing soil in the inter-row spaces crop.

Hand cultivator- It is used for weeding purpose and also for collecting stump and other debris, levelling nursery soil and mixing seed with soil.

Figure 3.11: Hand cultivator

Knap-sack sprayer- It is used for spraying pesticides.

Sickle- it is used for cutting leafy spices like fenugreek, coriander etc

Figure 3.12: Sprayer

Figure 3.13: Sickle

Nursery: Nursery is a well-protected place where seeds are sown in high density in small sized beds or in pots and seedlings/ saplings are maintained until they become ready for transplanting in the main field. There are two type of nurseries viz. temporary nursery and permanent nursery.

1. **Temporary:** Temporary type of nursery is raised in open place especially under sheltered position of tree or even in totally open condition. For such nurseries no provision of permanently walled-bed is made.
2. **Permanent:** Permanent type of nurseries usually has permanently walled-bed and often provided with overhead covering against rain or frost.

Benefits of raising nursery:

- The area being small and compact, it is convenient and easy to grow large number of seedlings per unit area.

- Managing favorable growing conditions become easy and feasible.
- The area being easily managed, management of diseases and pests becomes easy.
- It facilitates raising seedling prior to their normal season, off-season cultivation of spice is possible.
- As there is better germination due to properly managed conditions, nursery raising helps in curtailing seed requirement.
- Raising seedling in nursery ensure efficient optimum utilization of labour, water, nutrient s and other input.
- As nursery rising necessitates transplanting, hence, it helps in getting higher yields in those spice crops which respond to transplanting.
- Nursery provides an opportunity to select healthy, uniform and proper seedling and thus, helps in raising uniform crop in the field.
- It is the only way to obtain desirable type of plants.
- Ensures easy and cheap availability of plants.

Components of nursery

i. Selection of location and area
ii. Seed/ planting material and sowing
iii. After-care

i. Selection of location and area: The land area should be large enough that it may provide sufficient seedlings for transplanting of required acreage. The sizes of the nursery vary with type of spices to be sown. The following considerations are made while selecting location and site for successful nursery production.

- Select the site under open and protected condition.
- Avoid the site near and under influence of building.
- Shady sites are not ideal for nursery raising.
- Raised area is preferred for nursery as it facilitates drainage of water and avoids water stagnation.
- Select the site near to irrigation source
- Watch hut should be located near the nursery.

- The location should be well connected with roads to have an easy access to market.

i. Seed and sowing:

- Seed is the backbone of good crop.
- It should be sound, healthy, high yielding and true to type
- Seed should always be purchased from reliable source.
- National Seed Corporation, State Seed Corporation, farms and nurseries of government, State Agriculture Universities etc. are reliable source of seed availability.
- From private shops, purchase of seed should always be done after thorough analysis of label provided on seed packet.
- Before sowing, seed and soil must be treated against seed and soil borne diseases.
- Three types of seed treatment are used to control diseases- disinfestations, disinfection and seed protection.

Preparation of nursery beds

- In order to prepare the fine tilth, it is necessary to stir the soil, remove stone, pebbles and crop residue
- After levelling land, mix farm yard manure at the rate of one basket full per square metre area of the seed bed.
- Mix farm yard manure well and level the land again. Prepare the nursery bed of suitable size about 60 cm apart.
- The width of the nursery bed should not exceed one metre to have an ease in intercultural operations without entering inside the bed.

There are three types of nursery beds;

I. Flat nursery bed
II. Raised nursery bed
III. Sunken nursery bed

I. Flat nursery bed-

- Flat nursery bed is prepared during spring-summer when there is no fear of rain.

- After dividing field into small size plots prepare ridges around each bed which facilitates the cultural practices.
- In the area where the soil is light sandy loam where there is no problem of water stagnation.
- In between two beds, central irrigation channel is prepared through which each bed is connected.
- This is very simple and easy to practise.

II. Raised nursery bed-

- This type of nursery bed is common in practice during rainy season when stagnation / excess of water is common.
- Raised bed of 10 to 15 cm height from ground level is prepared.
- All the stump, stone, stubbles etc. are removed from the bed.
- A space of 50 to 60 cm is left in between two rows for carrying out cultural practices easily.
- Sowing of seeds should be done in lines or broadcasted over the bed.

III. Sunken nursery bed-

- During winter season, this type of bed is useful for raising seedling.
- The nursery is prepared 10-15 cm downward from the soil surface.
- The seedling in the sunken nursery is not hit by the cool breeze as air blow across surface of soil.
- In order to protect the seedling from cool air, covering of the sunken bed with polythene becomes easy.

Sowing:

- Remove stones, pebbles, crop residue and stair the soil for preparation of fine tilth.
- Mix farm yard manure at the rate of one basket full per square metre area of the seed bed.
- Mix farm yard manure well and level the land again. Prepare the nursery bed of suitable size as needed.

- The width of the nursery bed should not exceed one metre to have an ease in intercultural operations from the ridge itself without entering inside the bed.
- Mark line at about 5cm to sow the seeds. The depth of sowing seed is kept approximately four times the size of seed.
- After sowing, the seeds are covered with very fine layer of sieved farm yard manure.
- Irrigation is provided using watering can with fine nozzle to avoid flooding of the seed.
- The plants are maintained in the nursery until they become ready for transplanting in the main field.
- During summer the plants are ready for transplanting in about 4 weeks and during winter after 6 to 8 weeks of sowing.
- At this age, the plants attain a height of about 15 cm and possess 4 to 6 leaves.

Seed sowing: In seed bed, the seeds should be sown in line. Line sowing is always preferential over broadcasting as:

- There is uninterrupted flow of air and thus attack of diseases and pests is minimal.
- Hoeing and weeding become easy.
- No invasion of damping-off disease takes place.
- Uprooting of seedling becomes easy.

iv. After-care

- To have better germination, uniform moisture level should be maintained in the nursery bed. Avoid irrigation through flood system until germination of seed.
- Water stagnation in the bed should be avoided. Water logging leads to incidence of damping off disease to the nursery plants.
- Remove weed from the bed as they compete for nutrients with nursery plants, harbour pests and diseases.
- Cover the seed bed using thatch or gunny bag or locally available grasses to protect the seedling against hot and dry summer.

- During winter, the seed bed should be covered using crop covers, nets and polyethylene sheet. When germination of seed is over, the covering should be practised only during night.
- During day time, the beds should be exposed to sunlight which provides heat and facilitates seed germination.
- Use Chlorpyriphos 20EC to protect the seedlings from termites and insect-pests.
- Spray Dithane M-45 or Carbendazim 50%WP against protection of disease.

Time of nursery raising

Generally, in India there are two distinct seasons of spices cultivation: autumn-winter and spring- summer. The time for raising of nursery depends accordingly. For autumn-winter crops, the nursery is raised during June-July and that for spring-summer crops, it is raised during November- January.

Essential operations in nursery raising

1. **Thinning:** The seeds of the majority of the spices being small, it becomes difficult to sow them properly. It results in the over-crowding of the seedlings. The practice of removal of excess seedling to facilitate aeration and better development, is termed as "thinning".
2. **Pricking:** The transferring of young seedlings into another bed, pan or tray is termed as pricking. The operation of pricking is practised at the stage when the seedlings become large enough to handle. It is done with the objective of fast and vigorous development of seedling and minimizing transplantable time.
3. **Hardening:** In nursery, usually the plants are raised under protected conditions of temperature and light. The plants are maintained under shade with ample moisture in the soils. Such conditions make the plants tender. If such plants are shifted in the field under open conditions, they receive severe set-back and show post-transplanting mortality. To avoid this, the nursery plants are exposed to uncontrolled environment, preferably under partial shade or green house, by transferring them in another bed or trays/ bags etc.
4. **Mulching:** It is a thin extraneous layer of farm waste, residues, wood-chips, saw dust, ash, polyethylene or other similar material applied on the surface to conserve moisture in the soil. After sowing seed, about 5 cm

thick layer of crop residue mulch is applied over the bed. When seed germinates, the layer of mulch is removed. Mulching helps in:

- Maintaining the surface moisture essential for germination of seed.
- Prevention of damage by birds.
- Minimizing splash damage by water and thus, avoid flow of seeds
- Suppression of weed growth in the bed.
- Maintain congenial temperature in rhizosphere.

Growing media for raising nursery plants

Different types of rooting media are used for germinating the seeds and sprouting cuttings. The following criteria should be considered while selecting the growing media for raising the nursery plants:

- It should be firm enough to hold the seeds or plants at its place.
- It should be porous enough to facilitate air and drainage.
- It should be retentive of enough moisture.
- It should be free from contamination.
- It should be preferably neutral in reaction.
- It should not denature upon pasteurization or steam treatment.

Some common growing media for raising the plants are: Compost, Soil, Sand, Sphagnum moss, Perlite, Vermiculite, Peat, Saw dust and cocopeat.

Propagation structure: Greenhouse, Lath house, Hot bed, Cold frame, other propagating frames.

Parts of nursery

1. **Seed bed/ Planting bed:** The bed used for raising seedlings is termed as seed bed. The cuttings are raised in planting bed. The bed is generally prepared under shade which curtails water requirement of plants and helps in retaining better moisture in the nursery.
2. **Mother plant:**

The mother plants should possess the following attributes:

- It should be of known identity.
- It should have high production potential.

- It should have commercial acceptance.
- It should be free from pests and pathogens.

The mother plant should be planted raised in the nursery in a separate block.

3. **Packing yard:** This is commercially important spot in the nursery**.** All the sold plants are packed over here. It should be located near office touching store-house. The vicinity of the office helps in preventing pilferages and the adjoining of store-house helps in easy approach of the material like polyethylene bag, tape, cushioning material usually available in store and required for packing.
4. **Pot-house:** For inarching, rootstocks are required to be grown either in polyethylene bags or earthen pots. For such purpose, provision for pot house should be made in nursery. The shady place should be utilized as pot house.
5. **Compost pit:** It is prepared to decompose waste material to get it decomposed as compost. Compost is used as a medium for growing seedlings and raisings cuttings. It is also used as a component in pot filling mixture. It is an ugly looking site. It is advisable to have provision for it in one corner of the nursery under the shade of the tree.

Activities

Activity 1: Identification and listing the tools using in nursery and field preparation

Material required: Pen, pencil, practical notebook etc.

Procedure:

- Visit to nearby registered nursery or field by Govt.
- Identify the available equipment's and tools
- Collect the pictures and list out their names

Activity 2: Preparation of nursery beds

Material required: Arrange the equipment's like spade, hoe-cum-rake, shovel, trowel and Khurpi, farm yard manure etc.

Procedure:

- To prepare the fine tilth, it is necessary to stir the soil, remove stone, pebbles and crop residue

- After levelling land, mix farm yard manure at the rate of one basket full per square metre area of the seed bed.
- Mix farm yard manure well and level the land again. Prepare the nursery bed of suitable size about 60 cm apart.
- The width of the nursery bed should not exceed one metre to have an ease in intercultural operations without entering inside the bed.

Activity 3: Carry out essential operations in nursery raising

Material required: Arrange the equipment's like spade, hoe-cum-rake, shovel, trowel and Khurpi, farm yard manure etc.

Procedure:

- The practice of removal of excess seedling to facilitate aeration and better development, is termed as "thinning".
- The transferring of young seedlings into another bed, pan or tray is termed as pricking. The operation of pricking is practised at the stage when the seedlings become large enough to handle.
- In nursery, usually the plants are raised under protected conditions with foggers and shed nets to control temperature and light. The plants are maintained under shade with ample moisture in the soils. Such conditions make the plants tender. If such plants are shifted in the field under open conditions, they receive severe set-back and show post-transplanting mortality.
- It is a thin extraneous layer of farm waste, residues, wood-chips, saw dust, ash, polyethylene or other similar material applied on the surface to conserve moisture in the soil.

Check Your Progress

Fill in the blanks

1. The aim of land preparation is loosening of the top _____layer.
2. _____is a well-protected place where seeds are sown in high density in small sized beds.

3. There is major two type of nurseries viz. _____ nursery and _____ nursery.
4. _____ nursery bed is prepared during spring-summer when there is no fear of rain.
5. Spray of Dithane M-45 or Carbendazim 50%WP against protection of_____.
6. For inarching, rootstocks are required to be grown either in polyethylene bags or earthen pots_____ house is important in nursery.
7. _____ tools are used for lifting and turning the soil and also used for digging the pit.
8. The hardy branch of plants and other woody shrubs can be easily cut with _____.
9. The bed used for raising seedlings is termed as _____.
10. The mother plant should be planted raised in the nursery in a _____.

Multiple Choice Questions

1. Major components of nursery is
   (a) Selection of location (c) Seed and sowing
   (b) After care (d) All of the above
2. The height of raised type of nursery bed from ground level is _____
   (a) 20 to 25 cm (c) 25 – 30 cm
   (b) 10 to 15 cm (d) All of the above
3. The types of nursery beds are
   (a) Flat nursery bed (c) Sunken nursery bed
   (b) Raised nursery bed (d) All of the above
4. The transferring of young seedlings into another bed, pan or tray is termed a_____
   (a) Pricking (c) both a and b
   (b) Picking (d) None of these

Subjective Questions

1. Discuss about the tools and equipment are used in field and nursery preparation?

2. Describe the benefits of raising nursery?

3. Discuss about the parts of nursery?

4. Discussed about types of nurseries?

Match the Column

A	B
1- Packing yard,	a- Raising nursery
2- Compost pit	b- Commercially important spot in the nursery
3- Growing media	c- Thin extraneous layer
4- Mulching	d- Decompose waste material
5- Better germination	e- Sphagnum moss

Session 2: Manage the Soil Fertility

Plant nutrient

The plant nutrients are the chemical elements which are needed by plant for their growth and production. Plant nutrition refers to supply and absorption of chemical compounds required for metabolism and plant growth. In metabolic process, the nutrients are change into cellular component or used for energy production. Plants nutrients are absorbed in more or less in smaller quantity for transformation of light energy into chemical energy which is being used by plant for growth and development**.** Successful growth and production of the plants, in general, requires a proper supply of the 17 elements. These nutrient elements are regarded as essential to life in higher plants.

The nutrients that are required in relatively large quantity are termed as macro-nutrients and they are divided into primary and secondary and those in relatively less quantity are termed as micro-nutrients which are divided into cation and anions.

Table 3.1: Classification of plant nutrients:

Basic Elements	**Mineral elements**			
	Macro-nutrients		**Micro-nutrients**	
	Primary	**Secondary**	**Cations**	**Anions**
Carbon (C), Hydrogen (H), Oxygen (O)	Nitrogen (N), Phosphorous (P), Potassium (k)	Calcium (Ca), Magnesium (M g), Sulphur (S)	Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (C u), Nickel (Ni)	Boron(B), Molibdenum (M o), Chlorine (Cl)

Soil nutrient:

In broad sense plant nutrition refers to supply and absorption of chemical compounds needed for metabolism and growth of plant. It is the process of absorption and utilization of essential elements for growth and reproduction of plant. The essentiality of nutrients for growth and development of plant is as mentioned below.

1. In the situation of deficiency of the element it is impossible for plant to make its life cycle complete.
2. The deficiency is specific in reference to the element concerned.
3. The concerned element is directly involved in the plant nutrition.

Initially there were 17 essential elements as per Arnon Criteria but recently the essential element for plant nutrition has been increased to 20. The twenty essential elements are as under:

Carbon (C), Hydrogen (H), Nitrogen (N), Phosphorus(P), Sulphur(S), Potassium(K), Calcium (Ca), Magnesium (Mg), Iron (Fe), Manganese (Mn), Copper(cu), Zinc (Zn), Molybdenum (Mo), Boron(B), Clorine (Cl), Sodium (Na), Silicon (Si), Cobalt (Co) and Vanadium (V).

Role of nutrients-

Carbon, Hydrogen and Oxygen- Carbon is obtained from air in the form of carbon dioxide and hydrogen and oxygen are obtained from the soil in the form of water. Carbon. Hydrogen and Oxygen are the important basic component of protoplasm, cell wall and other organic constituent of the plants. Therefore, they called basic elements. The carbon is a building block of all organic compounds. Hydrogen is a component of water and all organic compounds. The element of oxygen works as s final electron acceptor in aerobic respiration and acts as a constituent in carbohydrate, nucleic acid and in many organic compounds.

Table 3.2: Role and deficiency systems of nutrients in plants

Name	Role of nutrient	Nutrient deficiency symptoms
Nitrogen	• Nitrogen is very helpful in the synthesis of proteins, protoplasm and chlorophyll promotes growth and development of roots.	• Loss of vigour and yellowing of green parts • Shortening of the stem, leaves become paler and remain small in size

Phosphorus	• Phosphorus is very important for storage and transfer of energy in which two important compounds namely adenosine di-phosphate ADP and adenosine triphosphate ATP are involved. • It promotes cell division, development and formation of fat and albumin.	• Growth of a plant is retarded at the early stage • Older leaves curl up and become purplish in colour
Potassium	• It is an activator of enzyme responsible for energy metabolism, starch synthesis and nitrate reduction. It is essential for photosynthesis and translocation of sugar. • Potassium helps in formation of protein and chlorophyll.	• On the older leaves, the edges will look burned. In case of acute deficiency, leaf margins dry up and often premature death of a plant occurs.
Calcium	• Calcium is an important secondary nutrient element and an important constituent of cell wall and it increase the stiffness of the plant.	• At apical tip failure of development of terminal buds is observed • Deficiency of calcium results in turning brown and dying of growing tips of root.
Magnesium	• Magnesium is a constituent of chlorophyll hence play important role in the process of photosynthesis and metabolism of carbohydrate	• Green parts between veins in leaves become pale, though the veins remain green leaf tips curl up

Sulphur	• It is required for synthesis of sulphur containing amino acids cystine, cysteine and methionine amino acids.	• Shoots become light green; veins on the leaves also turn paler
Iron	• Iron helps in the formation of chlorophyll. A deficiency of iron causes chlorosis in between the vein of leaves and the deficiency symptoms first appears on young leaves.	• Yellowing of younger leaf blades, while veins and petioles remain green • In severe deficiency the entire plant may be light green in colour
Manganese	• Oxidation-reduction reactions and decarboxylation and hydrolysis process are activated by manganese. It helps in the maintenance of chloroplast membrane structure.	• light interveinal chlorosis of leaves is observed in plant.
Boron	• It involves in the translocation of sugar, starch and phosphorus etc • It is required for synthesis of amino acids and protein.	• Loss of apical dominance, Leaf blades develop pronounced crinkling, Darkening and crackling of petioles
Molybdenum	• It is involved in nitrogen fixation and nitrate assimilation.	• Wilting and falling of leaves.
Copper	It is involved in normal plant metabolism as a component of phenols, lactase and ascorbic acid oxidise and photosynthesis, protein and carbohydrate metabolism.	• Necrosis symptom develops on the margin of young leaves. • Defoliation leaves of deficient plants curl

		up and their petioles bend downwards
Chlorine	• Chlorine plays very important role in cell proliferation and differentiated of xylem and palisade cell, involved in osmotic and cation neutralization.	• Chlorotic leaves, Leaf spots, Brown edges, wilting of leaves at margins and leaf mottling
Zinc-	• Zinc is improving quality and yield of crop. Acting as metal activator of the enzyme, there by ultimately increasing crop yield.	○ Younger leaves become yellow ○ Slow or retarted growth of the plant

Application of manure and fertilizers for crops

A balanced application of nutrients in soil is essential to improve the crop yield and its quality without affecting the soil's health. There are two sources which are most widely used for nutrient management — organic source, generally, called 'manure', and chemical or inorganic source called 'fertilizer'.

Manures

Manures are organic material obtained from animal and plant residues and contain nutrients in the organic form. These organic nutrients decompose slowly, releasing plant nutrients, which can be used as organic nutrients in agriculture. Manures can be classified into Farm Yard Manure (FYM), compost, green manure, which contains less amount of nutrients and is applied in bulk, and concentrated manures (oil cakes, blood meal, meat meal, fish meal, horn and hoof meal, raw bone meal and steamed bone meal, which have high nutrient content and supply nitrogen for a longer period).

Advantages

(a) They improve the soil structure and increase its water holding capacity.

(b) Manures add organic matter to the soil and stimulate the activity of soil microorganisms.

(c) There is no risk of forming toxic build-up as observed due to the use of chemicals.

(d) Leguminous crops (peas and beans) when used as green manure add nitrogen to the soil.

(e) Manures are renewable, biodegradable and eco-friendly.

Disadvantages

(a) Manures are slow in action.

(b) These require moisture for decomposition and release of nutrients.

(c) The cost of green manure may be more than the cost of commercial fertilizers.

(d) There can be favorable conditions for pests if undecomposed organic manures are used.

(e) Nutrient ratio to the weight of the manure is less, so it is required in large quantities.

Common manures

Farm yard manure (FYM)

FYM is a decomposed mixture of dung and urine of farm animals, along with litter and leftover material from fodder or roughages fed to animals (Fig. 3.14). It takes 4–6 months for complete decomposition. On an average, decomposed FYM contains 0.5% N, 0.2% P and 0.5% K. Phosphorus and potash are available in the soil in the form of oxides (P_2O_5 and K_2O). It is the most commonly used organic manure in vegetable crops. It is applied at the time of first ploughing during field preparation.

Fig. 3.14: Farm Yard Manure

Compost

Compost is an organic manure produced by the decomposition of organic wastes (Fig. 3.15). It is made of cattle wastes, urine-soaked earth, cow dung, leaves and branches of plants, and is ready for use within four months. Compost improves the soil structure and stimulates beneficial micro-organisms.

Fig. 3.15: Compost

Oil cakes

These are coarse residues obtained after oil is removed from oilseeds. These are applied to the soil at the time of land preparation and can be used along with fertilizers. These cakes add nutrients to the soil, as well as, improve the soil structure. Oil cakes are of two types — edible and non-edible.

Edible oil cakes

These are obtained after the extraction of edible oil. These can be fed to the cattle. Groundnut cake (Fig. 3.16), linseed cake, rapeseed (*Brassica napus*) cake, cotton seed cake, safflower cake, sesame cake, etc., are examples of edible oil cakes.

Fig. 3.16: Groundnut cake

Non-edible oil cakes

These are mostly used for horticultural crops. These cakes are obtained after the extraction of oil, which is not edible. Karanja (*Pongamia species*) cake, neem (Margosa) cake and mahua (*Madhuca species*) cake, etc., are examples of non-edible oil cakes.

Table 3.3: Nutrients supplied by manures

Manure	
Manures of plant origin	**Manures of animal origin**
(a) Cotton seed cake	(a) Bird guano
(b) Green manure (avg.)	(b) Bone meal
(c) Groundnut cake	(c) Cattel dung and urine mixed
(d) Karanaj cake	(d) Dried blood
(e) Linseed cake	(e) Fish manure
(f) Neem Cake	(f) Night soil
(g) Rapeseed cake	(g) Settled sludge (dry)
Wood ashes	
(a)Ash babul	
(b) Ash coal	

Plant residue	
Groundnut husk	
Composite manures	

Green manure

Green manuring is a practice, wherein crops, like sunn hemp (*Crotalaria juncea*), dhaincha (*Sesbania aculeata*), pillipesara (*Phaseolu strilobus*) and cluster bean (*Cyamopsis tetragonoloba*) are grown and the entire crop is then turned down in the soil for improving its fertility. Green manures can be applied in two ways. They are:

Prior to the main crop

Specific green manure crop is raised in the field and at flowering, it is ploughed or turned into the soil. The crop on decomposition improves the physical structure and fertility of the soil. The green manure crop is grown in the field 1–2 months prior to the desired crop. Green manure crop can be cultivated during the Kharif season and incorporated for the benefit of Rabi crop.

Cultivated after main crop

In some areas, the green manure crop is cultivated after the main crop for the benefit of the succeeding crop. Here, the tender green twigs and leaves of the green manure plants are spread in the field and mixed into the soil at the time of land preparation. This is a common practice in Eastern and Central India.

Vermicompost

The organism, which plays the most important role in the fertility of the soil, is earthworm. Due to its merits, it is called a 'pudding of nature'. Vermicompost is prepared by the decomposition of organic plant material by earthworms (Fig. 3.17). Earthworms release faecal matter called 'vermicasting'. FYM, kitchen waste, plant litter and other kinds of biodegradable wastes are spread on the vermicast, which is kept moist by frequent watering. Under suitable environment, the earthworms consume the organic matter and turn it into vermicompost. It is estimated that one million worms present in one acre area will produce vermicompost of about 500 kg/day. Vegetable crops require 1.5–3 tonnes/ ha vermicompost and it can be applied at any stage of crop growth. It can be mixed with the soil, and then, broadcasted.

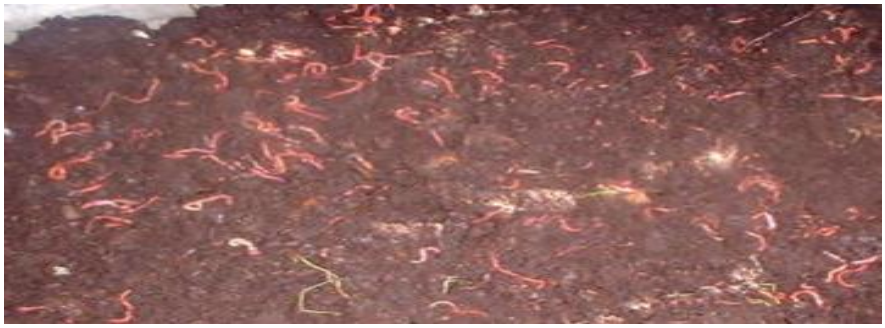

Fig. 3.17: Vermicompost

Advantages

(a) It can be used for all vegetable and spice crops at any stage of crop growth.

(b) It is rich in all essential plant nutrients and improves plant growth, yield and quality of produce.

(c) It is easy to handle, store and does not emit any odour.

(d) It contains certain microorganisms, which help in nitrogen fixation and phosphorus solubilisation.

(e) It minimises the incidence of pests and diseases in vegetable and spice crops.

(f) The percentage of nitrogen, phosphorus and potassium is more in vermicompost as compared to other compost.

(g) It improves the soil texture, structure, its water holding capacity, aeration and checks soil erosion.

Application of manures

Manures, such as oil cakes and FYM, should be applied or ploughed into the soil 15–20 days before sowing and transplanting due to the slow release of nutrients from manures. The crop growth is affected if undecomposed or fresh manure is used for cultivation. Therefore, it is advisable to use fully decomposed manure. An applicable dose of about 10–25 tonnes/ha is recommended for the cultivation of different spice crops.

Biofertilizers

Biofertilizers are preparation, containing beneficial living microorganisms, such as bacteria, fungi and algae in sufficient quantities, that enhance plant nutrition by increasing nutrient availability helping plant growth and nutrition. They decompose the complex organic matter and make them easily available to plants. The nitrogen present in the atmosphere is transferred to the soil by bacteria,

which further helps boost plant growth. Bio-fertilizer includes microorganisms, which add, conserve and stimulate plant nutrients in the soil. Thus, their activities are helpful in increasing the soil's fertility. Bio-fertilizers should never be mixed with insecticide, fungicide, herbicide and fertilizers.

Classification of Biofertilizers

Bio-fertilizers can be broadly divided into two groups:

(a) Nitrogen fixing bio-fertilizers: These can fix the atmospheric nitrogen, e.g., Rhizobium, Cyanobacteria or BGA, Azotobacter and Azospirillum.

b) Phosphate mobilising bio-fertilizers: These can solubilise or mobilise phosphate in the soil, e.g., bacteria, like Bacillus and Pseudomonas, and fungi, like Aspergillus and Penicillium.

Types of Biofertilizers

Rhizobium

These bacteria fix nitrogen in the roots of leguminous crops. They colonise in roots of specific leguminous plants to form a tumor-like structure called 'root nodules' (Fig. 3.18). These nodules fix the atmospheric nitrogen symbiotically. Rhizobium– legume association can fix up to 100–300 kg of N per ha/year.

Fig. 3.18: Rhizobium nodules

Azospirillum

Besides fixing nitrogen, these bacteria also increase mineral and water uptake in plants. This nutrient in crop plants leads to improved root development and vegetative growth. Azospirillum can fix 25–30 kg N/ha. This results in 15–30% increase in the crop yield. It is recommended for onion and co-inoculants for legumes.

Azotobacter

It is non-symbiotic bacteria that fixes nitrogen and produces growth promoting substances, like vitamin B group, indole Acetic acid and Gibberellic acid. Azotobacter fixes nitrogen 20–30 kg/ha from the atmosphere. This biofertilzer is recommended for different vegetable crops, like potato, onion, brinjal, tomato, chilli, cabbage, cauliflower and okra. Apart from nitrogen, this organism is also capable of producing anti-fungal and anti-bacterial compounds.

Blue Green Algae (BGA)

BGA is also known as 'Cyanobacteria'. These are phosphoric in nature and produce auxin, indole Acetic acid and Gibberellic acid. Nitrogen fixation in flooded rice fields is done by BGA.

Phosphorus solubilising Biofertilizers (PSBF)

These microorganisms can convert insoluble soil phosphate into soluble forms by secreting several organic acids. These are found effective in increasing soluble phosphorus in a soil by 10–20 per cent. It is recommended for all crops. These microorganisms are mainly bacteria and fungi. They include bacteria, like Bacillus and Pseudomonas, and fungi, like Aspergillus and Penicillium.

Vesicular Arbuscular Mycorrhiza (VAM)

VAM enhances the uptake of phosphorus, zinc, sulphur and water, leading to increased yield and uniform crops growth. VAM builds resistance against root diseases and improves the hardness of the transplant stock. It is recommended for maize, millets, sorghum, barley and leguminous crops.

Application of Biofertilizers

Seed treatment (seed dressing)

For treating seeds, a solution is prepared by adding 100 g of inoculants (culture of microbes) in 200 ml of water. The seeds are then dipped in the solution.

Seedling root dip

The method of seedling root dip is used in crops that require transplanting. Inoculants measuring 400 g is mixed in 20 litres of water to prepare a suspension slurry (solutions). Seedling roots are dipped in the suspension slurry for 15–30 minutes.

Tuber dip treatment of potatoes

A suspension is prepared by adding 1 kg inoculants in 40–50 litres of water. The tubers are immersed in the suspension for 5–10 minutes and planted immediately.

Soil treatment

Inoculant measuring 5–7 kg is mixed in about 50–100 kg rotten FYM or soil and applied in one hectare land. In case of direct sowing of seeds, Rhizobium is applied for all legumes as inoculants, whereas, Azospirillum/ Azotobacter is inoculated through seeds, seedling root dip, direct sown crops and soil treatment.

Fertilizers

Fertilizers are inorganic or organic made of chemicals, which supply essential nutrients to plants. They are available in concentrated forms and contain higher amount of nutrients than manure, and are, therefore, used in small quantities. There are three kinds of fertilizers used for spice crops viz., nitrogenous, phosphatic and potassium. Fertilizers can also be classified into straight, compound and mixed.

Advantages

Fertilizers are readily available source of nutrients to plants. The exact amount of a given element can be calculated and applied to plants. Some of their advantages are: (a) Fertilizers are easy to carry as they are packed in 50kg plastic bags. (b) They can be easily applied in different ways. (c) Fertilizers are easily available in different formulations and concentrations.

Disadvantages

(a) A fertilizer costs much higher than organic fertilizers, if used in bulk. (b) The nutrients can easily be leached or washed away in rainwater or irrigation water. (c) It is harmful if applied more than the required dosage. (d) It converts in available form fast and has to be applied frequently. (e) It contains certain compounds and salts, which are not absorbed by plants, and therefore, has an adverse effect on soil properties.

(b) Chemicals and their reactions prove harmful to biological activities of the soil.

Type of fertilizers

Sole fertilizer or straight fertilizers

These fertilizers have only one chemical compound or supply only a single nutrient. It is sometimes accompanied by a minor element. Sole fertilizers are further grouped according to the nutrient they supply. The nutrient content of different fertilizers is shown in Table 3.4.

Nitrogenous fertilizers

These are prepared and applied as a source of nitrogen to the crop. They release an in available form very fast and hence applied in split doses at the time of sowing and the rest as top-dressing during flowering and fruit set. Commonly available nitrogenous fertilizers are urea, calcium, Ammonium nitrate and Ammonium sulphate.

Phosphorus or phosphatic fertilizers

Phosphatic fertilizers are expressed in terms of the percentage of Phosphorus pentoxide (P_2O_5). They are the main source of phosphorus. The mobility of phosphorus is very slow. It is used as a basal application during land preparation. Some commercially available Phosphatic fertilizers are Single super phosphate, Double super phosphate, Triple super phosphate, Dicalcium phosphate, etc.

Potassium fertilizers

These fertilizers are applied as a source of potassium to plants and expressed as K_2O. These are applied before sowing or during seed sowing. Commonly used potash fertilizers are Potassium chloride or muriate of potash, Potassium sulphate, etc.

Mixed fertilizers

Fertilizers supplying more than one macro-nutrient to plants are known as mixed fertilizers. These are mixtures of nitrogen, phosphorus and potash (N, P and K) in various suitable proportions. Commonly used mixed fertilizers are Nitrogen phosphate with potash (15:15:15), NPK (10:26:26) and NPK (12:32:16).

Compound fertilizers

These fertilizers supply more than one plant nutrient, usually two, such as nitrogen and Phosphoric acid or nitrogen and potassium. The commonly used

compound fertilizers are — Diammonium phosphate (18:46:0), Ammonium phosphate sulphate (16:20:0), Monoammonium phosphate (11:52:0), etc.

Table 3.4: Approximate nutrient content in different fertilizer

Fertilizer	**N (%)**	**P_2O_5 (%)**	**K_2O (%)**	**Others**
Nitrogenous fertilizers				
Ammonium chloride	25.0	-	-	-
Ammonium sulphate	20.5	-	-	-
Anhydrous ammonia	82.2	-	-	-
Calcium ammonium nitrate	25.0	-	-	-
Urea	46.0	-	-	
Phosphatic fertilizers				
Ammonium phosphate	20.0	20.0		
Diammonium phosphate (DAP)	16	46	-	-
Rock phosphate		20.0-40.0		
Single super phosphate	-	16.0	-	12% S
Double super phosphate		32.0		
Triple super phosphate	-	46.0	-	
POTASSIUM FERTILIZERS				
Muriate of potash (MOP)	-	-	60	-
Potassium Magnesium sulphate	-	-	22.0	11.0 (Mg) 18.0 (S)
Potassium nitrate	13.8	-	44.0	-

Potassium Polyphosphate	-	56.0	24.0	-
Sulphate of potash	-	-	50	17% S

Micronutrient fertilizers

Micro-nutrients are required by plants in small quantities. Chemical compounds, which are used as sources of micro-nutrients and applied to plants, are called micro-nutrient fertilizers. Zinc sulphate (ZnSo4), Copper sulphate (CuSo4), Ferrous sulphate (FeSo4), Manganese sulphate (MnSo4), etc., are commonly used micro-nutrient fertilizers. All are soluble in water and can be used as soil application or foliar spray.

Methods of fertilizer application

Soils react differently with the application of fertilizers. Similarly, the requirement of nitrogen, phosphorus and potash vary from crop-to-crop. The requirement of these nutrients is not the same at different stages of growth or in different types of soil. In general, full amount of phosphorus and potash and half amount of nitrogen are applied during land preparation as basal dose, and the remaining half nitrogen is top-dressed in 2–3 split doses.

Basal application

This method refers to the application of fertilizers into soil before or at the time of planting. There are several methods of basal application, which are listed as follows:

(a) broadcasting of nitrogen, phosphorus and potassium fertilizers in large quantities on the surface before ploughing (Fig. 3.19)

(b) placement of fertilizers in a continuous band at the bottom of a furrow opened during ploughing

(c) fertilizers are applied in bands 2–3 inches or more away from the row and 2–3 inches or more below the surface

(d) combination of broadcasting or plough furrow placement with band placement at the side of the row at sowing and transplanting

(e) the fertilizers are applied with a drill below the surface of the soil before sowing or during seed sowing with a seed-cum-fertilizer drill

Fig. 3.19: Fertilizer broadcasting

Top dressing

The fertilizer is applied in the standing crop in case of top dressing. There are several methods of top dressing. (a) broadcasting fertilizers in moist fields 2–5 days after irrigation

(b) applying fertilizers around individual plants

(c) applying fertilizers along rows

Foliar application

Macro-nutrient fertilizer can also be applied through foliar spray (Fig. 3.20). The nutrients enter the leaves through the stomata, correct certain disorders, and improve the yield and quality of the produce. Among the macro-nutrients, urea (0.5–1.5%) is highly suitable for foliar application because of its high solubility, ease and quick absorption by plant tissues.

Fig. 3.20: Foliar application of fertilizer

Methods of micro-nutrient application

There are four ways of applying micro-nutrients.

Soil application

Micro-nutrient along with fertilizers can be applied to the soil for desirable plant growth and yield. The recommended dose of micro-nutrient for soil application

is 0.5–10 kg/ha for iron, 5–12 kg/ha manganese, 0.5–8 kg/ha for zinc, 0.5–5 kg/ha for boron and 0.05–1 kg/ha for molybdenum.

Seedling root dipping

Seedlings should be dipped in a prepared solution before transplanting. Generally, use 0.2–0.3% solution of Zinc sulphate for root dipping.

Seed treatment

The seeds are sown after they are treated with chemical compounds of Cu, Fe, Mo, Zn, B and Mn, etc.

Foliar spray

Foliar application of micro-nutrients is widely used as they are convenient to apply, required in small quantities, do not get fixed in the soil and help correct deficiency or disorders.

Individual spice crop requires specific doses of various nutrients in the form of nitrogen, phosphorus and potash (NPK).

Indicators of nutrients deficiency

Some plants reflect the deficiency clearly and quickly when exposed to deficient condition of particular nutrients. These are as under:

- Oat is good indicator of magnesium, manganese and copper deficiency.
- Wheat and barley can be used as indicator plant for magnesium deficiency
- Maize is a good indicator of nitrogen, phosphorus, potassium, magnesium, iron, manganese and zinc deficiencies.
- Sugar beet is a good indicator of potassium and manganese deficiency.
- Celery and sunflower are good indicators of boron deficiency.
- Flax is a good indicator of zinc deficiency.

Activities

Activity 1: Identification and list out the macro and micro nutrient of plant

Material required: Pen, pencil, practical notebook etc.

Procedure:

- Visit to nearby registered nursery or field by Govt.
- Identify the available nutrients

- Collect the pictures and list out their names

Activity 2: Collect and identified the nutrient deficiency symptoms of spice crops and prepare herbarium file

Material required: Pen, pencil, practical notebook and herbarium file

Procedure:

- To identify the plants and symptoms of deficiency
- Collect the sample of this
- Paste in the herbarium file

Check Your Progress

Fill in the blanks

1. _____, _____ and _____are the major important basic component of protoplasm and cell wall.
2. _____is very helpful in the synthesis of proteins, protoplasm and chlorophyll.
3. _____deficiency causes characteristic resetting or clustering of small leaves at the top of the plant.
4. _____ nutrient primarily involved in osmotic and cation neutralization which are important in the biochemical process.
5. _____ nutrient involved in nitrogen fixation and nitrate assimilation.
6. _____ nutrient facilitates fertilization and plays very important role in active salt absorption, water relation and photosynthesis.

Multiple Choice Questions

1. Nutrient helps in utilization of iron during chlorophyll synthesis is _____

   (a) Boron (c) Zn

   (b) Copper (d) All of the above

2. Nutrient plays very important role in cell proliferation and differentiated of xylem and palisade cell_____

   (a) Zn (c) Chlorine

(b) Copper (d) All of the above

3. It is very help full in the synthesis of proteins, protoplasm and chlorophyll is called

(a) Nitrogen (c) Carbon

(b) Hydrogen (d) None of the above

4. Plant nutrient helpful in the synthesis of sterol and lignin

(a) Nitrogen (c) Iron

(b) Carbon (d) Sulphur

Subjective Questions

1.Discuss about the Classification of plant nutrients?

2.Describe the application of manure and fertilizers for spice crops?

3. Discuss about the role of N,P,K, S nutrient?

4. Explain the deficiency symptoms of N,P,K, S nutrients?

Match the Column

A	B
1- Osmotic pull	a- Structure and permeability of cell membrane
2- Calcium	b- Synthesis of biotin and thiamine
3- Magnesium	c- Potassium
4- Phosphorus	d- Metabolism of carbohydrate
5- Sulphur	e- ADP and ATP
6- Haemoglobin.	f- Boron
7- Absorption of nitrogen	g- Manganese

Module 4
Irrigation Management in Spice Crops

Module Overview

Irrigation is defined as the process of applying judicially controlled amount of water to plants at required stages of plant growth through different systems such as deep basin, furrow, tubes, sprayers and pumps. Artificial application of water to soil to supplement rainfall for crop production is also called as irrigation. It helps to grow crops, maintain landscapes and revival of vegetation in disturbed soils, dry arid areas and under dry spells or of less than average rainfall conditions.

Learning Outcomes

After completing this module, you will be able to:

- Explain the importance of irrigation in spice crop cultivation, including water requirements, timing, and methods to ensure optimal growth and yield.
- Describe different methods and systems of irrigation suitable for spice crops, such as drip irrigation, sprinkler irrigation, and flood irrigation, considering efficiency, water conservation, and crop-specific needs.

Module Structure

- Session 1: Irrigation in Spice Crops and Methods and System of Irrigation

Session 1: Irrigation in Spice Crops and Methods and System of Irrigation

Importance of irrigation:

Irrigation helps to germinate seed, grow and survival of crops. It protects crops from frost and suppressing weed growth in the fields. Scheduled irrigation is important factor for maximize crop yields. Amount of irrigation vary from crop to crop with their throughout growing season. Irrigation improves the growth of crops and yield under irregular or uneven rainfall conditions. In many parts of the world irrigation is practiced for crop production since time immemorial. The growth and yield of irrigated crops are higher compared to the un-irrigated crops. Irrigation helps in enhancing cropping intensity in a region

or country. Creation of the facility of irrigation facilitated to put most of the barren area under cultivation. Irrigation improves the afforestation. Stabilized yield of crops and protects from famine. Enhance domestic and industrial water supply. The productivity of land can be enhancing with the application of irrigation water resulting in increase in income of farmers. Irrigation has stabilized yield and output level of crops. It helps in protection from famine. Sometime large irrigation channel can be used as a mean of communication. The falls which come across the irrigation channel can be utilized for hydro electricity generation.

Disadvantages of irrigation:

- The excessive seepage and leakage of water form marshes and ponds along the channel resulting in rising in water logged area.
- Application of water through irrigation results in loss of nutrients through leaching.
- Cultivator have to pay more charges for irrigation due to higher cost of project.
- Irrigation work becomes obstacle in free drainage of water during rainy season.

Irrigation requirement of spice crops:

Irrigation scheduling is important factor for growth, yield and quality of spices crops because most of the tree spices grown in Western Ghats of South India such as Karnataka, Kerala, Tamilnadu, Nilgiri hills and most of the seed spices are grown in uneven distributed rain fall area. The irrigation requirement of spices crops depends on their period of growth and developments, and they vary from crop to crop and area to area.

Table 4.1: Irrigation requirement of some spice crops:

S. No.	Crop	Irrigation required
1	Coriander	4-6 irrigation
2	Cumin	3-4 irrigation
3	Fennel	6-10 irrigation
4	Fenugreek	4-5 irrigation
5	Celery	8 irrigation

6	Ajwain	5 irrigation
7	Dill	4-5 irrigation
8	Nigella	5 irrigation
9	Anise	4-6 irrigation
10	Caraway	5-6 irrigation
11	Black pepper	10-15 irrigation
12	Cardamom	10-15 irrigation
13	Ginger	4-5 irrigation
14	Turmeric	4-5 irrigation
15	Clove	10-15 irrigation
16	Nutmeg	Regular irrigation is required.
17	Cinnamon	Regular irrigation is required.
18	Tamarind	Tamarind being rain fed crop normally no need of irrigation.
19	Vanilla	The cuttings are planted in main field with onset of rains so irrigation is not required.

Methods and system of irrigation:

In present scenario, the irrigation water is becoming a limiting factor for crop growth. Many part of India is facing crisis in irrigation water. This necessitates the farmers to adopt the suitable water management practice according to their farming conditions.

Major four types of irrigation systems are used:

1. Surface irrigation system

2. Sub-surface irrigation system

3. Sprinkler irrigation system

4. Drip irrigation system

1. Surface irrigation system: Surface irrigation system is most popular system of irrigation in India. Under this system four type of irrigation methods are followed:

a. Flood irrigation method:

This method is very simplest and easiest to practise. The water is allowed for irrigation without making any beds, basins or any other configuration as in other methods. The water floods the entire field. This system requires more quantity of water to irrigate the field. This system is practised in canal command area where ample water is available for irrigation.

Advantages:

- Any type of boundaries or bunds and field layout are not necessary except levelling of fields.
- More area of irrigation in the fields is utilized for water distribution and thus very less wastage of land.
- Flood irrigation minimize the requirement of labour for supervision.

Disadvantages:

- It is ancient and in efficient method of irrigation in which water use efficiency is only 20 percent and rest water are lost as percolation, seepage and evaporation.
- Levelling of field is very costly.
- Flooding result in water stagnation in the field, hence crop which require more aeration cannot be grown under flood irrigation system.
- Distribution of water is not even leading to uneven crop growth.
- There is a possibility of soil erosion.
- In flood irrigation system distribution of water is uneven so the growth of crop is not similar.
- Leads to leaching of nutrients.

b. Furrow irrigation method:

The furrow method of irrigation is adopted in crops grown with ridges and furrows. This type of irrigation is most suited in wide spaced spices crops like ginger, turmeric, garlic, fennel, ajwain and dill. The size and shape of furrow

depends on the crop grown and spacing adopted. Water is allowed into 3-5 furrows from the channel at a time depending on the stream size. This system is also practised in newly planted orchards. Taking the plants in the centre, an irrigation channel of 20 cm depth and 60 cm width is prepared. There is water saving in this system, as only limited area is wetted.

Advantages:

- Initially cost of equipment is low.
- Lower pumping costs per acre-inch of water pumped.
- Minimum cost of irrigation due to less cost, water and labor requirement.
- Minimum loss of chemical fertilizers and others by leaching.
- High crop yield and income of farmers.
- Water in the furrow contact only one half to one fourth the land surface, thereby reducing evaporation losses.
- Crust problem is avoided altogether in furrow irrigation.
- Inter-culturing is possible

Disadvantages:

There are several disadvantages of furrow irrigation method

- This method is oldest method of irrigation
- Salinity increases between the furrows
- Use of farm equipment's, problematic for moving across the furrow
- Furrow making in the field is more expensive and increase cost of cultivation
- Difficult to automation to distribute the same amount of water in each furrow.
- Difficult to install in the slopy, undulated and uneven areas.
- Any type of small hills appear in the field are remove because they stop the gravitational flow of irrigation water to ensuring uniform dispersion of water over a given field.

c. Basin irrigation method:

This method is more suitable for fruit trees. A basin proportionate to the size of the tree is prepared. The basins are then connected to each other through irrigation channels. The water moves ahead after irrigating individual basin of tree. Basin occupies very less area and large area remains unoccupied which can be used for inter-cultivation. (Fig 4.1)

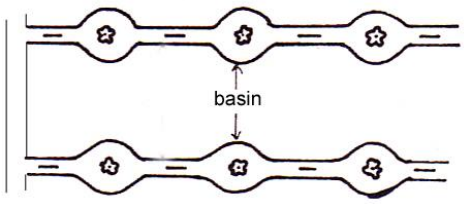

Figure4.1: Basin irrigation system DAAH

Advantages:

- This is the time saver method for irrigation in the orchard.
- Irrigation water automatically moves from one to another plant.
- Initial cost to establishment is less.
- It is beneficial method for irrigating orchard trees.

Disadvantages:

- It is not useful for all crops especially field crops.
- In this method water wastage is more.
- Diseases spread in trees such as fungal and bacterial diseases.

d. Ring irrigation method:

A circular ring in the periphery of the plant is prepared for irrigation. While preparing rings, care is taken that the ring is prepared away from tree trunk towards outer periphery of the tree. In between two ring basins, a sub channel connecting the ring basins of the tree is prepared. The water flows through central channel and move ahead naturally after flooding two ring basins at a time. This is very suitable method of irrigating grown up trees in the orchards where ample water is available.

Advantages:

- Ring irrigation method is superior type of irrigation methods for orchard plants in any type of soil.
- It is an efficient method for judicious use of water.

- This method is more economic.

Disadvantages:

- The cost of preparation of basin is high.
- It is not suitable for field crops and some orchard also.
- Supply of water in the orchard is not same for all the plants.

(e)**Check basin method:**

Check basin method of irrigation is the most common method among surface method of irrigation. It is suitable for close growing crop like cumin, nigella, coriander, methi etc. Field is divided into small plots surrounded by bunds on all the four sides. Water is supplied from the head channel to the field channel one after the other. Water is supplied in each field channel which ensure water availability to two rows of check basin and then water is supplied to one basin after another. The size of check basin ranges from 4 m x 3 m to 6mx5m depending on the stream size and soil texture.

Advantage of check basin

- In this method uniform application of water is ensured thus it is more efficient method of irrigation
- In this method there is good control on irrigation and high-water application efficiency is obtained.
- The soil erosion and wastage of water is greatly reduced
- Small irrigation channel can be used efficiently

Disadvantage of check basin.

- Labour requirement is more for preparation of field lay out
- Larger field area is lost in preparation of ridges of basin
- Lay out requirement in land preparation and irrigation is much bigger in check basin.
- More land is wasted under channels and bunds.
- Inter-cultivation is difficult due to obstruction by bunds.

2. Subsurface/subsoil irrigation system

Application of water to soil directly under the surface is called sub-surface irrigation method. Moisture reaches the plant roots through capillary action. Water is distributed through a system of pumping stations gates, ditches and

canals by raising the water table. The essential pre-requisite for subsoil irrigation is:

- At a depth of 2.0 meter or more there should imperviously sub soil.
- Sub soil should be permeable.
- Surface soil should be loam or sandy loam.
- Topographic condition should be uniform
- Ground slope should be moderate.
- There should be no salinity problem in soil.

Types of subsurface/ subsoil irrigation methods:

This method of irrigation involves application of water from beneath the soil surface either by constructing trenches or installing underground perforated pipelines or tile lines.

i. **Perforated pipe distribution method:** It is practiced for the production of cash crops like spices, vegetables on small areas. A perforated pipe distribution system is placed in the soil well below the surface. The soils which have very slow downward movement of water, permit free lateral movement of water and rapid capillary movement of water in the root zone are very suitable for this method. In this method water is forced through underground perforated pipe or tiles, hence water trickle out through perforations in pipes or gaps in between tiles. Under sub-surface method of irrigation movement of water takes place laterally and upward to moist the root zone under capillary tension. During the period of irrigation pipe lines remains filled with water. This method of irrigation is very costly. As compared to surface irrigation method, the requirement of water is only one third under sub-surface irrigation method and yield of crop, fruit and vegetable also improves. Water application efficiency in this method varies between 30 and 80 per cent.

ii. **Ditch or trench method**:

In this method water is discharged into ditches/trenches and during the whole period of irrigation, water is allowed to stand for lateral and upward movement of water by capillarity to the soil between trenches. At a depth of 30 to 120 cm artificial water table is created depending on crops to be grown. Nature of soil capillarity and the depth of impervious soil layer by constructing a series of ditches or trenches 60 to 100 cm

deep and 30 cm wide and the two side of which are made vertical. Ditches should be spaced 15.0 to 30.0 m apart.

Advantages

- In this method suitable water retention tension favourable for good plant growth and high yield can be maintained.
- There is huge reduction of evaporation loss of water from soil surface.
- Cost of water application is very low
- Suitable for soils with low water holding capacity.
- Most suitable where sprinkler irrigation is expensive,
- The upper layers of soil remain relatively dry so less weed growth

Disadvantages

- Uniform topographic conditions and moderate slope is required.
- Good quality water during whole crop growing season is required.
- Proper drainage system is essential requirement for success of this system.
- Sub surface drip irrigation limited to shallow rooted crop only.

1. Sprinkler irrigation system:

In this method of irrigation, water is applied as a spray or as rain drop over the crop. In this system supply of water distribution in the field is done by pumping water in pipes having sprinklers on the top connected upward with a main pipe. The important component of a sprinkler irrigation system is the pump, main pipeline, lateral pipeline, riser pipe and sprinkler. The pump send water under pressure in the pipeline system to sprinkle water over the crop. The main pipeline is connected to lateral pipeline. Riser pipes are fixed vertically on lateral pipe. The height of riser pipe depends upon the height of the crop. It should be equal to the maximum height of the crop. Sprinkler heads of rotation type are fixed on the riser pipe line. It is necessary to overlap the area of influence of each of the sprinkler for achieving uniform sprinkling of water.

The sprinkler irrigation method in the crops field is similar to natural rainfall. In this method water is supplied in the field by pipes and a pumping system. The water is sprayed into the air with the use of

sprinkler so that it breaks up into small water drops which falls to the ground as rainfall. This system of irrigation is very simple method of irrigation for irrigating undulated field and levelled field. In present scenario, when irrigation water is limited and some part of India, they facing crisis in this everywhere, the farmers should adopt the suitable water management practice.

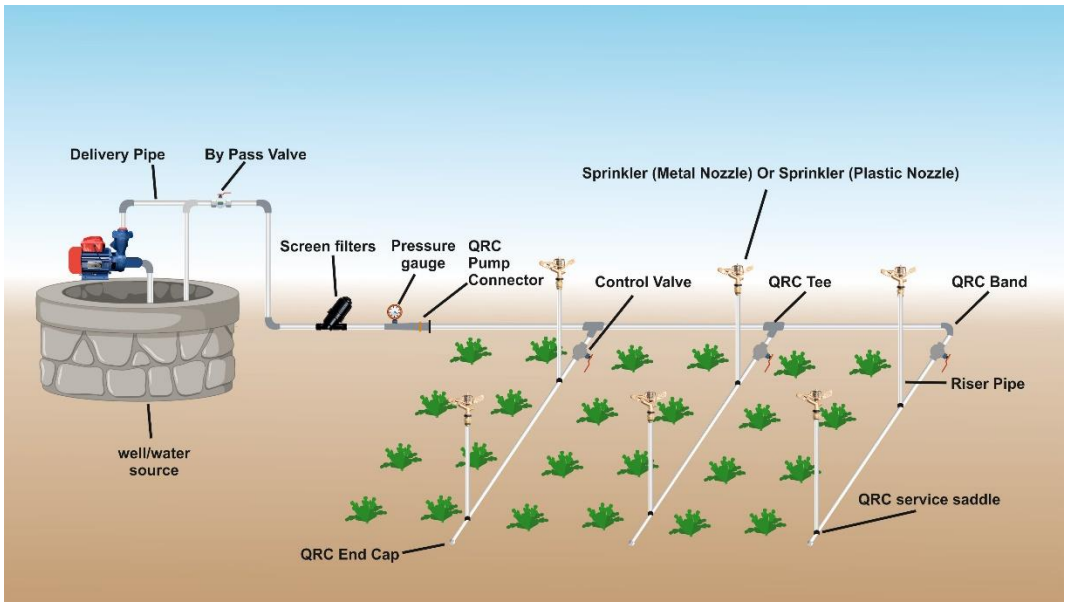

Figure4.2: Sprinkler or overhead irrigation system

Advantages:

- It increases crop yield and quality.
- It is helpful to check soil erosion.
- In areas with high silt deposition on surface of soil, sprinkler system is good choice.
- This is suitable method to prevent the crops from frost and low temperature.
- There is no conveyance and application losses
- With sprinkler, it is possible to irrigate area by 1.5 to 2.0 times over surface irrigation
- This is suitable method to prevent the crops by frost and temperature.
- Saving of water ranges from 25-50 per cent for different crop

- As the application rate is less than intake rate, hence no soil loss through erosion.
- It is most suitable method of irrigation for sandy and undulating soil
- It is especially suitable for steep slope and rolling topography.

Disadvantages:

- This is expensive to install in the field.
- Requires technical knowledge.
- It cannot be recommended for all type of crops
- Sprinkler irrigation does not work under high wind velocity situation
- It is also not suitable for area with hot dry winds as considerable amount of water is lost through evaporation
- Power requirement is usually high since sprinkler operate at a high pressure of 0.5 to 1.0 kg/cm^2

4. Drip irrigation system:

It is a one type of micro irrigation system which is very much potential to save water and nutrients by supplying water drop by drop to the roots of plant either from above ground or installed below the surface. The major goal of drip irrigation is to supply water directly into the root zone and minimizing evaporation. In a drip irrigation system, water is applied under the pressure, dripping one drop at a time through the small outlets/ emitters. The basic principle of this system is to supply water only in the root zone of the crop instead of the entire field surface, thereby water availability in the crop root zone is always remain as optimum. Drip irrigation system is the most efficient irrigation system and water application and water use efficiency ranges from 80-90 per cent. This system of irrigation is most suited in the crop production situation of dry, salinity, low drainage soils and on the soil moisture maintenance may result in high insect pests and disease incidence.

Component of drip Irrigation

Drip irrigation system consists of the following component

1. Pump for lifting of water from source of supply.
2. A head unit comprising of tank for maintaining required and circulation of water.
3. A central distribution system connected to the main water supply which regulates water pressure and quantity.

4. A fertilizer tank connected to the central distribution system, to supply soluble plant nutrient along-with irrigation water.
5. A filter connected to the central distribution system, to remove material suspended in water.
6. PVC main supply of suitable diameter and length to deliver the desired discharge.
7. Sub mains or lateral of suitable diameter and length connected in a parallel way to the main line.
8. Plastic drippers inserted in the lateral at the desired spacing (equal to the intra row spacing of the plant).

Types of drip irrigation system

A. According to outlet/ emitter structures drip irrigation systems can be divided into four types:

i. Point-source emitters:

This type of emitters is installed on the outside of the distribution line. Point source emitters distribute water with pressure through a long narrow path and very small orifices before discharging into the air. The discharge rate of water ranges from 0.5 to 2.0 gallon per hour.

ii. In-line drip emitter:

These are suitable for narrowly spaced crops and gardens. Drip lines are either installed under soil surface or on the surface. The emitter spacing is selected to closely fit plant spacing for most line sown crops. The discharge is usually expressed in gallons per minute along a 100-foot section.

iii. Basin bubblers:

The basin bubblers irrigate on per plant basis. Water from the bubbler head either runs upward in an umbrella pattern or downward from the outlet. Most of the bubbler heads are used in tree wells, planter boxes or specialized land scape application where deep localised water is preferred. The water flow rate is between 2 and 20 gph.

iv. Micro spray sprinkler:

Water can also be sprayed as fine mist or small streamlets over a portion of land surface. The outlets (emitters) are commonly known as sprinkler or spray heads. Less sprinkler heads are cover to cover larger areas. The water flow rates from emitters vary from 3 to 30 gph depending on the size and line pressure

B. According to installation of outlet it is of two types

i. Sub-surface drip Irrigation

The drip outlet (emitter) is put below the soil surface. Sub-surface drip irrigation has the advantage of nearly zero evaporation but the outlet of drip may get closed by soil or damaged.

ii. Surface drip irrigation

The emission device (outlet/emitter) is placed at the surface of soil.

C. According to pressure

i. High pressure drip system

It works at operating pressure of 30 PSI or more. Generally used to irrigate large fields and against slope through piping and emitters connected to pump.

ii. Low pressure drip system

This system operates at less than 30 psi pressure. In this system water supplied through piping and emitters from an elevated reservoir e.g. pond irrigation ditch and tank to a garden or land scape at a head of less than 20 feet or less than 30 psi pressure to the emitters.

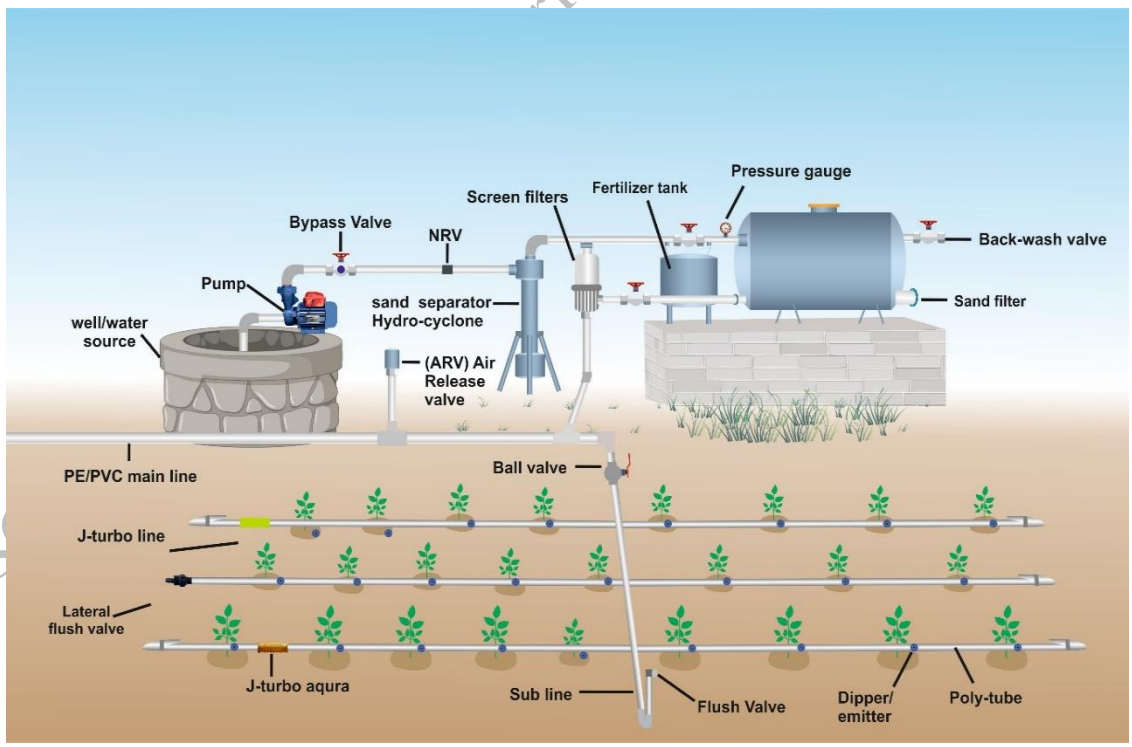

Figure4.3: Drip irrigation system

Advantages of drip irrigation:

- **Water saving:** In this system, water is applied directly in the root zone and very less area is wetted. Furthermore, water wastage through percolation, seepage and evaporation is also checked due to use of water carrying main lines and laterals. There is 30 to70% saving of water in this system.
- **Labour saving:** There is no requirement of labour to prepare beds, borders and channel etc. after switching on the motor pump, the water starts dripping out. Thus, the labour requirement is minimized considerably. There is 60 to 90% labour saving in drip system.
- **Use of hilly terrain:** Through surface flow irrigation system, it is impossible to irrigate the land in hilly and undulated terrain. In drip irrigation system, through pressure, it becomes possible to irrigate the land even in hilly and undulated land terrain.
- **Suppressed weed growth:** As only limited area is wetted in drip irrigation; the weed growth is checked. It becomes very easy to remove the weed from very limited wet area.
- **Increased growth, vigour and yield:** As the water is supplied to the plants matching exactly to the requirement of water, the plants face no water stress and obtain better growth and vigour and ultimately yield high.
- **Ease in orchard operation:** The main lines and lateral lines remain underground in drip system. Hence, manual or mechanical operations in the orchard can be carried out with ease.
- **Use of low-quality water:** In arid region brackish water is a problem in successful cultivation of crops. Root zone areas remain continuously moist with least evaporation under drip irrigation system. The salt moves away from the root zone and the accumulation of salt in the upper layer of soil is restricted. Thus, drip irrigation makes it possible to use saline water.
- **Ease in operation:** Drip irrigation can be operational during any hour. It is not affected by wind, day or night.
- **Suitability for light soil:** Light soils have very less water holding capacity. Water leach-down quickly and crop face water stress. As drip

system is operated at close interval, water becomes available to the plant easily even in light soil.

- **Ease in fertilizer application:** Drip irrigation is provided with fertilizer mixing tank. Hence, there is no need of fertilizer application separately. The fertilizer is mixed in fertilizer tank and passes through dripper to get it discharged to the plants.
- **Less incidence of disease:** In drip irrigation only soil of root zone is wetted and stem is not wetted. Hence, the chance of disease like stem rot or collar rot is totally eliminated

Disadvantages

- **Management:** Drip irrigation systems normally have more maintenance needs. Soil particles, algae, or mineral precipitates can close the outlets.
- **Prone for damage:** Animals, rodents and insects may cause damage to some components. The drip and bubbler irrigation systems need additional equipment for protection from frost.
- **High initial cost**: Micro-irrigation systems are ideal for infrastructures of high value such as orchards, vineyards, greenhouses, and nurseries where traditional irrigation methods may not be practical. However, the investment cost can be high.

Fertigation: It refer to combined application of water and plant nutrients which results in saving of both water and fertilizer and enhancing yield and quality of crops. In India since last two decades drip irrigation has received greater attention of both farmers and government in view of its well proven advantage in both water scarce and sufficient areas. The factors that govern the fertigation are soil type, crops, method of irrigation used water quantity, type of fertilizer available, economic feasibility etc. In modern agriculture, the fertigation has become an important and attractive method of fertilization and irrigation. In this method of irrigation, liquid fertilizers are applied frequently and periodically to crop in small amount with each irrigation in order to supply optimum amount of water and nutrient in the root zone.

Advantage of fertigation:

- In drip fertigation, application fertilizer synchronised with plant need
- Improve fertilizer use efficiency and only 60-80 percent fertilizer of recommended doses is needed in fertigation.

- High nutrient availability due to maintenance of soil moisture near field capacity.
- There is much reduction in labour and energy cost by making water distribution system for nutrient application also.
- In this method uniform flow of water and nutrient is achieved.
- Availability of nutrient and their uptake by plants is improved hence high nutrient use efficiency obtained.
- In fertigation soil and water erosion is prevented.

Dis-advantages of fertigation

- Cost of water-soluble fertilizer is very high.
- It is difficult to maintain drip irrigation
- Clogging of emitter is a serious problem
- It needs water soluble fertilizer availability of which is limited

Characteristics of fertilizer for fertigation:

- Fertilizer must be completely soluble in water
- Must not react with dissolved elements in water
- High nutrient content in the saturated solution.
- pH of water should not get change so that precipitation and clogging may not take place.

Activities

Activity 1: List out the spices crops with their source of water and requirement

Material required: Pen, pencil, practical notebook etc.

Procedure:

- Visit to nearby nursery or spice growing field.
- Identify the available spice crops grown and source of irrigation
- Collect the pictures and list out their names

Activity 2: List out and draw a suitable diagram of surface irrigation methods

Material required: Pen, pencil, practical notebook etc.

Procedure:

- Visit to nearby nursery or spice growing field.
- Collect the pictures and list out their names
- Draw a picture in note book

Activity 3: Installation of drip irrigation system in the field nursery

Material required: Arrange the equipment's and materials used in drip systems etc.

Procedure:

- Previously collect all the equipment's and drip fitting accessories.
- Draw a diagram on paper for installation of drip
- Install a drip line according to crop grown

Check Your Progress

Fill in the blanks

1. _____helps to grow and survival of crops.
2. Scheduled irrigation is important factor for maximize _____ yields.
3. Application of water through irrigation result in loss of nutrients through_____.
4. In nursery of nutmeg seedling, regular irrigation is necessary for_____.
5. The cuttings are planted in main field with onset of rains so irrigation is _____required.
6. In_____ water use efficiency is only 20 percent and rest water are lost as percolation, seepage and evaporation.
7. The _____of irrigation is adopted in crops grown with ridges and furrows.
8. _____ method is more suitable for fruit trees.
9. The major goal of drip irrigation is to supply water directly into the root zone and minimizing_____.
10. In drip irrigation system water saves up to _____ per cent.

Multiple Choice Questions

1. Irrigation improves the _____

(a) afforestation (c) deforestation

(b) dissertation (d) All of the above

2. Irrigation requirement of cumin is _____

(a) 5-6 (c) 7

(b) 3-4 (d) All of the above

3. Regular irrigation is needed at nursery stage in which crop_____

(a) Cumin (c) Dill

(b) Cinnamon (d) None of the above

4. Furrow method of irrigation between the furrow's salinity _____

(a) increasing (c) Decreasing

(b) Neutral (d) All of the above

5. In sprinkler system of irrigation saving of water ranges from

(a) 15-20 per cent (c) 10-15 per cent

(b) 25-50 per cent (d) None of the above

6. Water saving in Drip irrigation ranges from

(a) 30-80% (b) 80-90%

(c) 30-70% (d) 50-90%

7. Water use efficiency of drip irrigation ranges from

(a) 80-90% (b) 70-90%

(c) 30-70% (d) 70-80%

Subjective Questions

1.Discuss about the importance of irrigation?

_____

_____

_____

2.Describe the emitter structures drip irrigation systems?

3.Discuss the advantage and disadvantage of sprinkler irrigation system?

4.Write the types of surface irrigation system with definition?

5.Explain the fertigation with their advantages?

Match the Column

A	**B**
1- Drip irrigation system	a- Surface irrigation system
2- Ajwain	b- Furrow irrigation method
3- Cardamom	c- uniform flow of water and nutrient
4- Flood irrigation method	d- 5 irrigation
5- Limited area is wetted	e- Sprinkler irrigation system
6- Diseases spread maximum	f- micro irrigation system
7- Undulated or un even land	g- basin irrigation method
8- Fertigation	h. 10-15 irrigation

Module 5
Health and Safety Measures at the Workplace

Module Overview

Different workplaces have different levels of challenges especially in terms of physical hazards inherent in the nature of work or the workplace. Workplace accidents put a heavy, harmful, unfortunate, and counterproductive impact on workers, their co-workers, and their families. They suffer pain, disability, stress, and in some cases even loss of employment. Hazard is defined as a dangerous condition or event that portends or has the potential to cause injury, threaten life, damage the property, etc. Hazards in agriculture include mechanical hazards, ergonomic hazards, chemical hazards, accidents, hazards related to the occupancy of confined places, occupational diseases, and various other hazards arising from associated land, water, and air. All efforts are necessary for personal safety of the workers and the users of agrochemicals and farm machinery, at all times, on ethical, health, and professional grounds.

Accidents may occur while being at work in the field, transporting animals, and crops, or by falling, slipping, tripping, drowning, machinery hits or by adopting bad or unhealthy work practices. Hazards caused by human factors, such as those caused by awkward postures, and damage to muscles and tendons, mainly due to poorly designed tools, are of common occurrence at agricultural farms. Hazards related to confined spaces (warehouses, wells, manholes) are of great concern to the safety of workmen.

This Module will help you learn about various health and physical hazards faced by farm workers and the safe work procedures that ought to be adopted for reducing the persisting risks and preventing the occurrence of accidents.

Learning Outcomes

After completing this module, you will be able to:

- Demonstrate knowledge of the safe handling, storage, and application of agrochemicals, including pesticides, herbicides, and fertilizers, to minimize environmental impact and ensure human health and safety.
- Explain the principles of safe operation and maintenance of agricultural machinery, including tractors, harvesters, and irrigation equipment, to prevent accidents and ensure efficient farm operations.

Module Structure

- Session 1: Safe Use of Agrochemicals
- Session 2: Safe Use of Agricultural Machinery

Session 1: Safe Use of Agrochemicals

Harmful effects of agrochemicals

Chemical hazards in agriculture are related to the dangerous pesticides being used, as well as in the maintenance of plant protection equipment and spraying of pesticides. It has been reported by WHO that there are three million cases of agrochemical poisoning with up to 20,000 reported (unintentional) deaths in a year in developing nations. The term 'pesticides' is indeed a non-specific and broad term, and includes as diverse a group of chemicals as herbicides, fungicides, insecticides, nematicides, rodenticides, molluscicides, acaricides, plant growth regulators, and chemical fertilizers commonly used in agriculture.

Some of these pesticides can be harmless, while others can cause severe to very severe damage to the central nervous system, kidney, or increase the risk of cancer. Initial symptoms may be variable and misleading such as muscular weakness, headache, dizziness, and nausea. Continuous use of certain agrochemicals, especially pesticides with which our body comes in contact or is exposed to, results in long term damage to organs like kidney, liver, or the nervous and the endocrinal system inside our body.

Pesticides must not be found in food products but may be present due to the following reasons:

- Indiscriminate and extensive use of chemical pesticides.
- Non-observance of prescribed safety norms
- Discriminate or indiscriminate sourcing leading to the use of unsafe or sub-standard pesticides.
- Wrong advice and supply of pesticides to the farmers by vendors of agrochemicals
- Leakage or lack of care in disposal of agrochemicals or its waste by-products by manufacturers
- Unclean or improper maintenance of the premises of agrochemical manufacturing area.
- Unclean or improper maintenance of the premises of agrochemicals to rage and preparation are a by farmers.
- Not using appropriate apparels necessary for the personal safety of

the field operators and other such factors.

Methods of safe use of pesticides

Use of safety procedures

Individuals who handle and use pesticides should review safety procedures on a regular basis. These are generally exhibited on the pesticide container labels Orin the literature provided with the market product.

Some important dos and don'ts:

- Do not ignore, read, and follow the label information and directions.
- While working with hazardous products, do wear a clean personal protective equipment (PPE).
- Remove your contact lenses before handling the pesticides.
- Wash the hands after you have handled or have had a contact with a pesticide, especially and more so, before eating, drinking, smoking, or using the toilet.
- Remove and wash off the contaminated clothing and any spilled pesticide on a person.
- Showerandwashthehairandcleantheundersideoffingernailsattheendofeachday.
- Take proper care with respect to the pesticide as per toxicity labels marked on the pesticide packing.

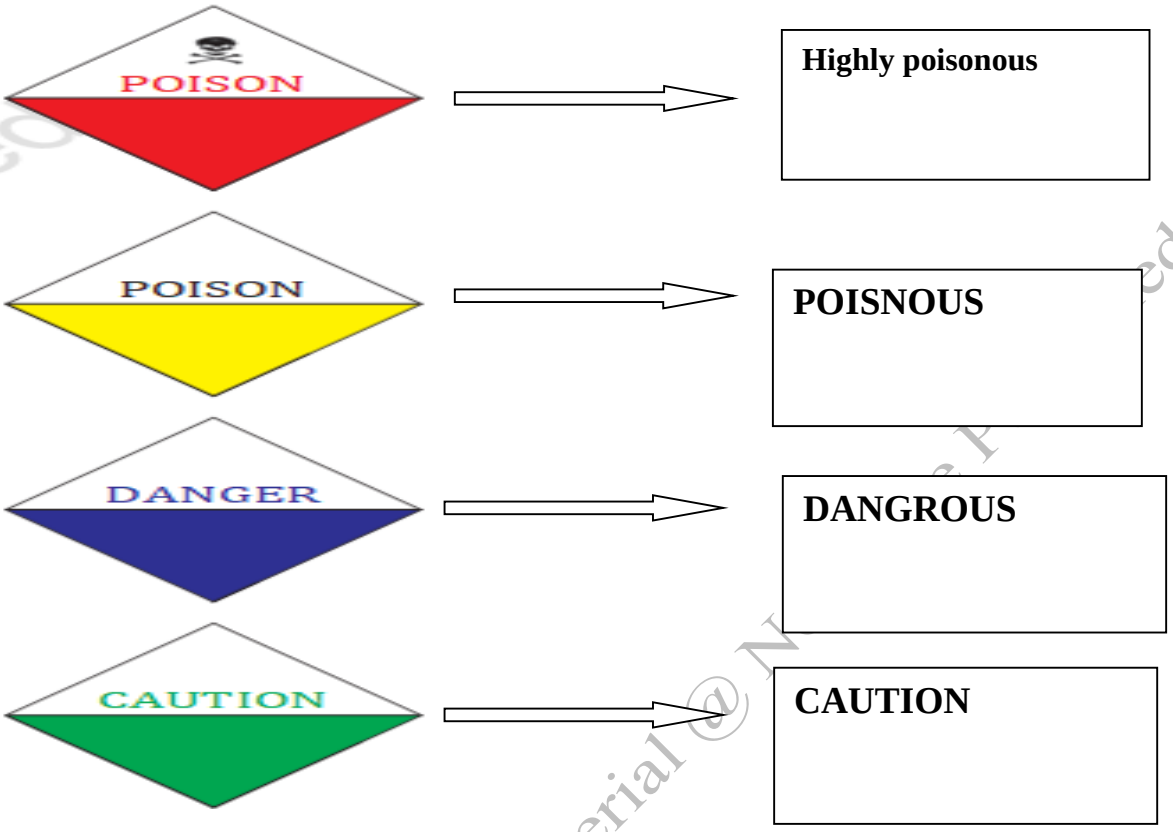

Figure 5.1: Labels of colours showing toxicity of pesticide

Selecting and buying right pesticides and in required quantity

- Safety begins with choosing and buying a pesticide as per one's need only. Check out the following before buying a pesticide:
- Label shows the pesticide as approved for the intended use.
- The pesticide can be used in an integrated pest management programme.
- Purchase just as much as is needed by carefully calculating on the basis of cropped or storage area to be covered.
- Read and follow the instructions that come with the agrochemical.

Protecting oneself while using the equipment

Several articles of personal dressing or covering are essential while using hazardous chemicals or working with powered machines, viz., rubber gloves, respiratory guards or filters, full overall but not loose fitting (with missing buttons or zips), etc.

Figure5.2: Safety apparel for preparing spray

Safety protocol for mixing or applying a pesticide

• Pesticides should be mixed and used at prescribed or recommended rates.

• Use pesticides under favourable weather conditions only; avoid bad weather.

• Don't use muddy or unclean water for mixing with pesticide and for personal clean up.

• Whenever handling the pesticides, clean water tanks should be kept nearby.

• Never smoke or eat in between or while mixing or applying pesticides.

• Some pesticide products are flammable. Take care against fire breaking out due to smoking or any other use of matchsticks or fireplace.

• Read and follow the instructions on the user guide or label properly.

• Use correct pesticide for the pest or disease for which it is meant.

Use the recommended dose and quantity only

• For preparing the aqueous solution of the pesticide, use outdoor open space.

• Use the recommended amounts and dilutions strictly.

• Do not prepare more than the required amounts for field application on a given day only; never try to store for possible future use.

During application of pesticide

• Don't undertake the task of pesticide spraying on a windy day.

• Position yourself in a way that the wind drift blows pesticide spray (or dust) away from your face.

• Before indoor spraying, close the doors and windows of hall or home.

• During the spray operation, keep the nozzle close to the target plants to avoid waste of solution caused by drifting.

• Spraying excess quantity will be wasteful and leave residual harmful amounts on the produce, which if consumed, will be detrimental to the health of the consumer.

While preparing the spray solution of pesticide, try to stay away from an open well used to draw drinking water.

Figure 5.3: Caution signages while pesticide spraying

Figure 5.4: Signage for pesticide application in a field

Cleaning and disposal empty pesticide containers

Pesticide containers should be cleaned when emptied, removing the pesticide residues before they dry. Keep the following points in mind while emptying a pesticide container:

- For liquids, transfer the pesticide into a spray tank or mixing

tank. Let the last drop get emptied. Use a strong nozzle to triple rinse or pressure rinse the metal, plastic, or glass containers, unless otherwise instructed on the label.

- Likewise, for solids, gently shake the bag into tank or hopper until no loose foggy dust is visible. Gently rinse the bags once, if possible, unless otherwise instructed on the label.

Pesticide disposal

Disposal of Concentrated Pesticide

Planning your pesticide purchases will minimize the excess pesticide concentrates leftover after an application or use in one season. Review the records of prior applications. Use the pesticide that is on hand before buying more. Contact the pesticide manufacturer or a local vendor to be sure that the old stocks are still effective.

It is best to prepare just the right quantity of pesticide concentrate or solution to avoid disposal problems. Itis safer to prepare less quantity rather than preparing excess, which may have to be disposed of unsafely.

Un opened containers may sometimes be returned to the manufacturer or local dealer. Applicators can also contact the pesticide regulatory body for advice on proper disposal of unused pesticides. If excess quantity is lift in storage, either use it yourself or let a neighboring farmer use it, if possible.

Don't stockpile buys and use as per need. If you have to store the pesticides, keep it out of reach of children. Do lock all the pesticides in a cabinet in a well-ventilated utility area or farm shed.

Disposal of surplus prepared mixture

- Prevention is better than cure' has to be the guiding principle for pesticide use.
- Accurately measure the area to be treated.
- Confirm the application rates of agrochemicals.
- Calibrate the application equipment.
- Use all the solution or dispose it off safely.

First-Aid, treatment and safety equipment

Accidents might happen inspite of all the precautions and care. It is essential for students to know about the immediate medical aid for a chemical accident, and to learn about the safety devices needed to prevent accidents.

Chemical poisoning and First-Aid measures

Chemical poisoning may result from continuous contactor absorption through skin, inhalation of toxic vapor or swallowing it directly. Common symptoms of pesticide poisoning are headache, nausea, vomiting, tremors, convulsion, and difficulty in respiration. A first-aid kit with necessary antidotes should be available at the worksite for each type of poisoning. Antidotes are always mentioned on the pesticide containers.

Treatment for simple chemical poisoning

Swallowed poison

If the poison has been swallowed, induce vomiting immediately. Table salt in a glass of warm water is good for this purpose. Touching the throat internally with finger will also induce vomiting. Vomiting process should be continued till a clear liquid starts coming out of the stomach. If the patient goes into convulsions or in unconscious state, vomiting should be induced and consult to the nearest health center or doctor immediately.

Skin contamination

Contaminated clothes may at once be removed. Contaminated skin should be washed with soap and water and also flushed with plenty of water to reduce the extent of injury.

(i) **Eye poisoning**

Eyes of the victim may be washed with plenty of water, keeping the eyelids open. A quick decisive action is desirable as a delay of a few seconds may greatly increase the extent of the injury. Refer to an eye doctor immediately.

(ii) **Inhaled poison**

The victim of inhaled poison must be immediately exposed to an open area with fresh air. Keep the patient quiet as far as possible. Provide a

blanket to avoid chilling. If breathing stops, artificial respiration technique through mouth may be used.

Safety and protective devices

Protective and safety devices will minimize the chances of a major accident. The protective and safety equipment essentially include a gas mask, hand gloves, shoes, eye shields, headgear, protective clothing, respiratory devices, etc.

Gasmask

It is a device to protect the eyes and respiratory tract from toxic gases, and aerosols. It gives clean air to the operator by removing contamination from the ambient air by using a filter or bed of absorbent material.

Hand gloves

Always use rubberized waterproof gloves, not ones made of leather, cotton, or any fluid-absorbing material.

Shoes

The shoes made of rubber or any synthetic water proof material is used is instead of leather or canvas shoes.

Eye shields

These must be worn to prevent eye poisoning.

Protective clothing

The skin should be protected by wearing an apron while working with treated crops. Wash clothing before reuse.

Health and safety awareness in the workplace

- Encourage seniors to keep an eye on those working at the workplace.
- Use charts and visuals to demonstrate commitment to health and safety.

Figure 5.5: Hand gloves and mask

Figure 5.6: Protective clothing

- Encourage safe work practices while discouraging unsafe work practices.
- Even at the cost of repetition, communicate that safety is of prime importance while at work.
- Those new to undertaking spray or pesticide application must be supervised or advised to report immediately about any adverse development concerning the health of the operator.
- Respond and act promptly to all health and safety concerns.
- Setanexampleintheuseofallpreventiveandprotectivematerialsandp ractices.
- Keep young trainees away from operational area, or supervise them personally to ensure that they do not come close to working machinery or handling devices and equipment which they are not yet rained to use.

Amenities and environment

- Train all workers rotationally in the use of first aid equipment and provide first-aid kit sat easily accessible points.
- Insist on first-aid training for all the fieldworkers.
- There should be free access to washroom and toilet facilities with running water or stored clean water.
- There should be free access to potable, clean, and cool drinking water.
- As far as possible, take steps to prevent the entry of poisonous creatures like scorpions, snakes, leeches, etc.
- Don't keep flammable materials in large quantities or in easily approachable or accessible are as prone to fire hazard.

Emergency response

- Train a task force for emergency response action for the workplace (for example, snakebite, fire, confined space entry, heat stress, or chemical spill).
- Keep safety aware ness level of workers high at all times.
- Maintain emergency response equipment.

Manual tasks for personal safety

- Use appropriate restraint systems when and where required.
- Take care to avoid crush injuries to hands.
- Use aids to lift or move down the injured animals when and where possible.
- Try and minimise the risk of slips, trips and falls; provide non-slip flooring.
- Wear cotton cloths while working in field or with equipment
- Avoid wearing too loose, fancy or flair dresses while working with machines and tools in the field.
- Always wear proper size shoes while working in the field.

Case study

Shri Ram Singh was working in a spice field where he inhaled insecticide accidently while working in the field. Due to over doze of spray he lost is consciousness and fall on the ground. His elder brother Shyam sows this and ran to help Ram Singh. As the poisonous effect was in the air and accumulated densely in that particular area of the field. When Shyam entered to field to save his brother, he also breath in the same infected air and got faint on the ground. Anyhow they were managed to take to nearest hospital by other villagers but it was too late and both lost their lives. Both the brother committed very silly mistakes unknowingly.

Major mistakes by Singh's brothers are:

a. Ram Singh was spraying the insecticide standing opposite to wind flow hence insecticide was inhaled by him unknowingly.

b. Shyam Sing entered to field to save his brother without using any safety measures and wearing any face mask.

What to do tips:

i. Avoid using any poisonous chemical when you are alone in field

ii. Always check the wind direction before spraying anything

iii. Always follow wind direction for spray to minimize the chemical movement to the person working

iv. Always were gloves, mask while working

v. Before helping anyone ensure your safety measures first.

Activities

Demonstration of safety devices and measures to be followed

Material Required: First-aid kit, gas mask, protective clothing, eye shields, hand gloves, shoes, and pictorial charts.

Procedure:

- Identifythedifferenttypesofprotectivedevicesusedwhilehandlingandapplyingthechemicals.
- Understand their Seth rough pictorial charts.
- Identify and understand about each item and its uses.
- Discussthedifferenttypesofchemicalpoisoninganditsimmediatesymptoms.
- Demonstrate the use of different protective devices.

- Prepare a chart showing different protective devices and their use.

Check Your Progress

Filling the Blanks

1. Use to..... while working with hazardous chemicals.
2. Coloured label show the .....pesticide.
3. To protect eye sand respiratory tract from toxic gases, Is used.
4. Hand gloves made up of are used to handle chemicals.
5. For inhaled poison, first-aid can be .

Multiple Choice Questions

1. Common symptoms of pesticide poisoning are:

(a)Headache (b)Vomiting and nausea

c)Difficulty in respiration (d)All of these

2. To prevent hazards at working place, availability of following materials should be ensured:

(a)SDS (b)First-aid kits

(c)Protective clothing (d)All of these

3. Emergency services comprise.

(a)Ambulance (b) Fire brigade

(c)Both(a)and(b) (d)None of these

4. Potentially dangerous creatures around house and office buildings include.

(a)lizards (b)snakes

(c)spiders and scorpions (d)All of these

5. What safety measures are required during the application of pesticides to the crop?

(a) Mixing the correct quantity of pesticide and clean water, and spraying during evening time

(b) Use of any type of nozzle and spray mixture

(c) Spraying of insecticides with flat nozzle against the direction of wind

(d) Spraying at any time during the day

6. What safe pesticide handling practices are required to be followed by the farmers?

(a) Wearing clean personal protective equipment (PPE)

(b) Wash hands with clean water before doing any activity which involves food intake or use of area around mouth, eyes, nostrils, etc.

(c) If an insecticide or its solution happens to fall on the clothing or body of an individual, give a proper wash to remove the pesticide completely.

(d) All of the above

Subjective Questions

1.What are the first aid treatment measures for chemical poisoning?

2.What protective devices are meant for protection in the agricultural field?

3. Define agro-chemicals.

4. Discuss the various harmful effects of agro-chemicals.

Match the Columns

A	B
1.Eye	(a)Rubber
2.Shoe	(b)Shield
3.Protectiveclothes	(c)Apron

Session 2: Safe Use of Agricultural Machinery

Agricultural field operations today are dependent on various agricultural machinery, tools, and equipment. Use of machinery demands great care with all the necessary safeguards.

The accidents associated with agricultural machineries are caused due to the following reasons:

- lack of adequate or proper training to operators
- poor maintenance of tools and machinery
- using a machine that is not right or suitable for the task at hand
- failure in following proper norms of a safe system of work

• missing or defective safety devices or machine guards, thus exposing the workers to accidents

• unsafe methods for clearing blockages on the premise

Checking the tools and machinery before use

Before starting to work with a tool or machinery, one must make sure that it is in a good working condition and safe to use. While specific needs would vary with the machine to be used, basic checks must always be adopted and exercised:

- Check the operator manual of the machine for pre-operative instructions and follow them as advised.
- Particular attention is warranted to items like brakes, wheels, moving parts of machine (if openly visible) and tires of tractors or vehicles.
- Make sure that the guards and protective covers are securely positioned so that these would not come out loose.
- Promptly repair or replace the defective or damaged parts of machine, if any.
- Stopping devices should be functioning correctly, for example, brak es, emergency stops (electrics witches), etc.
- While coupling, engaging or attaching equipment or apart with the machines, make sure that the coupling or attachment is properly fit and is of appropriate size or specification and is not loose. Don't use wrong or make shift coupling devices and pieces.
- Vehicles and moving machines must have clear rear view mirrors along with fit, fine and properly working reversing aids.
- If the guards over moving parts of a machine are missing, get them fitted out and properly covered before using the machine.

Daily or periodic mandatory inspection for the use of machinery

1. Check water, fuel, fan belts, etc.
2. Inspect the hydraulic lines for kinks, cracks and general wear and tear.
3. Once the engine is running, check hand and air brakes, this ens ures that the brakes will hold while loading.

4. Inspect the cracks in the metal which may cause equipment to b reak or the parts come off unexpectedly.
5. Keep a safe distance from the equipment when loading or unloading.
6. Take care if the reare any overhead power lines, particularly during loading and offloading, or while lift removing of the produce or materials.
7. Do discuss any unsafe actions that come to the notice of supervisors so that preventive measures can be taken.

Guidelines to avoid accidents and enhance safety while working with harvesting and threshing machinery

- Familiarise yourself with safety risks and measures to overcom e the same.
- Harvesting and threshing machines are most prone to debilitating accidents, *viz.*, crushing, cutting, seizing of bod parts, especially hands, feet and trunk. Caution the operators accordingly.
- During field operations with moving vehicles, machinery with moving parts, handling the moving part of a machine, always ensure t o wear tight clothing and hair cover to avoid entanglement.
- Never clean, maintain, adjust or clear jams when the machine is on.
- Stay clear of outlets, discharges, and all moving parts of the machine.
- If an equipment breaks down, don't just improvise it, get it repaired.
- Avoid coming close to the moving parts of a powered machine
- Never leave a machine with the engine running.
- Don't let children come near a machine while at work.
- Don't refuel a machine with engine running.
- Don't let flammable articles or substances (like fuel, straw, etc.) close to the working area or machine in operation.

- Do not oil, grease, or adjust the machine during operation. Wait for the engine and moving parts to come to a full stop before doing this. Remember, the feeding area of a thresher is the most dangerous. Do not let your hand or a loose sleeve of shirt enter the feeding area of a thresher.
- Completely avoid working on a petrol or diesel driven machine in a closed shed or garage. Exhaust fumes are dangerous for your health.

Protective measures during operating machinery

Use of protective clothing is an extra measure of protection. All workers operating the machines must wear protective clothing or personal protective equipment as a protection against accident or hazards. Also, make sure that the protective dress is safe and body fitting (not loose or with loose ends). Features of protective dress and equipment:

- Good fit, appropriate, and clean or well maintained.
- Safe and preventive storage to avoid damage, cuts and insect infestation
- No rough edges
- Over all body coverage using overalls, aprons, vests, socks, and gloves
- Prevent noise pollution while at work.
- Hard hats are always desirable for head protection.
- make sure protective clothing is available for different parts of the body.

Clothes must be kept clean, fully functional, and sanitised.

Activities

Demonstrate general inspection for the use of machinery.

Material required: Different types of equipment, user's guide, pen, and notebook

Procedure

- Identify and select the machinery.
- Check the different parts of machinery.
- Identify the open moving parts or feeding parts which pose hazard.

- Check assembling of each part of the equipment.
- Demonstrate the use of machinery after inspection.

Check Your Progress

Fill in the Blanks

1. During harvesting, ensure that the operators wear _____, and secure them to avoid entanglement.

2. Nobody should be allowed to _____ onto the machine while it is in motion.

3. Operators must wear _____clothing.

Multiple Choice Questions

1. What is necessary to check before starting the machinery?

(a) Farm operations

(b) Fill the fuel

(c) Check the tires

(d) Check the lights

2. What type of care is required to avoid any machinery accident?

(a) Using a machine that is unsuitable for the task

(b) Using casual approach for operation

(c) Working with missing or defective guards and other safety devices

(d) Following all the precautions during the operation.

3. Which of the following safety precautions are necessary while refueling of tractor or any other machinery?

(a) Engine in running condition

(b) Engine in off position

(c) Engine in off position and no open flame nearby

(d) All of these

Subjective Questions

1. Enlist the general inspection points to be observed before using the machinery.

2. Describe the health and safety points to be followed during combine harvesting.

3. Describe the use of protective clothing during machinery operations.

Answer Key

Module 1 Scope and Importance of Spice Crops

Session 1: Scope and Importance of Spice Crops

Fill in the Blanks

1. Spices, 2. Charaka, and Susruta, 3.63, 4. India, 5. Pharmaceutical, cosmetic, Perfumery, 6. Preservatives 7. Garlic

Multiple Choice Questions

1. b 2. d

Match the Column

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

Session 2: Classification of Spice Crops

Fill in the Blanks

1. King of Spices, 2. Test imparting, 3. one-year, 4. Perennial plant, 5. Bark

Multiple Choice Questions

1. c 2.b

Match the Column

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

Module 2 Soil and Climatic Requirement of Spice Crops

Session 1: Soil Requirement

Fill in the Blanks

1.soil, 2. plants, 3. Red Soils, 4. Cardamom, 5. V, 6. 2 mm, 7. Black to dark brown, 8. Red, 9. Brown

Multiple Choice Questions

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

Match the Column

1. b 2. g 3. a 4. c 5. d 6. e 7. f 8. h

Session 2: Climatic Requirement

Fill in the Blanks

1. Climate, 2. Weather, 3. Winter, 4. 80% to 100%, 5. 1800 m to 3500, 6. Tropical, 7. Nigella, 8. Temperate

Multiple Choice Questions

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

Match the Column

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

Module 3 Field Preparation and Nutrient Management of Spice Crops

Session 1: Field Preparation

Fill in the Blanks

1.soil, 2. Nursery, 3. temporary and permanent, 4. Flat, 5. Disease, 6. Pot, 7. Spade8. bill hook, 9. seed bed, 10. separate block

Multiple Choice Questions

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

Match the Column

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

Session 2: Manage the Soil Fertility

Fill in the Blanks

1. Carbon. Hydrogen and Oxygen, 2. Nitrogen, 3. Zn, 4. Chlorine, 5. Molybdenum, 6. Boron

Multiple Choice Questions

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

Match the Column

1. c 2. a 3. d 4. e 5. b 6. h 7. f 8. g

Module 4 Irrigation Management in Spice Crops

Session 1: Irrigation in Spice Crops and Methods and System of Irrigation

Fill in the blanks

1.Irrigation, 2. Crop, 3. Leaching, 4. Germination, 5. Not 6. Flood irrigation method, 7. furrow method, 8. Basin irrigation, 9. Evaporation, 10. 30 to70%

Multiple Choice Questions

1. a 2. b 3. b 4.a 5. b 6.c 7.a

Match the Column

1. f 2. d 3. h 4. a 5. b 6. g 7. e 8. c

Module 5 Health and safety measures at the workplace

Session 1: Safe Use of Agrochemicals

Fill in the Blanks

1. protective devices 2. toxicity, 3. gasmask, 4. Rubber, 5. Artificial respiration

Multiple Choice Questions

1. (d) 2. (d) 3. (c) 4. (d) 5. (a) 6.(d)

Match the Columns

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

Session 2: Safe Use of Agricultural Machinery

Fill in the Blanks

1. tight clothes, hair, 2. Climb, 3. protective

Multiple Choice Questions

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

Glossary

Spice: an aromatic or pungent vegetable substance used to flavour food.

Herb: any plant with leaves, seeds, or flowers used for flavouring, food, medicine, or perfume. "Bundles of dried herbs" any seed-bearing plant that does not have a woody stem and dies down to the ground after flowering.

Antiseptic: A substance (such as isopropyl alcohol or chlorhexidine) that destroys or inhibits the growth or action of microorganisms (such as bacteria) especially in or on living tissue (such as the skin or mucous membranes) clean the wound with an antiseptic.

Wound: An injury to the body (as from violence, accident, or surgery) that typically involves laceration or breaking of a membrane (such as the skin) and usually damage to underlying tissues

Aromatic plants: Aromatic plants are those that contain aromatic compounds – basically essential oils that are volatile at room temperature. These essential oils are odorous, volatile, hydrophobic and highly concentrated compounds. They can be obtained from flowers, buds, seeds, leaves, twigs, bark, wood, fruits and roots

Food preservatives: Food additives are substances added to food to maintain or improve its safety, freshness, taste, texture, or appearance. Food additives need to be checked for potential harmful effects on human health before they can be used.

Hydrosols: Hydrosols, also known as "flower waters," are produced by distilling fresh leaves, fruits, flowers, and other plant materials. With similar properties to essential oils, these aromatic waters are much less concentrated. Their aromas are often soft and subtle when compared to their essential oil counterpart.

Immunity: A condition of being able to resist a particular disease especially through preventing development of a pathogenic microorganism or by counteracting the effects of its products — see also active immunity, passive immunity.

Antioxidant: A substance that protects cells from the damage caused by free radicals (unstable molecules made by the process of oxidation during normal metabolism). Free radicals may play a part in cancer, heart disease, stroke, and other diseases of aging.

Antibacterial: Directed or effective against bacteria antibacterial soap an antibacterial drug.

Pharmaceutical: Pertaining to pharmacy or the art of preparing drugs.

Herbaceous plant: Herbaceous plants are plants that, by definition, have non-woody stems. Technically, all annual plants are herbaceous, because an annual is a non-woody plant. Annuals take it a step further and die altogether at the end of their lone growing season, both above the ground and below it.

Shrubs: Shrub, any woody plant that has several stems, none dominant, and is usually less than 3 m (10 feet) tall. When much-branched and dense, it may be called a bush. Intermediate between shrubs and trees are arborescences, or treelike shrubs, from 3 to 6 m tall.

Bud: A small lateral or terminal protuberance on the stem of a plant that may develop into a flower, leaf, or shoot.

Soil: Soil is the loose surface material that covers most land. It consists of inorganic particles and organic matter. Soil provides the structural support to plants used in agriculture and is also their source of water and nutrients.

Rainfed: Rainfed agriculture is a type of farming that relies on rainfall for water. Rainfed agriculture includes both permanent crops (such as rubber, tea, and coffee) as well as annual crops (such as wheat, maize, and rice). For example, tubers, a staple crop for sub-Saharan Africa, have been all but uninfluenced by the technological developments of the green revolution.

Porous: In gardening, porosity refers to the part of growing soil that is not covered by organic matter or soil particles.

Organic matter: Organic matter includes any plant or animal material that returns to the soil and goes through the decomposition process. In addition to providing nutrients and habitat to organisms living in the soil, organic matter also binds soil particles into aggregates and improves the water holding capacity of soil.

Organic carbon: Soil organic carbon is a measurable component of soil organic matter. Organic matter makes up just 2–10% of most soil's mass and has an important role in the physical, chemical and biological function of agricultural soils

Humus: More precisely, humus is the dark organic matter that forms in soil when dead plant and animal matter (including aerobic compost) breaks down further, specifically through the action of anaerobic organisms. Humus has

many nutrients that improve the health of soil, nitrogen being the most important.

Ploughing: The process of loosening and turning the soil is called ploughing (tilling). Before sowing the seeds, it is necessary to loosen and turn the soil in the fields as to break it to the size of the grains which is done with the help of three main implements or tools to plough are hoe and cultivator.

Harrowing: The definition of harrowing is a soil preparation method that is often used in conjunction with plowing to ready a field for seeding. Harrowing is performed with a harrow, and it is sometimes confused with plowing, as they may appear similar at first, but plows go deeper into the soil and are typically wider.

Planking: Planking is done to crush the hard clods to smoothen the soil surface and to compact the soil lightly. Thus, the field is made ready for sowing after ploughing by harrowing and planking. Generally sowing operations are also included in secondary tillage.

Crop rotation: Crop rotation, the successive cultivation of different crops in a specified order on the same fields, in contrast to a one-crop system or to haphazard crop successions.

Germination: Germination is usually the growth of a plant contained within a seed; it results in the formation of the seedling. It is also the process of reactivation of metabolic machinery of the seed resulting in the emergence of radicle and plumule.

Drainage: drainage, in agriculture, the artificial removal of water from land; drainage is employed in the reclamation of wetlands, in the prevention of erosion, and as a concomitant of irrigation in the agriculture of arid regions.

FYM fertilizer: FYM stands for Farm Yard Manure. It is prepared mainly from cow dung, cow urine, waste grass, and other dairy products. It is an organic fertilizer to maintain soil productivity.

Compost: Compost is defined as a carbon-rich fertilizer derived from organic materials, including livestock manures, and other organic materials or mixed materials used to supply nutrients to soils. Compost is used to improve soil structure through the addition of carbon and provide plant nutrients

Fertilizer: Fertilizer, natural or artificial substance containing the chemical elements that improve growth and productiveness of plants. Fertilizers enhance

the natural fertility of the soil or replace chemical elements taken from the soil by previous crops.

Soil sampling: Soil sampling assists in finding out what nutrients are currently in your field. Soil sampling is important as it; Measures the nutrients that are left in your field following harvest. Tells you which nutrients are lacking or are in excess throughout the soil in a field

Spade: Spade can be described as a simple Farm implement that has a long wooden handle and broad metal blade. Generally, a speed and a shovel look almost the same. The edge of a spade I mean the metal blade is sharp so that he can easily be driven into the soil when digging soil.

Auger: Any of various tools or devices with a helical shaft or part that are used for boring holes (as in wood, soil, or ice) or moving loose material (such as snow)

Homogeneity: In ecology, species homogeneity is a lack of biodiversity. Species richness is the fundamental unit in which to assess the homogeneity of an environment. Therefore, any reduction in species richness, especially endemic species, could be argued as advocating the production of a homogenous environment.

Shallow-rooted crop: Shallow-rooted crops have main root systems in the top 1 to 2 feet of soil. Examples are cabbage, cauliflower, lettuce, celery, sweet corn, onion, white potato, and radish. Moderately deep-rooted crops are those with the main root system in the top 1 to 4 feet of soil.

EC: Soil electrical conductivity (EC) is a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil health.

Relative humidity: It is the ratio of actual water vapour content to the saturated water vapour content at a given temperature and pressure expressed in percentage (%). Diurnal variation in relative humidity: Mean maximum relative humidity occurs in the early morning.

Frost: Frost refers to an event where temperature falls to the point where ice forms inside plant tissues and causes damage to the cells.

Crop residue: Crop residue is plant material remaining after harvesting, including leaves, stalks, roots.

Nursery: Nursery, place where plants are grown for transplanting, for use as stock for budding and grafting, or for sale. Commercial nurseries produce and distribute woody and herbaceous plants, including ornamental trees, shrubs, and bulb crops.

Transplanting: Plant or tree removed from one location and reset in the ground at another. Most small deciduous trees may be moved with no soil attached to their roots.

Nursery bed: It refers to a land, which is made free from weeds, stumps, stones, pebbles, etc., and is used for sowing of seeds to raise seedlings and multiplication of different species of plants through asexual means.

Growing media: Growing media are materials that plants grow in. Growing media is specifically designed to support plant growth and can either be a solid or a liquid. Different components are blended to create homemade and commercial growing media. Different types of growing media are used to cultivate various plants.

Plant propagation: Plant propagation is the process of increasing the number of plants of a particular species or cultivar. There are two primary forms of plant propagation: sexual and asexual. In nature, propagation of plants most often involves sexual reproduction, or the production of viable seeds.

Mother plant: A mother plant is a plant grown for the purpose of taking cuttings or offsets in order to grow more quantity of the same plant.

Deficiency: When plants don't have enough of a specific nutrient they may display a range of symptoms, varying from morphological impairments (i.e., stunting), to chlorosis or necrosis, to premature seed set and ripening. Deficiency in any given nutrient comes with the presentation a specific symptom or combination of symptoms.

Necrosis: Death of a circumscribed area of plant or animal tissue as a result of disease or injury. Necrosis is a form of premature tissue death, as opposed to the spontaneous natural death or wearing out of tissue, which is known as necrobiosis.

Enzyme: Enzymes are proteins that work as the catalysts in the chemical reactions that take place. The catalysts are responsible for carrying out a particular reaction and expediting it.

Lodging: Lodging is the permanent displacement of cereal stems from their vertical position and usually only occurs after the ear or panicle has emerged. This can reduce yield by up to 80% and causes several knock-on effects including reduced grain quality, greater drying costs, and slower harvest.

Apical dominance: In botany, apical dominance is the phenomenon whereby the main, central stem of the plant is dominant over (i.e., grows more strongly

than) other side stems; on a branch the main stem of the branch is further dominant over its own side twigs.

Broadcasting: Broadcast planting is the method of sowing seeds by scattering them over the surface of the soil. In this process, the seeds are scattered on the seedbeds either mechanically or manually. In the broadcasting method of sowing, the seeds are spread uniformly and are then covered with planking.

Top dressing: It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants

Foliar spray: It is the application of fertilizers to foliage of the crop as spray solution is known as foliar spray. This method is suitable for application of small quantities of fertilizers, especially micronutrients. Major nutrients can also be applied by this method when there is no adequate moisture in top layer of soil.

Wound: an injury that involves cutting or breaking of bodily tissue.

Aromatic plants: Aromatic plants are a special kind of plants used for their aroma and flavour. Many of them are also used for medicinal purposes. Aromatic plants are from a numerically large group of economically important plants.

Hydrosols: The word hydrosol is a chemistry term meaning “water solution.” * They are an important co-product of distillation - the condensate of water coproduced during the steam (hydro-distillation) of plant material for aromatherapeutic purposes.

Organic matter: Organic matter, organic material, or natural organic matter refers to the large source of carbon-based compounds found within natural and engineered, terrestrial and aquatic environments.

Infiltration: Infiltration is the process by which water on the ground surface enters the soil. It is commonly used in both hydrology and soil sciences.

Farmyard manure: Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left-over material from roughages or fodder fed to the cattle.

Soil aeration: Soil aeration is critical for optimal functioning of the soil and it is generally governed by three factors: (1) soil porosity, (2) soil water content, and (3) the oxygen demand by soil organisms including microorganisms and plant roots.

Porosity: Porosity refers to how many pores, or holes, a soil has. The porosity of a soil is expressed as a percentage of the total volume of the soil material. Porosity is an important measurement in areas where drinking water is provided by groundwater reserves.

Seedling: A seedling is a young plant that has been grown from a seed.

RNA: Ribonucleic acid, a nucleic acid present in all living cells.

ATP: Adenosine triphosphate, also known as ATP, is a molecule that carries energy within cells. It is the main energy currency of the cell.

ADP: Adenosine diphosphate (ADP), also known as adenosine pyrophosphate (APP), is an important organic compound in metabolism and is essential to the flow of energy in living cells.

RuDP carboxylase: Ribulose bisphosphate carboxylase. (Science: enzyme) A copper protein that catalyses the formation of 2 moles of 3-phosphoglycerate from ribulose 1,5-biphosphate in the presence of carbon dioxide and is responsible for carbon dioxide fixation in photosynthesis.

Afforestation: Afforestation is the establishment of a forest or stand of trees (forestation) in an area where there was no previous tree cover. Many government and non-governmental organizations directly engage in afforestation programs to create forests and increase carbon capture.

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

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

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

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

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

Poison: substance capable of causing illness or death.

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

List of Credits

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Courtesy: https://goo.gl/uixDC7

Figure 5.4: Signage for pesticide application in a field

Courtesy: https://goo.gl/XzFfqn

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