Solanaceous Crop Cultivator

(Job Role)

Qualification Pack: Ref. Id. AGR/Q0402)
Sector: Agriculture

Textbook for Class IX

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NCERT
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FOREWORD

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values such as self-reliance, creativity and cooperation. Through work one learns to find one's place in the society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated in society. Work involves interaction with material or other people (mostly both), thus creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and the workplace. The NCF–2005 also emphasises on Vocational Education and Training (VET) for all those children who wish to acquire additional skills and/or seek livelihood through vocational education after either discontinuing or completing their school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or 'last-resort' option.

As a follow-up of this, NCERT has attempted to infuse work across the subject areas and also contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications according to levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learner must possess regardless of whether they are obtained through formal, non-formal or informal learning. The NSQF sets common principles and guidelines for a nationally

recognised qualification system covering Schools, Vocational Education and Training Institutions, Technical Education Institutions, Colleges and Universities.

It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT has developed learning outcomes based modular curricula for the vocational subjects from Classes IX to XII. This has been developed under the Centrally Sponsored Scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Human Resource Development.

This textbook has been developed as per the learning outcomes based curriculum, keeping in view the National Occupational Standards (NOS) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude.

I acknowledge the contribution of the development team, reviewers and all the institutions and organisations, which have supported in the development of this textbook.

NCERT would welcome suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

HRUSHIKESH SENAPATY
Director
National Council of Educational
Research and Training

New Delhi
June 2018

About the Textbook

Agriculture is an important part of India's economy, which accounts for about 18 per cent of country's GDP and occupies almost 43 per cent of India's geographical area. The Agriculture Industry employs a large number of people in the organised, as well as, the unorganised sector. The requirement of skilled workforce in this sector is increasing by the day. The various job roles, such as Solanaceous Crop Cultivator, Tuber Crop Cultivator, Floriculturist-open cultivation, Floriculturist-protected cultivation, Micro Irrigation Technician, etc., are in high demand by States for preparing skilled manpower.

A Solanaceous Crop Cultivator specialises in the cultivation of solanaceous crops as per the practices recommended for a particular agro-climate zone, type of soil, rainfall pattern and climatic conditions to achieve the desired yield. This textbook for the job role of a Solanaceous Crop Cultivator has been developed to impart knowledge and skills through hands-on-learning experience, which forms a part of experimental learning. It focuses on the learning process of an individual, therefore, the learning activities are student-centred rather than teacher-centred.

The textbook has been developed with the contribution of subject experts, vocational teachers, industry experts and academicians. Adequate care has been taken to align the content of the textbook with the National Occupational Standards (NOSs) for the job role so that the student acquires the necessary knowledge and skills as per performance criteria mentioned in the respective NOS of the Qualification Pack (QP). The textbook has been reviewed by experts so as to ensure that the content is not only aligned with the NOSs, but is also of high quality. The NOSs for the job role of a Solanaceous Crop Cultivator covered through this textbook are as follows:

1. AGR/N0408 — Seed selection and seedling production
2. AGR/N0409 — Soil preparation and transplanting in solanaceous crops
3. AGR/N0401 — Soil nutrient management in vegetable crops
4. AGR/N9903 — Maintain health and safety at a workplace

Unit 1 of the textbook introduces horticulture and its importance. Unit 2 focuses on seed selection and seedling production. It includes important varieties of solanaceous crops, nursery bed preparation and seed sowing. Unit 3 deals with field preparation and transplanting in solanaceous crops, whereas, Unit 4 focuses on the soil nutrient management in vegetables crops. It includes macro and micro-nutrients present in soil and different manures and fertilisers that can be used in vegetable crops. Unit 5 deals with the occupational health, hygiene and first aid practices that have to be followed in a farm.

We hope this textbook will be useful for students and teachers, who opt for this job role. Suggestions for improving this textbook are welcome.

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Contents

Do You Know ?

According to the 86th Constitutional Amendment Act, 2002, free and compulsory education for all children in 6-14 year age group is now a Fundamental Right under Article 21-A of the Constitution.

EDUCATION IS NEITHER A PRIVILEGE NOR FAVOUR BUT A BASIC HUMAN RIGHT TO WHICH ALL GIRLS AND WOMEN ARE ENTITLED

Give Girls Their Chance !

Unit 1

Introduction to Horticulture

Introduction

Horticulture is a science, as well as, an art of production, utilisation and improvement of horticultural crops, such as fruits and vegetables, spices and condiments, ornamental, plantation, medicinal and aromatic plants.

Horticultural crops require intense care in planting, carrying out intercultural operations, manipulation of growth, harvesting, packaging, marketing, storage and processing. India is the second largest producer of fruits and vegetables in the world after China. In India, about 55–60 per cent of the total population depends on agriculture and allied activities. Horticultural crops constitute a significant portion of the total agricultural produce in India. They cover a wide cultivation area and contribute about 28 per cent of the Gross Domestic Product (GDP). These crops account for 37 per cent of the total exports of agricultural commodities from India.

Session 1: Horticulture and its Importance

The term horticulture is derived from two Latin words *hortus,* meaning 'garden', and *cultura* meaning 'cultivation'. It refers to crops cultivated in an enclosure, i.e., garden cultivation.

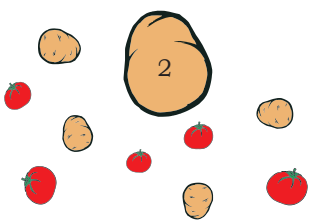
Features and importance

Horticulture crops perform a vital role in the Indian economy by generating employment, providing raw material to various food processing industries, and higher farm profitability due to higher production and export earnings from foreign exchange.

(a) Horticulture crops are a source of variability in farm produce and diets.
(b) They are a source of nutrients, vitamins, minerals, flavour, aroma, dietary fibres, etc.
(c) They contain health benefiting compounds and medicines.
(d) These crops have aesthetic value and protect the environment.
(e) The comparative production per unit area of horticultural crops is higher than field crops, e.g., paddy crop gives a maximum yield of only 30 q/ha, while banana crop gives 300–450 q/ha and grapes 90–150 q/ha.
(f) Fruit and plantation crops can be cultivated in places where the slope of land is uneven or undulating. Mango and cashew nut are cultivated on a large scale in hilly and hill back area of the Konkan region.
(g) The crops are useful for cultivation in wasteland or poor quality soil.
(h) Such crops are of high value, labour intensive and generate employment throughout the year.
(i) Horticultural produce serves as raw material for various industries, such as processing, pharmaceutical, perfumery and cosmetics, chemical, confectionery, oils and paints, etc.
(j) They have national and international demand and are a good source of foreign exchange.

Present status of horticultural crops in India

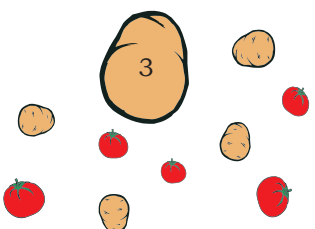
According to the data provided by the Government of India for 2016–17, horticulture crops in India are being cultivated in 24 million hectares, which is about 7 per cent of India's total cropped area. The annual horticultural produce is estimated around 295 million tonnes, which includes 175 million tonnes of vegetables and 92 million tonnes of fruits in



2016–17. India is the largest producer of okra (lady's finger). Among vegetables, India ranks second in the production of potato, onion, cauliflower, brinjal and cabbage. In fruits, it is the largest producer of banana, mango, guava, lemon and papaya. Mango, walnut, grapes, banana and pomegranate are the major fruits exported, while onion, okra, bitter gourd, green chilly, mushroom and potato have more exotic demand. Fruits and vegetables are mostly exported to the UAE, Bangladesh, Malaysia, the Netherlands, Sri Lanka, Nepal, the UK and Saudi Arabia.

Table 1.1: Important horticultural crops and their growing regions in India

State	Major Horticultural Crop(s)
Northern	
Haryana	Bottle gourd, marigold
Himachal Pradesh	Apple, potato
Jammu and Kashmir	Apple
Punjab	Citrus fruits
Uttarakhand	Potato
Uttar Pradesh	Mango, banana, potato, sweet potato, watermelon, bottle gourd, jasmine
Rajasthan	Pomegranate, onion, jasmine, tuberose
Western	
Chhattisgarh	Bottle gourd, rose
Goa	Coconut, arecanut, cashew nut
Gujarat	Banana, papaya, sapota, pomegranate, potato, onion, tomato, rose, marigold
Maharashtra	Mango, banana, grapes, citrus fruits, sapota, pomegranate, chilli, onion, rose, chrysanthemum, tuberose, marigold
Madhya Pradesh	Citrus fruits, papaya, pomegranate, chilli, potato, sweet potato, onion, bottle gourd, tomato, chrysanthemum, marigold
Southern	
Andhra Pradesh	Mango, banana, grapes, citrus fruits, papaya, sapota, pomegranate, coconut, chilli, watermelon, tomato, jasmine, tuberose, marigold
Karnataka	Mango, banana, grapes, papaya, sapota, pomegranate, coconut, chilli, onion, watermelon, tomato, rose, chrysanthemum, jasmine, tuberose, marigold
Kerala	Banana, coconut, sweet potato, chrysanthemum, jasmine



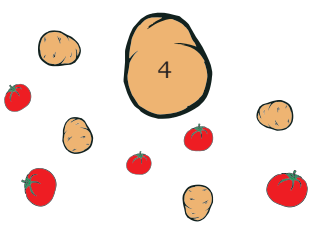
Tamil Nadu	Banana, papaya, sapota, coconut, chrysanthemum, jasmine, tuberose
Telangana	Mango, citrus fruits, tomato
Eastern	
Andaman and Nicobar Islands	Coconut
Bihar	Mango, chilli, potato, onion, bottle gourd
West Bengal	Coconut, potato, sweet potato, watermelon, rose, marigold
Odisha	Coconut, sweet potato, watermelon, bottle gourd
North-eastern	
Arunachal Pradesh	Turmeric, ginger
Assam	Banana, papaya, pomegranate, coconut, tuberose
Meghalaya	Papaya, arecanut, ginger
Sikkim	Ginger
Tripura	Papaya, arecanut, turmeric

Source: *Horticulture Statistics at a Glance 2017,* National Horticulture Board, Government of India

Prospects of horticultural crops in India

Diverse agro-climatic conditions in India ensure the production of all types of fresh fruits, vegetables and medicinal plants in different parts of the country (Table1.1). Health consciousness among people is increasing. Majority of the population in India is vegetarian. As a result, the demand of fruits and vegetables is also high. The production of horticultural commodities is far less as compared to the existing demand in the country. So, there is a vast scope to produce more horticultural crops. Major areas in the country are suitable only for horticultural crops, like mango, tea, coconut and arecanut, as they are non-arable, rocky, stony, marshy, undulated and sloppy.

There has been an increase in irrigation facilities but there are crops, which even with little watering, can survive. One only needs to ensure adequate water management. Some dry land horticultural crops, like *jamun*, *ber*, tamarind, wood apple, custard apple, *ramphal*, etc., can be grown on rainfed land also. Compared to other countries, agricultural labour and other agricultural inputs are far cheaper and easily



available here, which reduce the cost of production and generate more profit. High return, coupled with government assistance, through various schemes and financial aid, attract the rich and poor, trained and educated people towards horticulture. This leads to the use of intensive methods and improved technology in the production of horticultural crops. Awareness of storage and processing methods also increase the availability of the produce, job opportunity and income generation.

Employment opportunities in horticulture

The horticultural industry offers a variety of jobs, both directly and indirectly. Many jobs require knowledge and training in horticulture. The level of training could be vocational or at the college level. The nature of work may be indoor or outdoor. Intense manual labour or paperwork in office may be involved. The following are the identified categories of jobs that require varying degrees of familiarity with horticulture:

Nursery operation

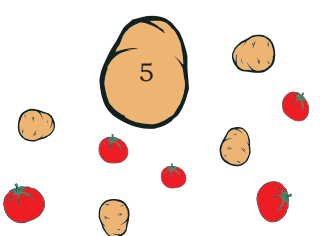
(a) Nursery manager (coordinates the entire nursery operations)
(b) Propagator (develops quality planting material)
(c) Field supervisor (supervises and plans fieldwork)
(d) Plant technician (advises and provides guidance on plant care)
(e) Salesperson (works on the promotion and sale of plant material)

Turf grass operation

(a) Landscape technician (establishes and maintains landscape)
(b) Golf course architect (designs a golf course)
(c) Golf course superintendent (supervises the construction and maintenance of the golf course)

Crop production

(a) Farm manager (manages the horticulture farm)
(b) Crop grower (produces vegetables, fruits and flowers)



Florist operation

(a) Floral designer (creatively arranges flowers)
(b) Store manager (manages and supervises the store of the farm)
(c) Plant rental supervisor (manages plants and pots, and does floral arrangements on rent)

Education

(a) Teacher/trainer (teaches horticulture in formal or informal system)
(b) Researcher (conducts research to develop new products and varieties)
(c) Extension person (disperses innovative techniques and methods among people)

Industrial operation

The horticultural industry has spawned a number of supporting or service industries, including the following:

Developer or producer

Agro-chemicals

The horticulture industry depends on a variety of chemicals, including fertilisers, pesticides and growth hormones. These chemicals are called agro-chemicals.

Farm machinery

Machinery, tools and implements are required for preparing the land, planting, cultivation, spray, harvest, store and packaging. Engineers design and construct the tools and machinery required for extensive and intensive production of horticultural plants. Home garden versions of some of these machineries and equipment are also available.

Distributors

Horticultural products need to be transported from the areas of production to nearby and distant markets, and ultimately, to consumers. Because of their highly perishable nature and in order to retain their quality for a long duration, horticultural products require special care and handling in transportation. It requires special personnel to look after this aspect.

What have you learned?

Now, I am able to:

- understand what is horticulture and its importance.
- understand the present status and prospects of horticulture in the country.
- know about nutritional value of fruits and vegetables.

Practical Exercises

Activity 1: Prepare a poster or a chart depicting the nutritional importance of horticultural crops.

Material required: Stickers, colour pencils, paper, paper clips, board pins, drawing board and glue

Procedure

- Collect or cut the pictures of fruits and vegetables from a chart purchased from the market.
- Fix the chart paper on a drawing board or a plane surface with the help of board pins.
- Outline the border of the chart.
- A sketch chart consists of cells of different sizes.
- Name the columns on the chart.
- Paste the picture of a fruit or a vegetable in each cell.
- Fill in the information about the fruit or vegetable in the cell opposite to the figure.

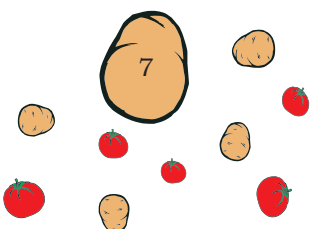
S. No.	Nutrient	Important source	Importance/ deficiency causes	Picture
1.	Vitamin A	Carrot	Night blindness	
2.	Vitamin B_1	Spinach	Beri beri	
3.	Vitamin B_2	Cauliflower	Ulcer of the mouth	
4.	.....	.....		
5.	.....	.....		

Activity 2: Enlist the major horticultural crops grown in your locality.

Material required: Branches or leaves of horticultural crops, sticking tape, A–4 size white paper, newspaper, etc.

Procedure

- Collect the leaves of different fruit and vegetable crops in your vicinity.
- Trace the specimen in the right side on a newspaper.
- Cover it with another newspaper and keep it under a heavy thing for a few days.



- This will remove moisture from the leaves and they will become partially dry.
- Stick the specimen with the help of a sticking tape on the A–4 sheet.
- Label the specimen.

Check Your Progress

Fill in the Blanks

1. India ranks _____ in fruit and vegetable production in the world.
2. Latin word *hortus* means _____ and _____ means 'cultivation'.
3. _____ crops are of high value but labour intensive.
4. _____ is the largest producer of okra.
5. India ranks _____ in the production of bananas.
6. Horticultural crops, like mango, tea and coconut can be grown on _____.

Descriptive Questions

1. Define horticulture.

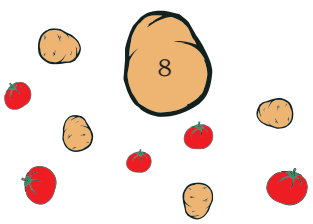
_____
_____
_____

2. Write the importance of horticulture.

_____
_____
_____

3. Explain the employment opportunities in horticulture.

_____
_____
_____



Session 2: Branches of Horticulture and Special Horticultural Operations

Horticulture is perhaps the most important branch of agriculture. It is further divided into four different branches as shown in Fig. 1.1.

Fig. 1.1: Branches of horticulture

Pomology

The term is derived from Latin words *poma* and *logus*. *Poma* means 'fruit' and *logus* means 'study, knowledge or discourse'. It can be defined as a branch of horticulture, which deals with the scientific study of fruit crops (Fig. 1.2).

Fig. 1.2: Fruit cultivation

Olericulture

The term is derived from Latin words *olerus* meaning 'vegetables' and *cultura* meaning 'cultivation'. It can be defined as a branch of horticulture, which deals with the scientific study of vegetable crops (Fig. 1.3).

Floriculture

The term floriculture is derived from Latin words *florus* and *cultura*. Florus means 'flower' and *cultura* means 'cultivation'. It can be defined as a branch of horticulture, which deals with the scientific study of flowering and ornamental crops (Fig. 1.4). Landscaping is the art of beautifying a piece of land using garden designs, methods and plant material. Professionals who do landscaping are called 'landscape architects'.

Fig. 1.3: Vegetable cultivation

Post-harvest technology

It is a branch of horticulture, which deals with the principles and practices of handling, packaging and processing of harvested crops to increase their storage life and availability.

Vegetable crops are different from fruit crops. Some important differences between them are given in Table 1.2.

Fig. 1.4: Flower cultivation

Table 1.2: Difference between fruits and vegetables

S. No.	Fruits	Vegetables
1.	Most fruit plants are perennials.	Most vegetables are annuals.
2.	Fruit plants are generally woody in nature.	Vegetable plants are, generally, herbaceous and succulents.
3.	They are commercially propagated asexually.	They are commercially propagated sexually (by seed).
4.	Fruit plants require special cultural practices, i.e., training, pruning, etc.	Vegetables are seasonal and only staking and pruning are required in some crops.
5.	Fruits are mostly consumed fresh after ripening.	Most vegetables require cooking for consumption.

Classification of vegetable crops

If the growing of each vegetable is dealt with in detail, it will lead to too much repetition. It is, therefore, desirable to classify vegetable crops into certain groups as per their similarities (Fig. 1.5). This will also help in studying them easily.

Based on the nature of plant (stem)

(a) *Herbaceous and succulents*: Leafy vegetables
(b) *Shrubs*: Brinjal, chilli, tomato, etc.
(c) *Trees*: Drumstick, jackfruit, etc.
(d) *Vines*: Cucurbits, etc.

Based on the life span (from seed-to-seed)

(a) *Annuals*: The life span of annual plants or annuals is a season or a year, e.g., brinjal, chilli, cabbage, cauliflower, cucurbits, tomato, leafy vegetables, etc.
(b) *Biennials*: The life span of biennials is of two seasons or two years, e.g. onion, radish, carrot, etc.
(c) *Perennials*: The life span of perennial plants is more than two years, e.g., drumstick (*moringa*), asparagus (*shatawari*), pointed gourd (*parwal*), etc.

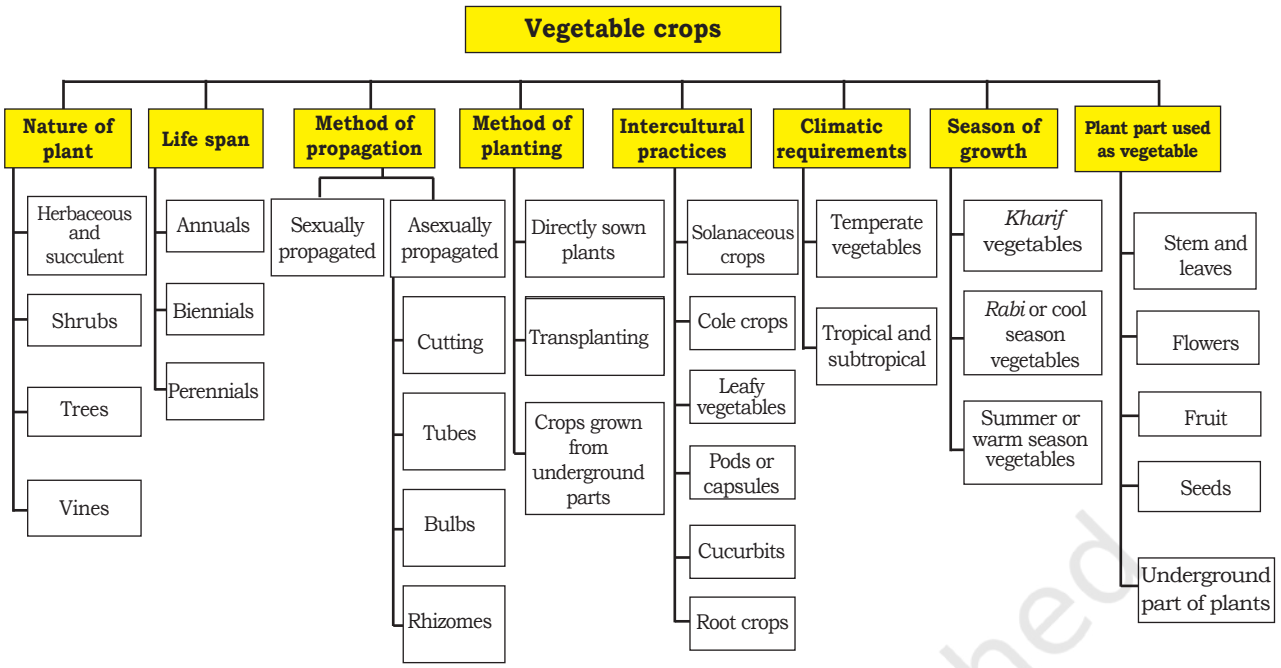


Fig. 1.5: Classification of vegetable crops

Based on the method of commercial propagation

(a) *Sexually propagated (by seed)*: Brinjal, chilli, cauliflower, cabbage, cucurbits, tomato, leafy vegetables, etc.

(b) *Asexually propagated (vegetative parts)*: Asparagus, dioscorea, potato, sweet potato, onion, garlic, *taro*, yam, etc.

- *Cuttings*: Asparagus
- *Bulbs*: Onion, garlic
- *Rhizomes*: Colocasia, ginger, coleus
- *Tubers*: Potato, sweet potato

Based on the method of planting

(a) *Directly sown plants*: Okra, leafy vegetables, carrot, radish, peas and beans

(b) *Transplanting*: Tomato, brinjal, chilli, cauliflower, cabbage, onion, potato, sweet potato, cassava, pointed gourd, etc.

(c) *Crops grown from underground parts*

- *Root vegetables*: Radish, carrot, turnip, beetroot
- *Rhizome*: Colocasia, ginger
- *Bulb*: Onion, garlic
- *Tuber*: Potato, sweet potato, cassava and yam

Based on intercultural practices

(a) *Solanaceous crops*: Tomato, brinjal, chilli, bell pepper, potato
(b) *Cole crops*: Cabbage, cauliflower, *knol-khol*, broccoli and Brussels sprouts
(c) *Leafy vegetables*: Spinach, *methi*, lettuce and *chaulai* (*amaranthus*)
(d) *Pods or capsules*: Pea, cowpea, cluster bean, okra
(e) *Cucurbits*: Gourds, melons, cucumber, pumpkin
(f) *Root crops*: Carrot, radish, turnip, beetroot

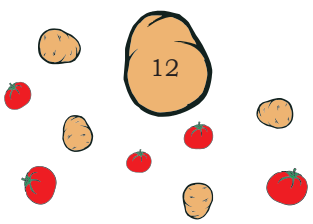
Based on climatic requirements

(a) *Temperate vegetables*: Radish, potato, carrot, cabbage, cauliflower, *knol-khol*, broccoli, etc.
(b) *Tropical and subtropical vegetables*: Watermelon, musk melon, cucumber, tomato, brinjal, chilli, etc.

Based on the season of growth

In India, seasonal or annual vegetables can be classified according to their season of growth. Season of growth is the period in which the climatic conditions are favourable for the growth and production of a crop.

(a) *Kharif season vegetables*: These may also be called rainy season crops. These vegetables require hot and humid climate. The season tentatively starts from 7 June and lasts till 6 October every year. The sowing of seeds may be undertaken from mid-May to late July. Vegetables, like okra, cowpeas, cluster beans, etc., are examples of *Kharif* vegetables.
(b) *Rabi or cool season vegetables*: These may also be called cool or winter season crops as these vegetables require low temperature for growth. The season tentatively starts from 7 October and lasts till 6 February. The sowing of seeds may be undertaken from mid-September to late October. Vegetables, like peas, radish, carrot, cauliflower, cabbage, *knol-khol*, leafy vegetables, etc., are examples of *Rabi* vegetables.
(c) *Summer or warm season vegetables*: The season tentatively starts from 7 February and lasts till 6 June. The sowing of seeds may be undertaken



from mid-January to late February. These crops require hot and dry climatic conditions for better growth and maximum production. Cluster bean, musk melon, cucumber, watermelon, etc., are summer season vegetables.

Based on plant part used as vegetable

(a) *Stem and leaves*: Cabbage, lettuce, spinach, *methi*, coriander, amaranthus, etc.

(b) *Flowers*: Broccoli (head 'flower buds'), cauliflower (curd 'pre-floral stage'), etc.

(c) *Fruits*: There are various stages where the fruits of vegetable crops can be harvested for consumption, such as

- *Ripened fruits*: Watermelon, musk melon, tomato, etc.
- *Immature and tender fruits*: Cucumber, bottle gourd, bitter gourd, ridge gourd, okra, brinjal, green chilli, cowpea, French beans, dolichos beans, etc.

(d) *Seeds*: Peas, etc.

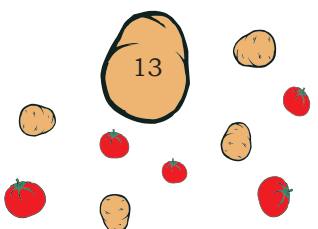
(e) *Underground parts of plant*

- *Taproot*: Tapering root growing vertically downward, e.g., carrot, radish, etc.
- *Bulb*: A fleshy leaved storage organ in some vegetables sending adventitious roots downward and leaves upward, e.g., onion, garlic, etc.
- *Tuber*: Thick, short and rounded underground stem with modified nodes and buds, e.g., potato, sweet potato, etc.
- *Rhizome*: Underground root-like stem having roots and shoots, e.g., colocasia, ginger, etc.

Important horticultural operations

Training

When a plant is made to grow with or without support, in a desired fashion by removing or fastening some of its parts with a view to give it a better framework or shape, the operation is called 'training'.



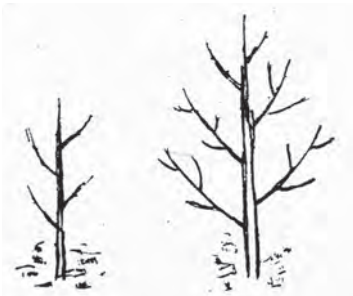


Fig. 1.6: Central leader system

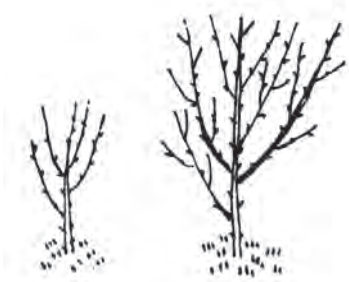


Fig. 1.7: Open centre system

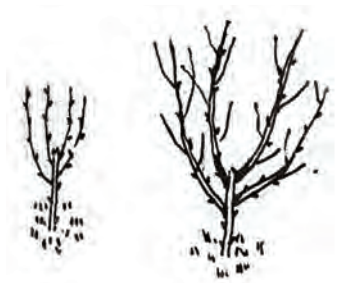


Fig. 1.8: Modified leader system

System of training

There are three systems of training in fruit trees:

Central leader system

In this system, the main stem of a tree is allowed to grow straight from the ground level to the top, which is called the central axis of the tree. The smaller side branches grow from this central axis in various directions (Fig. 1.6). Such a tree grows tall and bear fruits mostly near the top. The lower branches, gradually, become less vigorous and bear less fruits.

Open centre system

In this system, the main stem of a tree is allowed to grow up to a desired height and the top is headed to induce lateral branches, resulting in a low-headed and open at the centre tree. In this system, the sunlight reaches all branches and the crop is borne closer to the ground (Fig. 1.7). It facilitates harvesting and thinning of fruits, as well as, plant protection operations.

Modified leader system

This system is the modification of the central leader system and the open centre system (Fig. 1.8). The main stem grows for a few years, and after some time, lateral branches are induced to grow, which are widely spaced and spread on all sides not as in the open centre system. Thus, the tree is fairly strong and moderately spread, allowing easy orchard management operations.

Precautions taken during the training of fruit trees

- First, remove the branches arising from the main or scaffold limbs after maintaining only one vigorous branch, which is developed at a wider angle.
- Remove the branches turning towards the central axis from their bases.
- Remove suckers, which arise from the roots or underground parts of the stem or are very close to the crown. This is commonly observed in guava and pomegranate trees.
- Remove certain loop side growth to maintain the balance and framework of the tree.

Pruning

Judicious removal of any part of a plant to divert sap towards its producing areas, leading to an improvement in the quality of yield is called 'pruning'. It is done during the later stage of plant life when it becomes ready to produce flowers and fruits. Decayed parts can also be pruned off (Fig. 1.9).

Fig. 1.9: Pruning in a rose plant

Objectives of pruning

- to maintain flowering and fruiting balance
- to obtain regular bearing in fruits
- to remove pest-infected branches
- to ensure adequate sunlight for plant growth
- to maintain a balance between vegetative and reproductive growth stages

Types of pruning

Thinning out

When a shoot or a branch is removed entirely without leaving any stub is called 'thinning out'.

Heading back

When the terminal portion of a branch or a shoot is removed partially, leaving the basal portion intact, it is called 'heading back'.

Extent of pruning

If a small portion of a terminal of a branch or shoot is removed, it is called 'light pruning'. When a longer terminal portion is removed, it is called 'medium pruning', and depending upon its severity, it can be described as 'heavy pruning'.

Fig. 1.10: Staking in tomato crop

Staking

Staking in tomato crop

As shown in Fig. 1.10, staking is a practice of supporting tomato plants, especially of indeterminate type, to keep the plants and fruits off ground.

Advantages of staking

- It provides support to a plant.
- It keeps fruits above the ground and helps in maintaining the health of the plant.
- There are lesser chances of plants getting infested with pests and diseases.
- It facilitates spraying and dusting of pesticides and fungicides.

Practices for inducing flowering

Bending

In this operation, erect growing branches of guava trees are bent towards the ground without breaking them.

Notching

A small notch of bark, particularly, just above the bud is removed to accumulate nitrogen and induce vegetative growth from the bud. The branches are notched below the bud to accumulate carbohydrate and induce an individual bud to turn into a fruitful one. This practice is followed on a large scale in fig plants.

Topping and pinching

It includes the removal of succulent terminal shoots or just pinching of the last small terminal portion of a shoot. It is practised in fruit plants or vines, which throw shoots that are fast growing, thus, diverting the sap flow to the terminal ends.

Bahar treatment

Some fruiting plants have vegetative and reproductive growth 3–4 times a year. This behaviour of plants in an orchard is not desirable. One good crop at a required time is more desirable for decent economic returns. Fruits developing and maturing at one time facilitate orchard fertilisation, irrigation, harvesting and other such operations.

Transplanting

It is an agronomical practice, in which seedlings are moved and planted in growing places. In solanaceous crops, seedlings are ready after 4–5 weeks of sowing or

when they attain the 4–5 leaf stage. Seedlings should be hardened (it is a process of withholding watering for 4–5 days to reduce the moisture content and develop a water stress condition) before transplanting them. Solanaceous crop seedlings are transplanted on one side of the ridge bed or in flat beds, depending upon the crops or the facilities a grower can provide.

What have you learned?

Now, I am able to:

- differentiate between the different branches of horticulture.
- explain the classification of vegetable crops.
- understand the growing regions of horticultural crops.

Practical Exercises

Activity 1: Prepare a chart for major horticultural crops in your locality.

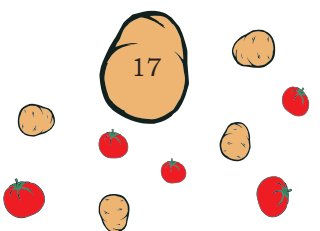
Material required: Colour pencils, notebook, pen, scale and eraser.
Procedure: Prepare the chart with crops available in your locality in the following way:

S. No.	Name of the crop	Nature of the crop	Part used as food
1.	Tomato	Shrub	Fruits
2.	Radish	Herbaceous	Taproot
3.	Cucumber	Vine	Fruit
4.	.....	.....	.....
5.	.....	.....	.....

Check Your Progress

Fill in the Blanks

1. Based on the life span, onion is a _____ crop.
2. The edible part of cauliflower is known as_____.
3. Plants having a life span of one year or one season are called _____.
4. In India, *Rabi* season starts from _____.
5. Watermelon is a _____ season crop.



Multiple Choice Questions

1. _____ is a crop that belongs to cucurbits.
   (a) Chilli (b) Cucumber
   (c) Drumstick (d) Asparagus
2. Cabbage grows well in _____.
   (a) winter (b) summer
   (c) rainy (d) all through the year
3. We consume _____ part of radish.
   (a) rhizome (b) bulb
   (c) tuber (d) taproot
4. Drumstick is an example of _____ vegetable.
   (a) annual (b) biennial
   (c) perennial (d) none of the above
5. The Latin word *olerus* means _____.
   (a) fruit (b) vegetable
   (c) flowers (d) root
6. The removal of succulent terminal shoots from a plant is called _____.
   (a) bending (b) notching
   (c) pinching (d) bahar treatment

Descriptive Questions

1. What are the different branches of horticulture?
   _____
   _____
   _____
2. Classify vegetable crops based on the plant part used as a vegetable.
   _____
   _____
   _____
3. Distinguish between fruit and vegetable.
   _____
   _____
   _____
4. Describe *Kharif* and *Rabi* vegetables.
   _____
   _____
   _____
5. With examples, name the underground part of plants used as vegetable.
   _____
   _____
   _____

6. What is training? What are different systems of training?

_____

_____

_____

7. What do you mean by pruning? Explain the different types of pruning.

_____

_____

_____

8. Explain the following:

(a) Bending: _____

_____

_____

(b) Notching: _____

_____

_____

(c) Pinching: _____

_____

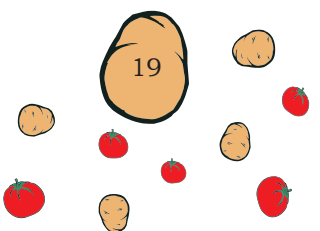
_____

Match the Columns

Plant parts	Vegetables
1. Stem and leaves	(a) Cowpeas, French beans
2. Curd	(b) Peas
3. Ripened fruits	(c) Gourds
4. Tender fruits	(d) Tomato, melons
5. Seeds	(e) Cauliflower
6. Immature pods	(f) Leafy vegetables

SESSION 3: OLERICULTURE AND ITS IMPORTANCE IN HUMAN NUTRITION

Olericulture is a branch of horticulture, which deals with the study of cultivation of vegetable crops. The term vegetable is applied to edible herbaceous plants or parts, commonly used for culinary purposes. It may be grains as in maize cobs (sweet corn, baby corn), peas, bulbs, corms, rhizomes, roots and tubers, leaves, pods, fruits or curds, mushroom, etc.



Possibilities of vegetable cultivation in India

More crops per year

Vegetable crops grow fast and require only a few months to mature. Therefore, a number of crops can be cultivated in a year.

Profitability

The yield of vegetables per unit area is higher than cereals. In some cases, it is reported 4–6 times high, so vegetables can profitably grow on small and marginal holdings. This enables increase in the income of small and marginal farmers.

Utilisation of land

Vegetables can be cultivated on a small scale and for a family even in the backyard of a house. It ensures the utilisation of wasteland, household waste and wastewater.

Growing crops in uncertainty of weather

Due to global warming and increase in pollution, there are sudden changes in climatic conditions. Short duration vegetables can be grown effectively because a crop standing for long period will suffer more from climatic adversities.

Employment

Vegetables are labour-intensive crops and can be grown throughout the year. This provides employment opportunity to agricultural labourers in rural areas.

Advanced techniques of cultivation

Polyhouse and shade-net house techniques of vegetable cultivation enable to get quality produce with maximum returns from a small area. Exotic vegetables with special cultural practices can be grown in such structures and more income can be generated.

Seed industry

Seed is an important factor governing the production of vegetables. Quality seed production is a technical

matter, which requires specific environmental conditions and technical knowledge. Quality seeds increase the crop yield, and subsequently, the income of farmers. Exporting vegetable seeds to countries in South East Asia and Africa helps in foreign exchange.

Increasing irrigation facilities

Awareness about water conservation and construction of dams, canals, ponds and other water bodies to be used as sources of irrigation are increasing by the day. Adequate irrigation facility ensures growing vegetable crops throughout the year.

Better transport facilities

The country's transport infrastructure is improving, and interior and remote areas are gradually getting connected with highways and railways. This ensures early and better transportation of the produce to urban and remote markets.

Skilled manpower

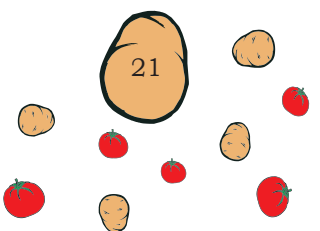
Cultivators, these days, are more skilled. Farmers are educated and trained in innovative practices and new scientific techniques. Their problems are effectively solved through various agencies, such as universities, radio, television, mobile phones, extension workers and other digital means.

Government assistance

The government is emphasising on the development of horticulture. Several schemes and financial assistance regarding infrastructure, irrigation, greenhouse and other farm inputs are being provided to farmers through National Horticulture Mission (NHM), National Horticulture Board (NHB), etc.

Importance of vegetables in human diet

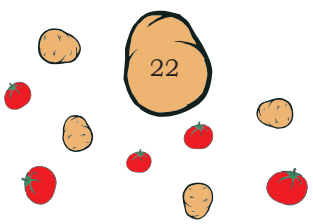
Vegetables constitute an important component of the human diet. They are natural sources of vitamins and minerals, like calcium, phosphorus and iron, carbohydrates and proteins (Table 1.3). These nutrients



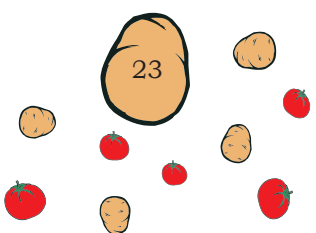
are necessary for growth and build resistance against diseases. Hence, vegetables are termed as 'protective foods'. Vegetables increase the palatability of food and eliminate acidity developed due to the consumption of non-vegetarian foods. They are a valuable source of roughages, have a higher digestibility coefficient and remove constipation. Dieticians recommend that the balanced diet of an adult should consist of 300 g of vegetables per day.

Table 1.3: Importance of vegetables in human diet

S. No.	Nutrients	Vegetables	Importance	Deficiency symptoms
1.	Vitamin A (β-carotene)	carrot roots, leaves of turnip, beetroot sweet potato, *methi*, spinach, lettuce, green onion, cabbage, tomato, green chilli	essential for the growth of body, healthy eyes and skin	retardation of growth, dry and flaky skin, drying of tear glands, night blindness, conjunctivitis, kidney stones, etc.
2.	Vitamin B_1 (thiamine)	cabbage, cowpea, onion, carrot, lettuce, etc.	essential for growth and reproduction, normal functioning of nervous and digestive systems	beri beri, paralysis, loss of appetite, weight loss, fall of body temperature, heart failure, nerve disorder, etc.
3.	Vitamin B_2 (riboflavin)	all green leafy vegetables	useful for skin, digestibility and growth	pellagra, ulcer of the mouth, cracked lips, loss of appetite, glossy tongue, fatigue, skin disorders
4.	Vitamin C (ascorbic acid)	cabbage, *methi*, spinach, cauliflower, tomato, green chillies, bitter gourd, sweet potato, etc.	essential for healthy veins and blood circulation	scurvy, bleeding of gums, tooth decay, heart attack, pain in the gum and joint pain, delay in healing of wounds, weak bones
5.	Vitamin D (calciferol)	all green vegetables	essential for healthy bones and teeth, helps in calcification	rickets, dental disease
6.	Vitamin E (tocopherol)	cabbage, lettuce, germinated beans, peas, etc.	anti-ageing vitamin, essential for reproduction, fertility and hair	sterility, hair fall and baldness, anaemia in infants



7.	Calcium	carrot, cauliflower, cabbage, cowpeas, tomato, onion, peas, spinach and other green vegetables	essential for building resistance against diseases, growth and strength of teeth and bones, helps in blood clotting	rickets, osteoporosis, irritability, retardation of growth, trouble in child birth
8.	Phosphorus	potato, carrot, spinach, *methi*, tomato, beans, cowpeas, cucurbits, etc.	essential for different intra-cellular activities, helps in cell division and multiplication, oxidation of carbohydrates and growth of bones	weakness, retardation of normal growth
9.	Iron	spinach, cabbage, cowpeas, peas, beans, tomato, etc.	important constituent of red blood corpuscles, carries oxygen to various parts of the body	anaemia, lip, eye and nail diseases
10.	Carbohydrates	radish, carrot, sweet potato, potato, tapioca, watermelon, musk melon, beetroot, etc.	provide energy for normal functioning of body and aid different biochemical activities in a cell	weakness due to reduced biochemical activities in the cell
11.	Proteins	spinach, cabbage, radish, peas, beans	constitute the chief solid matter of organs and muscles and are the main constituent of skin, hair, nails, bones, blood cells and serum; contain amino acid, which is necessary for the formation and maintenance of body tissues, and help in the neutralisation of acids produced during digestion, thereby, improving digestibility	retardation of growth, indigestibility, diseases of skin, hair and bones
12.	Fats	seeds of chilli, brinjal, coriander, tomato, radish, cucurbits, etc.	reserved food material, and help in the lubrication of various tissues and organs	weakness, hinder joint mobility



What have you learned?

Now, I am able to:

- understand the concept of olericulture.
- appreciate the importance of vegetables in human diet.

Practical Exercises

Activity 1: Prepare a chart depicting the nutritional importance of vegetable crops.

Material required: Colour pencils, notebook, pen, scale and eraser
Procedure: Prepare the chart in the following way:

S.No.	Name of the crop	Nutrient(s)	Importance	Deficiency symptoms
1.				
2.				
3.				

Check Your Progress

Fill in the Blanks

1. The branch of horticulture that deals with the scientific study of vegetable crops is known as _____.
2. The element, which is essential for building resistance against diseases, growth and strength of teeth and bones is _____.
3. Carrot, beetroot, *methi*, spinach and green chilli are sources of vitamin_____.
4. Pea and broad bean are the sources of _____ nutrient.

Multiple Choice Questions

1. _____ is the branch of horticulture dealing with the study of the cultivation of vegetable crops.
   (a) Olericulture (b) Floriculture
   (c) Pomology (d) Preservation
2. _____ is essential for different intra-cellular activities.
   (a) Calcium (b) Phosphorus
   (c) Iron (d) Iodine
3. _____ nutrient is a reserved food material.
   (a) Carbohydrates (b) Proteins
   (c) Fats (d) Vitamin

Descriptive Questions

1. Define olericulture. Explain its importance.

   _____
   _____
   _____

2. What are the possibilities of vegetable cultivation in India?

   _____
   _____
   _____

3. Give the dietary importance of vitamin A.

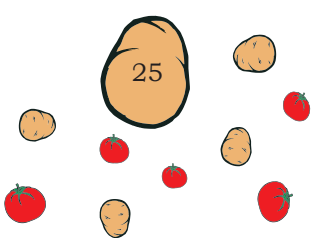
   _____
   _____
   _____

4. What are important minerals supplied by vegetables?

   _____
   _____
   _____

Match the Columns

Nutrients	Causes of deficiency
1. Vitamin A	(a) Anaemia
2. Vitamin B_1	(b) Osteoporosis
3. Vitamin B_2	(c) Rickets
4. Vitamin C	(d) Pellagra
5. Vitamin D	(e) Scurvy
6. Vitamin E	(f) Beri beri
7. Calcium	(g) Conjunctivitis
8. Iron	(h) Sterility



Unit 2

Seed Selection and Seedling Production

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Introduction

Seed is a fundamental requirement to grow most crops. In a broad sense, it is that part of a plant which is used for propagation, planting, or regeneration purpose. Vegetable seeds are costly and their wastage during sowing or handling increases the cost of cultivation. Healthy and good quality seeds lead to a healthy crop. Hence, the selection of seeds is crucial. Only quality seeds that are sown, according to the instructions set by the National Food Corporation, can give a desirable crop yield.

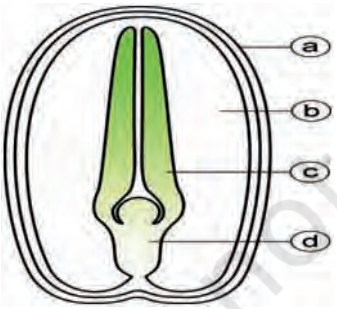


Fig. 2.1: Parts of a seed — (a) Seed coat, (b) Embryo, (c) Plumule bud and (d) Radicle

Session 1: Seed

Seeds can be defined as a dormant embryo (micro-seedling), which develops into a plant when subjected to required environmental conditions.

Parts of seed

A seed comprises the following parts (Fig. 2.1):

(a) Seed coat
(b) Embryo: Cotyledons or endosperm
(c) Plumule bud
(d) Radicle

Seed quality parameters

A seed should be:

- genetically pure
- viable
- containing optimum moisture content
- free from mixture of other seeds
- healthy and free from infection or infestation
- intact, i.e., without any damage to any of its part

Seed producing agencies

Seed production is specialised cultivation of a crop under the supervision of trained personnel or experts. The authorised sources of seeds in the country are:

- Indian Council of Agricultural Research (ICAR) institutions
- State Agricultural Universities (SAUs)
- Sponsored breeders recognised by selected State Seed Corporations
- National Seeds Corporation (NSC)
- State Seeds Corporation (SSC)
- State Farms Corporation of India (SFCI)
- Krishi Vigyan Kendras (KVKs)
- Non-governmental Organisations, etc.

Role of private seed sector

At present, a large number of seed companies are engaged in seed production or seed trade. In case of vegetable seeds and planting material, private sector is the dominant producer in India.

All these parameters are minutely checked and tested during seed certification. So, it is always better to sow only certified seeds.

Characteristics of important varieties

Tomato

The growing habit of tomato differs in two ways.

Determinate type

The growth of some tomato plants terminates in the flower bud. These are also called self-topping or self-pruning type. These plants are comparatively shorter in height with strong stem and several lateral branches. They are mostly of early varieties.

Varieties: Vaishali, Rupali, Rashmi and Pusa Early Dwarf

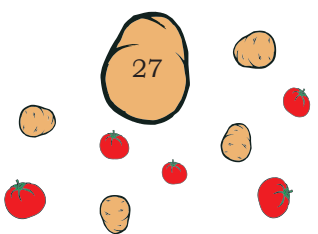


Fig. 2.2: Indeterminate type tomato cultivation

Indeterminate type

These plants terminate in the vegetative bud and show continuous growth, like vines (Fig. 2.2). These are also called vine tomatoes. Their stem is long and weak, hence, they require support and staking. Fruiting is seen on lateral growth. Varieties of this group flower in cluster and fruiting is delayed.

Varieties: Arka Rakshak, Arka Meghali, Arka Samrat, Arka Saurabh and Arka Shreshta

Important varieties

Popular varieties

Pusa Rubi, Pusa Sadabahar, Punjab Chhuhara, Arka Vikash, Hisar Lalit and Pusa Gaurav

Hybrids

Pusa Hybrid–1, Pusa Hybrid–2, Pusa Hybrid–8, Pusa Hybrid–10, Pusa Hybrid–11, ATH–1, ATH–2, Vaishali, Rupali, Sheetal and Ratna

Hybrid varieties: a group of plants grown from seeds produced by cross-pollinating two or more parental breeding stocks.

Varieties for protected cultivation

Indeterminate varieties, like Arka Meghali, Arka Saurabh, Pusa Cherry Tomato–1, Himsona and Himshikhar are developed under protected conditions.

Brinjal

Brinjal is also known as eggplant. Based on the shape and the colour of the fruit, brinjal is classified into three types.

Fig. 2.3: Round-shaped brinjal

Important varieties

Round fruit

Fruits shown in Fig. 2.3 are round type.

Varieties: Pusa Hybrid–6, Pusa Hybrid–9, Pusa Upkar (purple), Arka Kusumakar (green) and Manjari Gota (bicolour)

Fig. 2.4: Long-shaped brinjal

Long fruit

Fruits shown in Fig. 2.4 are long fruited type.

Varieties: Pusa Bhairav, Pusa Hybrid–5, Pusa Kranti, Pusa Purple Cluster, Pusa Purple Long (purple in colour) and Arka Shirish (green in colour)

Small and oval fruits

Fruits shown in Fig. 2.5 are oval type.

Varieties: Arka Navaneet, Bhagyamati, Pusa Uttam and Pusa Bindu — purple in colour; Vaishali (bicolour)

Fig. 2.5: Oval-shaped brinjal

Chilli

Fig. 2.6 and 2.7 depict long and pungent type chilli or hot pepper. Some of these types of chilli are — Pusa Jwala, Pant C–1, Pusa Sadabahar, Andhra Jyoti, Bhagya Laxmi, etc.

Fig. 2.6: Green chilli

Sweet Pepper

This type of chilli is used as a vegetable. It is popularly known as 'Shimla Mirch'. The fruits are of different colours — red (Fig. 2.8), yellow (Fig. 2.9) or green (Fig. 2.10). These are less pungent, bigger in size, broadly ribbed, fleshy with lesser seeds and hollow. Sweet pepper has more demand in foreign markets. The important varieties are — California Wonder, Yolo Wonder, Arka Mohini, Arka Gaurav and King of North.

Fig. 2.7: Red chilli

Potato

Potato are early varieties, mid-season varieties, late varieties and varieties suitable for processing (Fig. 2.11).

Fig. 2.8: Red sweet pepper

Important varieties

Early varieties

Kufri Ashoka, Kufri Chandramukhi and Kufri Surya (heat tolerant)

Fig. 2.9: Yellow sweet pepper

Fig. 2.10: Green sweet pepper

Fig. 2.11: Potato tubers

Mid-season varieties

Kufri Jyoti, Kufri Badshah, Kufri Bahar, Kufri Lalima, Kufri Jawahar, Kufri Sutlej, Kufri Pukharaj and Kufri Giriraj

Varieties suitable for processing

Kufri Chipsona–1, Kufri Chipsona–2 and Kufri Frisona

Late varieties

Kufri Swarna and Kufri Sinduri

Seed rate

The amount of seeds to be used depends upon their purity, viability, planting time, soil conditions, and size and vigour of the plant. Solanaceous crops require different seed rate as shown in Table 2.1.

Table 2.1: Seed rate for solanaceous crops to produce seedlings for one hectare field

Crop	Pure varieties (gm/ha)	Hybrids (gm/ha)
Tomato	400–500	100–150
Brinjal	400–500	150–200
Chilli	1000–1250	200–250
Sweet pepper	750–800	200–250

Potato

(1) Whole tubers: 15 to 22.5 qt/ha.
(2) Cut tubers: 15 to 20 qt/ha.

What have you learned?

Now, I am able to:

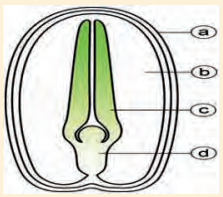
- explain the seed quality parameters.
- list important varieties of solanaceous crops.
- explain desirable characteristics of the produce for better marketing and export.

Practical Exercises

Activity 1: Identify the seed parts.

Material required: A picture showing seed parts, pencil or pen

Procedure: Label the parts of a seed.



Activity 2: Prepare a herbarium of seeds of vegetable crops.

Material required: Transparent sachet (small pouch), stapler, herbarium book and pen

Procedure:

- Collect small quantity of seeds.
- Weigh the seeds and count the total number of seeds.
- Fill them in a sachet.
- Label the sachets.
- Staple the sachet on individual pages of the herbarium.

Check Your Progress

Fill in the Blanks

1. In _____ type of tomato, the growth of plants terminates in the flower bud.
2. Pusa Sadabahar is a variety of _____.
3. Fruits of _____ variety of brinjal are long and green in colour.
4. The variety of potato suitable for processing is _____.

Multiple Choice Questions

1. Seeds can be defined as a dormant _____
   (a) embryo (b) ovule
   (c) ovary (d) fruit
2. Which of the following is not a part of a seed?
   (a) Seed coat (b) Embryo
   (c) Cotyledon (d) Ovary
3. Determinate type tomato comprises _____ varieties.
   (a) late (b) early
   (c) mid-season (d) all of the above
4. Which one among the following does not belong to determinate type tomato?
   (a) Vaishali (b) Rupali
   (c) Arka Saurabh (d) Rashmi
5. Which tomato variety is not an indeterminate type?
   (a) Arka Rakshak (b) Arka Meghali
   (c) Arka Samrat (d) Pusa Early Dwarf

6. Long fruited brinjal is _____.
   (a) Pusa Hybrid–6 (b) Pusa Hybrid–9
   (c) Pusa Upkar (d) Pusa Purple Cluster
7. Which of the following is a sweet pepper variety?
   (a) Pusa Jwala (b) Pant C–1
   (c) Andhra Jyoti (d) Arka Gaurav
8. Seed rate of pure variety of tomato is _____ g/hectare.
   (a) 400 (b) 200
   (c) 600 (d) 700

Descriptive Questions

1. What is seed? What are the different parts of a seed?

   _____
   _____
   _____

2. Which agencies in India are responsible for producing certified seeds?

   _____
   _____
   _____

3. Differentiate between determinate and indeterminate type of tomatoes.

   _____
   _____
   _____

4. Describe seed quality.

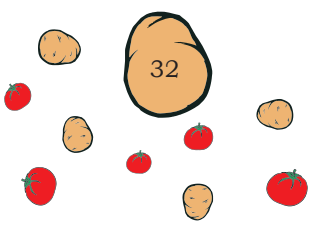
   _____
   _____
   _____

5. Give the seed requirement of solanaceous crops per hectare.

   _____
   _____
   _____

Match the Columns

Vegetable	Variety
1. Tomato	(a) Kufri Jyoti
2. Brinjal	(b) Arka Mohini
3. Chilli	(c) Pant C–1
4. Sweet pepper	d) Arka Kusumakar
5. Potato	e) Arka Meghali



Session 2: Nursery Bed Preparation and Seed Sowing

Nursery bed

A nursery bed is a small area where necessary soil and environmental conditions, such as germinating media, plant nutrients, water, temperature, oxygen and weather protection are provided for the germination and growth of seeds into healthy seedlings (Fig. 2.12).

Fig. 2.12: Nursery beds

Benefits of nursery bed

- convenient to look after seedlings
- cropping period gets reduced
- helps in better land and time management as seedlings preparation in nursery beds gives more time for the preparation of the main field
- helps produce uniform and healthy seedlings

Method to prepare nursery or raised beds

- Prepare 15–20 cm raised beds. The width should be between 0.45 and 1.20 m, whereas, the ideal length ranges from 3 to 5 m.
- This enables drainage during rains and avoids water stagnation.
- The nursery bed is thoroughly mixed with 10–15 kg of decomposed farmyard manure per square metre.
- All weeds, stones, stumps, clots, etc., are removed from the field and the bed should be levelled.
- The seeds are sown in lines in the bed.
- To carry out cultural practices, the space between two beds should be 30–40 cm.

Preparing the site for seed bed

The selection of a site for creating a nursery bed depends on the following factors:

- sunny location
- availability of a water source nearby
- fertile and sterlised soil

Soil sterilisation

Nursery plants are prone to many soil-borne infections and infestations. The soil of the nursery should, therefore, be sterilised. The soil can be sterilised by the use of chemical, physical or biological sterilisers.

Chemical steriliser

Fumigants, like formaldehyde, chloropicrin, methyl bromide and vapam are used for sterilising of soil. These chemicals are mixed with water and spread over the area. The soil is, then, covered with polyethylene sheets for 2–3 days. After 2–3 days, the sheets are removed and the beds are prepared after seven days. This treatment will kill all weeds and microorganisms present in the soil.

Fungicides, like *Carbendazim* and *Copper oxychloride*, are used to inhibit soil-borne fungi. Fungicide solutions are poured or sprayed on the soil uniformly.

Insecticide, like *Chlorpyriphos*, is also used to kill insects present in the soil. Approximately, 2 litre of *Chlorpytiphor* is mixed with 1 litre of water and is applied to a depth of 15 to 20 cm in the soil to kill insects, including ants and their eggs, nematodes, etc.

Physical steriliser

The soil and sand used for the preparation of the bed can be sterilised in an autoclave at 121 °C for 30 minutes. This will kill almost all weeds and microorganisms present in it. It is difficult to execute the process on a large scale as certain beneficial factors may get lost from the soil.

Mostly, soil solarisation, i.e., solar energy, is used as a method to sterlise the soil.

Bio-agents

- Certain biological agents, like *Trichoderma* species, are effective in controlling soil-borne pathogens.
- These bio-agents are mixed well in soil, say 10–25 g/square metre.
- Seeds should be sown 2–3 days after the application of a bio-agent.

Seed treatment

Hot water treatment

Dry seeds are placed in water having a temperature of 48–55 °C for 10–30 minutes prior to sowing. This reduces seed-borne inoculums.

Chemical treatment

Seed treatment with fungicides, like *Thiram* at the rate of 3 g/kg or *Carbendazim* at the rate of 2 g/kg, is done to prevent fungal attack on seeds. Similarly, insecticides, like *Imidacloprid* 70% WS at the rate of 7 g active ingredient per kg of seed, can be used for the protection of seeds against insects and pests. The seeds are shaken with the chemical in a closed container or seed treating drum, so that each seed gets pelleted with the pesticide. In another method, the seeds are kept in a pesticide solution for specific a period prior to sowing.

Biological seed treatment

Some bio-agents are used for seed treatment to control seed and soil-borne inoculua, such as *Trichoderma haerzianum*. For the improvement of germinability and production of leguminous crop, seeds are treated with biofertilisers, like *Rhizobium* species.

Sowing on seed bed

Line sowing

Seeds are sown in lines on a seed bed. The depth of sowing is usually 1.5–2 cm and the ideal spacing between the lines is 5–7 cm. The fine seeds should be mixed with sand for uniform distribution. After sowing, the lines are filled with sieved compost or the leaf mould, and the bed should be covered with dry grass till germination. Irrigate the beds daily with the help of a watering can.

Fig. 2.13: Seeds sown in pro-trays

Seed sowing in pro-trays

Pro-trays are filled with the growing medium, which is prepared by mixing coco peat, vermiculite and perlite in 3:1:1 proportion (Fig. 2.13). Coco peat is obtained from the coir industry as a by-product. One seed is sown

per plug. Small depressions (0.5 cm) are made at the centre of the plugs with fingertips or mechanical tools for the sowing of seeds. The seeds are then covered with the medium. Arrange the pro-trays one on the other to enhance the temperature, which will help in germination. When germination starts, the pro-trays are separated and watered with a watering can.

Factors affecting seed germination

Temperature

Almost all solanaceous crops cannot withstand frost. Seeds cannot germinate at a low temperature. Temperature range of 13 to 21 °C is favourable for seed germination.

Moisture

Moisture is of prime importance in initiating germination in a seed.

Sowing time

The time of sowing a seed (Table 2.2) or plant a particular species in the open determines the success or failure of a crop to a considerable extent. The planting time should be determined by taking into consideration the soil and weather conditions, the kind of crop, and the time when the produce is desired for vegetable purpose.

Depth of sowing

Small seeds if sown deep in the soil fail to germinate. The depth at which a seed has to be sown in decided according to its size. The seeds of solanaceous crops are small in size and can be sown up to a depth of 2 cm. The seeds, if sown shallow, may be picked up by birds.

Seed coat

Sometimes, the germination of a seed is inhibited or delayed due to the presence of a hard seed coat. In such cases, the seed coat is broken or softened by various methods, like soaking the seed in water or acid or rupturing the seed coat mechanically.

Seed viability

The capability of a seed to germinate and produce normal seedlings is known as 'seed viability'. Seed viability

is not retained indefinitely and the seed, gradually, deteriorates and dies due to ageing. The viable period of a seed varies from crop-to-crop and even on variety within a crop.

Seed dormancy

Usually, potato seeds show dormancy due to which they do not germinate. The treatment of thio-urea or dipping of tuber in a solution of *Gibberellins* at 0.5–1 ppm reduces dormancy.

Seed pests

Insects, pests and mites in storage are responsible for damaging the seed structure by biting or chewing the seeds.

Seed diseases

The association of certain bacteria and fungi shorten seed viability, and thus, affect germination.

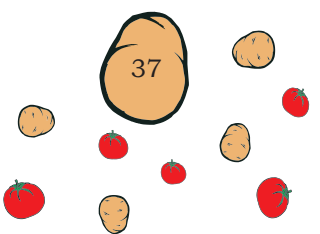
Table 2.2: Timing of sowing solanaceous crops

S. No.	Name of the crop	Sowing time
1.	Tomato	June–July (for *Kharif* crop) September–October (for *Rabi* crop) December–January (for summer crop)
2.	Brinjal	June–July (for *Kharif* crop) September–October (for *Rabi* crop) December–January (for summer crop)
3.	Chilli	June–July (for *Kharif* crop) September–October (for *Rabi* crop) December–January (for summer crop)
4.	Potato	First fortnight of October (for early crop) October mid–November (for main crop)

Soil nursery

Advantages

(a) It helps reduce the wastage of small and expensive hybrid seeds due to better care in a nursery.
(b) The germination per cent is high in nursery beds as compared to direct sown crops.
(c) The nursery area is small, hence, seedlings can be managed in a better way with minimum care and cost.



(d) By selecting vigorous and healthy seedlings in a nursery for transplanting, better and uniform crop growth can be obtained in the main field through better survival chances.
(e) It helps reduce crop duration in the main field by at least a month, which saves both land and labour.
(f) Controlling insects, diseases and weeds is easy during the initial stage.
(g) Nursery raising reduces the overall crop period and favours early maturity.
(h) It provides employment opportunities for skilled, semi-skilled and unskilled human resources.

Disadvantages

(a) In comparison to pro-tray technique, more seeds are required in a nursery.
(b) Seedlings may get injured during uprooting, so irrigate the beds just before uprooting.
(c) Chances of soil-borne infections are more, if soil treatment is not done carefully.
(d) Chances of loss due to rodents are more. To avoid such a situation, carefully select a site.
(e) Seedlings may grow dense, which affects the growth of plants. Hence, line sowing and thinning can be done.
(f) A nursery requires more watering and intercultural operations for healthy seedlings.

What have you learned?

Now, I am able to:

- understand the importance of a nursery bed.
- learn the process of a nursery bed preparation.
- explain the factors affecting seed germination.
- explore various methods of seed sowing.
- explain the advantages and disadvantages of soil nursery.

Practical Exercises

Activity 1: Demonstration of the procedure for the preparation of a nursery bed

Material required: Spade, pick axe, *khurpi*, rake, black polythene sheet, watering can, 2% formalin or formaldehyde solution and measuring cylinder of 100 ml capacity

Procedure

- Level the seed bed.
- Wear mask and gloves.
- Prepare 2% formalin or formaldehyde solution by mixing 40 ml formalin of 48% purity in 1 litre water for fumigation of the soil.
- Treat the seed bed the with 1% formalin solution at the rate of 3–5 litre/sq. m by drenching the soil with the help of a water can.
- Cover the treated soil with a black polythene sheet so that the fumes do not vapourise.
- Remove the black polythene sheet after 48 hours.
- Expose the fumigated soil for at least seven days before sowing the seed.
- Prepare the seed bed of 15–20 cm height and 45–120 cm width.

Precautions

- Mask and gloves should be worn before starting fumigation.
- Fumigation of the soil should not be done on a windy day.

Activity 2: Study seed germination

Material required: Seeds, watering can, pots filled with medium

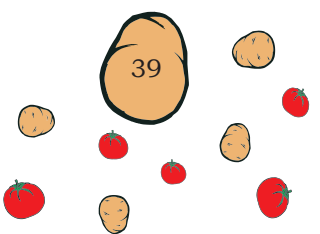
Procedure

- Take a seed sample.
- Refer to the seed germination standard of a crop to know the quality of the seeds.
- Take counted number of seeds for testing. Sow the seeds in a pot filled with growing medium.
- Cover the seeds with soil.
- Water the pot.
- Keep the pots under optimum conditions for the germination of seeds.
- After germination, count the seedlings that have emerged.
- Calculate the seedling germination by dividing the number of seedlings emerged by the total number of seeds sown multiplied by 100.

Check Your Progress

Fill in the Blanks

1. All solanaceous vegetables except _____ are transplanted crops.
2. The _____ beds are prepared 15–20 cm high from ground level.
3. The width of a raised bed should not be more than _____ m.
4. In _____ method of soil treatment, the energy from the Sun is used.



5. Certain biological agents, like _____, are effectively used for controlling of soil-borne pathogens.
6. Temperature range of _____ is found favourable for the germination of seeds of solanaceous crops.
7. The depth of sowing solanaceous crop is usually _____ cm in a nursery bed.
8. The spacing of sowing solanaceous crop seeds is _____ cm.
9. A by-product of the coir industry, which is a part of the germination medium, is known as _____.

Multiple Choice Questions

1. Raised beds are _____ cm high from the ground level.
   (a) 5–10 (b) 15–20
   (c) 25–30 (d) 30–35
2. A space of _____ cm is left between two beds.
   (a) 30–40 (b) 20–25
   (c) 15–20 (d) 20–25
3. The soil is sterilised in an autoclave at _____°C for 30 minutes.
   (a) 100 (b) 140
   (c) 121 (d) 80
4. In hot water seed treatment, seeds are placed at a temperature of _____ °C for 10–30 minutes.
   (a) 48–55 (b) 30–35
   (c) 20–25 (d) 15–20
5. Fungus used for seed treatment to control seed and soil-borne inoculums is _____.
   (a) *Trichogramma* (b) *Trichoderma*
   (c) *Rhizopus* (d) *Rhizobium*
6. The capability of a seed to germinate and produce normal seedlings is called _____.
   (a) seed vitality (b) seed viability
   (c) seed dormancy (d) compatibility

Descriptive Questions

1. What is a nursery bed? How is it prepared?

   _____
   _____
   _____

2. How the soil for a seed bed can be sterilised chemically?

   _____
   _____
   _____

3. Why is seed treatment followed before sowing?

_____

_____

_____

4. Describe soil sterlisation.

_____

_____

_____

5. How is the medium for pro-trays prepared?

_____

_____

_____

6. List the factors which affect seed germination.

_____

_____

_____

7. Describe the advantages and disadvantages of soil nursery.

_____

_____

_____

Match the Columns

1. Bio-agent	(a) Protection to seedling during high wind
2. *Thiram*	(b) *Trichoderma*
3. Sunken beds	(c) Chemical for soil sterilisation
4. Formalin	(d) Seed treatment

Session 3: Nursery Raising in Soilless Medium

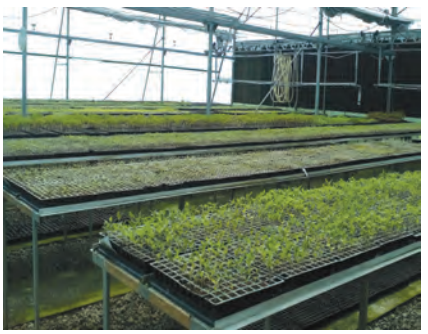


Fig. 2.14: Seedlings in pro-trays

Pro-trays

Pro-trays are made of soft plastic with shallow plugs, in which seeds are sown in soilless germination medium (Fig. 2.14).

Selection of pro-trays

The most common pro-trays used for vegetable transplants have 50, 72, 98, 128 or 200 cells per tray.

The cells in these pro-trays are round or square in shape and are close to each other. However, they are equally spaced in order to maximise the number of plants in a tray. For larger crops, like pumpkin, bitter gourd, etc., there are pro-trays having 36 or 24 cells of larger size. The bigger size of cells allows larger root balls.

The size of a cell influences the field performance of the transplant. When bigger cells are used, the plant has more space to grow and it results in the early maturity of crops. Dark coloured trays absorb more heat and tend to produce faster growth than light coloured ones. A deep celled tray has a larger cell volume, and it retains more water and fertilisers to promote rapid growth.

Nursery technique under protected cultivation

The growing medium is prepared by mixing 5 kg neem cake, 100 kg vermiculite or perlite, and 300 kg sterilised coco peat. For filling one pro-tray, approximately 1.2 kg of growing medium is required. About 238 pro-trays (with 98 cells per tray) are required for the production of 23,334 seedlings. These seedlings are enough for planting one hectare land. Trays with the medium is compressed or 'dibbled' to make a uniform surface for the seed. The medium should be compressed from 1/4 to 3/8 inch deep. One treated seed must be sown in each cell of the pro-tray. The seeded trays are, then, covered with medium-grade vermiculite. Vermiculite is preferred because of better aeration and it does not support algae. The trays are covered with a polythene sheet till germination starts. Place the pro-trays separately on a raised bed in the shade net. Water the trays with rośecan every day and drench with foliar spray formulation having Nitrogen, Phosphorous and Pottasium (N, P and K) in the ratio of 19:19:19 at the rate of 0.5% (5g/l) 18 days after sowing.

Planting in pro-trays

Advantages

(a) More efficient use of expensive hybrid seeds.
(b) Individual seeds can be sown in each plug, which minimises the spread of diseases.

(c) Sterilised coco peat is used as the rooting medium, which reduces chances of soil-borne infections.
(d) Water holding capacity of coco peat is more so seeds in pro-trays require less watering.
(e) Transplanting shock is minimised.
(f) Seedlings can be uprooted easily for transplanting without any damage to the root system.
(g) Pro-trays can be moved easily to protect the seeds from adverse weather conditions.
(h) It needs less space.
(i) It fosters better and uniform plant growth.
(j) More cycles of nursery production is possible as seedlings can be prepared many times as compared to field conditions.
(k) A field or a part of the field or greenhouse is not engaged in the raising of seedlings.
(l) Individual seedlings get their own space and chances of high density are minimised.
(m) It facilitates better care and management of seedlings.
(n) There is no waterlogging.
(o) Weeding and thinning is easily carried out in pro-trays.
(p) Uniform transplants and transplanting can be mechanised.

Disadvantages

(a) It requires skilled labour.
(b) It requires special care and maintenance.
(c) Pro-trays are costly and difficult to dispose of.
(d) The use of pro-trays increases plastic waste in an agricultural farm.
(e) Pro-trays require coco peat as a growing medium, which is costly.
(f) The cost of seedling production is high, which increases the overall cost of production.

Depth and spacing for seed sowing

Soil nursery

Seeds of tomato, brinjal and chilli are small in size and light in weight. While planting on a nursery bed, the seeds are mixed with sand for uniform distribution on the bed. The seeds are sown width-wise in lines drawn

with sticks 5–7 cm apart. The seeds are sown at a depth of 2 cm and covered with soil.

Pro-trays

Sowing in pro-trays is shallow than in seed bed. In a plug filled with coco peat, make a depression of 0.5 cm with the help of your fingertips or mechanical dibbler and place one seed in each plug. Cover the plugs with coco peat.

What have you learned?

Now, I am able to:

- select pro-trays.
- germinate seeds of solanaceous crops in pro-trays in protected cultivation.
- explain the advantages and disadvantages of planting in pro-trays.

Practical Exercises

Activity 1: Preparation of pro-trays and sowing of seeds

Material required: Coco peat, neem cake, vermiculite, perlite, pro-trays, seeds, watering can, polythene sheet, etc.

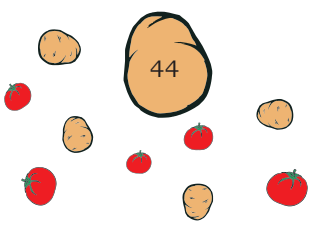
Procedure

- Prepare a growing medium by mixing coco peat with neem cake, vermiculite and perlite in 3:1:1 proportion.
- Fill the cell of pro-trays with the growing medium.
- Make small depressions (0.5 cm) in the centre of the plugs with fingertips or mechanical dibbler.
- One seed is sown per cell (plug) in the depression made in the plug.
- The seed is then covered with the medium.
- Ten pro-trays are arranged one on the other for better germination of seeds.
- Observe the seeds for the start of germination.
- Spray water with a rośecan in the pro-trays daily till the seeds attain the transplanting stage.

Check Your Progress

Fill in the Blanks

1. For pumpkin, pro-trays with _____ cells per tray are used.



2. Big size cell influences the _____ of the crop.
3. When bigger cells are used, the plant has more _____ to grow.
4. Dark coloured pro-trays tend to cause faster growth than _____ coloured trays.
5. About _____ pro-trays (98 cells/tray) are required for seedling production for one hectare.
6. The _____ allows good aeration to pro-trays.
7. Vermiculite does not support _____ growth in the tray.
8. Pro-trays are made of soft plastic with shallow _____.

Multiple Choice Questions

1. Pro-trays growing medium has vermiculite because _____.
   (a) it is easy to apply evenly
   (b) it has good aeration
   (c) it does not support algae
   (d) all of the above
2. Coco peat _____.
   (a) is sterilisable
   (b) is light in weight
   (c) has good water holding capacity
   (d) all of the above
3. Approximately _____ kg of coco peat is required for filling one pro-tray.
   (a) 1.2 (b) 2
   (c) 2.2 (d) 3

Descriptive Questions

1. Why do we raise nursery in pro-trays?
   _____
   _____
   _____
2. Which medium is used for filling pro-trays?
   _____
   _____
   _____
3. What is the significance of vermiculite used in the planting of a crop in pro-trays?
   _____
   _____
   _____

Notes

4. Write down the procedure of sowing seeds in pro-trays.

_____

_____

_____

5. What are advantages and disadvantages of planting seeds in pro-trays?

_____

_____

_____

6. Write the criteria for the selection of pro-trays.

_____

_____

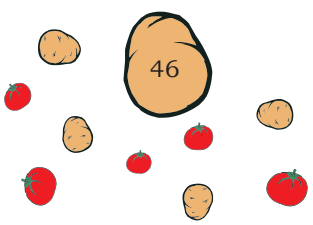
_____

7. Write about pro-tray nursery technique for solanaceous vegetables under protected cultivation.

_____

_____

_____



Unit 3

Field Preparation and Transplanting in Solanaceous Crops

Introduction

Soil is the most important and easily available growing medium for plants. Soils are of different types, depending upon their chemical and physical properties. Soil provides nutrients and moisture to plants, which are necessary for their growth and development. Manures and fertilisers are added to the soil to maintain its nutrient value. This ensures the availability of nutrients to plants and maintains productivity, as well as, fertility of the soil. Judicious use of fertiliser is always recommended to avoid crop and soil hazards. This may be achieved through testing of the soil and expert opinion. When a soil is pulverised, levelled and brought to fine tilth for the cultivation of a crop, it is called 'tillage operation' or 'preparation of the land'. Different advanced implements are used to prepare the land for cultivation. The need for water may be fulfilled by irrigation.

Most of the solanaceous vegetables are propagated by seed and seedlings are transplanted at requisite spacing in the main field. Seedlings are herbaceous and require care during uprooting and planting.

Session 1: Soil and Field Preparation

Definition of soil

Soil is derived from the Latin word *Solum*. It may be defined as a natural body developed as a result of weathering of rocks, in which plants and other forms of life grow and prosper. It is the upper loose layer of the earth crust rich in nutrients and minerals on which plants grow. Soil is composed of minerals (45–50%), organic matters (0.5–5%), water (25%) and a large number of plants, animals and microbes.

Importance of soil

Soil provides nutrients to plants, which help in their growth. It provides support to growing plants by holding their roots. It holds moisture and water for a long time and serves as a habitat for many micro and macro-organisms. Soil also provides heat, air and water to growing organisms living in or over it. It is the most important natural resource of a country.

Types of soil

There are different types of soil in India, which can be classified on the basis of their colour and characteristics.

Fig. 3.1: Black soil

Black soil

These soils are poor in nitrogen, phosphate and organic matter but rich in potash, calcium and magnesium (Fig. 3.1). The pH of black soil is 6.8.

Fig. 3.2: Red soil

Red soil

These are porous, friable and neutral to acidic in nature. These soils are poor in nitrogen, phosphate, lime and humus (Fig. 3.2). Generally, the pH of red soil is more than 5.

Lateritic (laterite)

These show acidic character with pH of 5 to 6. These soils are porous and have low water holding

capacity. Lateritic soils are deficient in nitrogen, phosphorus, potash, magnesium and lime. Such soils are, generally, found in the states of Karnataka, Kerala and Tamil Nadu.

Alluvial soil

These are productive soils, which are formed due to the deposition of silt by the Ganga and Brahmaputra rivers in course of their heavy flow during the rainy season. Due to meandering of the river course, a rich deposit of alluvial soil develops. The pH of alluvial soil ranges from 6.5 to 8.4.

Desert soil

Desert soils are sandy and found in low rainfall areas. These are alkaline soils with high pH value and are unproductive (Fig. 3.3). The pH of desert soil ranges from 7.6 to 8.4.

Fig. 3.3: Desert soil

Forest and hilly soil

These are the soils of higher and lower elevation found on hills. These are stony and infertile. The pH of such soil is 4.

Peat and marshy land

These soils are highly acidic in nature and black in colour. Excessive wetness of the soil, causing decay and degradation of dead vegetation, forms a layer of partially decomposed organic matter.

Soil particles

Soil particles namely sand, silt and clay are classified according to their size. Clay particles are the finest and are smaller than 0.002 mm in diameter. Loam particles are 0.002–0.02 mm in diameter. Silt particles have 0.02–2.0 mm diameter. Particles larger than 2 mm are sand, gravel or stones. Most soils contain a mixture of sand, silt and clay in different proportions (Table 3.1).

Table 3.1: Proportion of sand, silt and clay in various soils

Soil type	Sand (%)	Silt (%)	Clay (%)
Sandy loam	50–80	0–50	0–20
Loam	30–50	30–50	0–20
Clay loam	20–50	20–50	20–30
Silty clay loam	0–30	50–80	20–30

Soil testing

It is one of the methods to determine the fertility status of a soil, so that recommendations with respect to lacking nutrient or appropriate soil reclamation can be done. A complete soil test programme essentially consists of three basic steps, which are as follows:

(a) soil sampling
(b) soil testing
(c) soil test interpretation and fertiliser recommendations

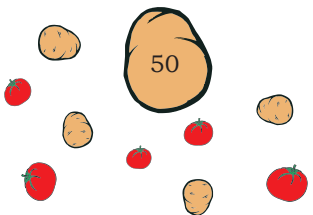
Why is soil testing required?

Soil testing is done to fulfill the following purposes:

(a) help in the evaluation and improvement of soil productivity
(b) determine the nature of soil, i.e., alkaline, saline, acidic, etc., and suggest corrective measures (Table 3.2 and 3.3)
(c) help in deciding the right kind and quantity of fertilisers to be used
(d) reveal the condition of a soil so that it can be improved with proper application of nutrients and other management practices

Soil sampling

Samples are taken using soil auger, soil tube, spade, etc. Different locations in a field are randomly identified. Soil from pits at plough depth (15–20 cm) is collected from identified locations, and then, composited. Samples should not be taken from the boundary of a field. Shady, marshy, near irrigation source and fertiliser applied areas are also avoided. The soil is



mixed thoroughly and spread on a clean sheet of paper or on a piece of cloth. It is divided into four equal parts by drawing a cross sign with the help of a wooden stick. Two opposite quarters are rejected and samples from the other two are mixed. The procedure is repeated till the desired size of the sample is obtained (1/2 kg), which is collected in a paper bag and later packed in a plastic bag.

This bag containing the sample is labeled and sent to the nearest soil testing laboratory of the Department of Agriculture, ICAR institutes, KVKs and SAUs, along with an information sheet.

Information sheet required for soil testing

- Name of the farmer
- Identification or the number of the field
- Date of sampling
- Depth of sampling
- Address of the farmer
- Type of land unirrigated, irrigated, waterlogged
- Source of irrigation (canal, well, tank, etc.)
- Topography (level, sloppy, undulated)
- Crop rotation followed
- Previous crop
- Next crop to be cultivated
- Details of manures or soil amendments applied earlier
- Any other remark
- Signature or thumb impression of the farmer

Soil test result

Based on the soil analysis, the soils are classified into categories according to the ratings as given in the following tables.

Table 3.2: Soil types on the basis of soil pH

S. No.	Type of soil	Soil reaction (pH)
1.	Acidic	below 7.0
2.	Neutral	7.0
3	Neutral to saline	7.0–8.5
4.	Tending to become alkaline	8.6–9.0
5.	Alkaline	above 9.0

Table 3.3: Soil types on the basis of soil Electro-conductivity (EC)

S. No.	Category	EC (milli-mhos/cm)
1.	Normal	below 1.0
2.	Critical for germination	1.0–2.0
3.	Critical for the growth of salt sensitive crops	2.0–3.0
4.	Injurious to most crops	above 3.0

On the basis of soil test interpretations, the recommendations for fertiliser and soil reclamation material for each crop can be made (Table 3.4).

Table 3.4: Rating of soil on the basis of nutrient availability

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

Soil Health Card Scheme

The scheme was launched by the Government of India in February 2015. Under this scheme, a Soil Health Card is issued to farmers. It contains information about the different nutrients present in a crop and fertilisers recommended for a farm. It helps farmers to improve their crop's productivity through judicious use of fertilisers and other resources. The soil crop's samples are collected on grid basis and tested in soil testing labs. The experts analyse the soil crop and suggest suitable measures for optimum crop production. The results and suggestions are displayed in the cards for farmers to understand the nature of the soil and its suitability to cultivate a particular crop.

Field preparation for solanaceous crops

Selection of field

Solanaceous crops are grown in different kinds of soil — ranging from sandy loam to clayey loam. For the successful cultivation of solanaceous crops, the soil must be fertile with continuous supply of nutrients and proper drainage facility. Light soils are preferred for early crop and loam or clayey soils for a higher yield. The optimum soil pH for tomato is 6–7. It can tolerate a little soil acidity up to 5.5. Brinjal can tolerate slightly acidic soil, pH ranging from 5.5 to 6.8. For chilli cultivation, the soil pH must be 6.5–7.5. Chillies are grown on heavy black cotton soil during the rainy season, particularly dry chilli.

Land 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 required 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.

Procedure for land preparation

A field should be ploughed up to a depth of 30 cm or more (Fig. 3.4). After this, discing or harrowing in two directions should be done using disc harrows (Fig. 3.5). If a field has to be furrow irrigated, make raised beds of 15–20 cm height using bed lifters. The bed height is determined by the type of the soil, irrigation method and intended crop. Raised beds must ensure the drainage of excessive water, rapid drying of soil surface and early soil warming, less chances of soil-borne diseases, and improved soil aeration. Manure and other compost in the soil must be applied at the time of land preparation. Heavy soils often break in clods and lumps. Heavy clods and lumps can be crushed with the use of a heavy roller. Irrigation before planting is needed if the soil has insufficient moisture after bed preparation. Once the soil dries, the rough beds should be reworked using a rolling cultivator or a power rotavator.

Fig. 3.4: Ploughing of a field

Fig. 3.5: Land preparation using disc harrows

Rotavator mellowing improves the soil structure by breaking up the clods and ploughing out the weeds that emerge after pre-plant irrigation. The final seed bed preparation can be done with the help of a bed roller, planker or laser leveler. It may be done manually by using a spade, hand hoe, etc.

Land and field preparation can be done by:

- deep working implements, like ploughs;
- surface working implements, like rotavator, harrows, hand hoes, *khurpi*, etc.; and
- compacting implements, like rollers, levelers, beams, etc.

What have you learned?

Now, I am able to:

- describe the soil and its types.
- understand soil testing and fertiliser or nutrient recommendation.
- demonstrate field preparation.
- understand the importance of Soil Health Card Scheme.

Practical Exercises

Activity 1: Preparation of a soil sample and with an information sheet

Material required: Soil auger, soil tube, spade, paper bag, plastic bag, weighing scale and wooden stick

Procedure

- Identify a location in a field from where a sample has to be collected.
- Dig pits of 15–20 cm and remove the dug out soil.
- Collect a sample for testing from below this depth.
- Similarly, identify other locations in the field and collect samples.
- Mix the samples thoroughly and spread it on a clean sheet of paper or a piece of cloth.
- Divide it into four equal parts by making a cross sign with the help of a stick.
- Mix the two opposite parts and discard the remaining two.
- Repeat the procedure till you have 500 g sample.
- Put it in a paper bag with a label inside.
- Put the paper bag in a polythene bag.
- Label it and send to a soil testing laboratory.

Precautions

- The sample must not be collected from the boundary of a field, shady and fertiliser applied areas.
- It must not be taken from a place near an irrigation source.
- The collected sample needs to be dried to get uniform mixing.

Check Your Progress

Fill in the Blanks

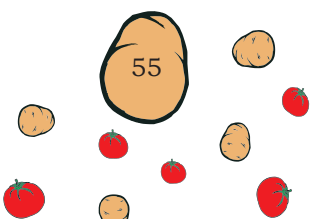
1. The word 'soil' is derived from a Latin word _____.
2. Soil develops as a result of _____ processes.
3. The pH of black soil is _____.
4. Laterite soils are mostly found in _____.
5. Soil sample is collected at a depth of _____.

Multiple Choice Questions

1. Black soil is _____.
   (a) poor in nitrogen
   (b) rich in organic matter
   (c) rich in phosphate
   (d) poor in potash
2. Red soil has which of the following character?
   (a) water stagnant (b) marshy
   (c) porous (d) infertile
3. Lateritic (laterite) soil is _____ in nature.
   (a) alkaline (b) acidic
   (c) neutral (d) saline
4. Which of the following is a characteristic of alluvial soil?
   (a) poor quality soil (b) non-productive
   (c) infertile (d) productive
5. Desert soil is found in _____.
   (a) low rainfall areas
   (b) average rainfall areas
   (c) high rainfall areas
   (d) all of the above

Descriptive Questions

1. What is soil? Briefly describe the properties of soil.
   _____
   _____
   _____
2. What is the importance of soil in relation to plant growth?
   _____
   _____
   _____
3. Classify the soils of India.
   _____
   _____
   _____
4. What do you understand by soil testing? Why is soil testing required and how is it done?
   _____
   _____
   _____
5. How is field preparation done for solanaceous crops?
   _____
   _____
   _____



6. Write short notes on:

(a) Soil Health Card Scheme

_____

_____

_____

(b) Nutrients required by solanaceous crops

_____

_____

_____

Match the Columns

Soil type	Characteristics
1. Black soil	(a) highly acidic and black
2. Red soil	(b) rich in potash, calcium
3. Lateritic soil	(c) sandy soil found in low rainfall areas
4. Alluvial soil	(d) stony and infertile
5. Desert soil	(e) low water holding capacity
6. Forest and hilly soil	(f) coastal regions
7. Peat and marshy land	(g) poor in nitrogen, phosphate and lime

Session 2: Transplanting of Seedlings

Transplanting

Transplanting is a process, wherein a seedling is uprooted from a nursery bed and transplanted to a permanent place, where it grows to produce yield. Solanaceous vegetable crops can endure transplanting shock and are able to form secondary roots. Hence, these can successfully be transplanted. Tomato, brinjal and chilli are ready for transplantation in 4–5 weeks after sowing.

Fig. 3.6: Seedlings of chilli in pro-trays

Fig. 3.7: Seedlings of tomato in pro-trays

Selection of seedlings for transplanting

In solanaceous vegetable crops, 4–5 weeks old seedlings with 10–15 cm height (4–5 leaves) are suitable for transplanting (Fig. 3.6 and 3.7). Do not select weak, lanky and overgrown seedlings. Watering of the nursery bed is required just before uprooting. During transplanting, a seedling must be:

- vigorous and sturdy
- having a healthy root system
- free from insects, pests and diseases
- hardened in the nursery

Ideal conditions for transplanting

Transplanting is done when the weather is cloudy, cool and moist. During sunny days, transplanting is preferred late in the afternoon to allow the seedlings to recover at the low temperature of the night.

Procedure for transplanting

Holes are made in the main field with the help of a *khurpi* or a shovel at a specified distance for a crop. One seedling is placed in each hole. Cover its roots with soil firmly. The seedlings of solanaceous crops are transplanted on a flat bed or on sides of ridges. When planted on a flat bed, ridges and furrow are made after the seedlings set firmly. Irrigation should be done immediately after transplanting. In the initial stages, seedlings are transplanted at the side of ridges, and later, earthling up is done to bring the plant in the centre of the ridges.

However, raised bed planting system is becoming popular. Beds of 15–20 cm height and 1.2 m width, irrespective of length, are prepared. These beds are either furrow irrigated or drip irrigated. Polythene mulching is another intervention to minimise weeds and save water.

Irrigation is preferably localised along plant rows, leaving areas between the rows dry for transplanting operation. This is possible with furrow and drip irrigation but not with sprinkle irrigation. Irrigate the field 2–3 days before transplanting, if the soil is sandy or sandy loam. In case of clayey soils, irrigate 5–6 days prior to transplanting. Light irrigation is necessary immediately after transplanting for better field stand of seedlings.

Time of transplanting

Solanaceous vegetable crops are warm season crops. In India, these can be grown throughout the year in areas where winters are less severe. *Kharif* season crops, like tomato, brinjal and chilli are sown in June–July and transplanted in the months of July–August. *Rabi* or winter season crops are sown in September–October and transplanted in November–December.

For summer crops, seeds are sown in January–February and transplanted in February–March.

Transplanting shock

Transplanting shock means temporary retardation in growth or subsequent mortality of seedlings just after transplanting. This can be prevented by hardening of the seedlings by withholding water for 3–5 days before transplanting. Seedlings can recover easily if watered frequently for about a week after transplanting.

Precautions

(a) Water the seedlings before uprooting them in order to reduce root injury.
(b) Tie the seedlings in suitable bundles for taking them to the field.
(c) Do not place the seedlings under direct sunlight after uprooting them.
(d) Protect the seedlings from farm animals.
(e) Preferably choose evening hours for transplanting.
(f) Treat the roots of seedlings with fungicides or insecticides to prevent them from diseases, insects and pests.
(g) Ensure that the field is kept moist for better growth of the seedlings.

Staking (in tomato and chilli)

Staking is supporting a plant's stem or branches by tying them to wooden or metal stakes (planks). Staking prevents dislodging of the plant due to wind. It is observed that when solanaceous plants bear heavy fruiting, their branches may get broken or bend downwards. The breakage of branches reduces the yield, while their bending brings the fruits in contact with the soil and impairs their quality. Staking is, generally, done to support the plant to keep it in an upright position and the fruits in a hanging position above the ground. Individual plants are staked on wooden or metal planks. Indeterminate type of varieties are staked by tying them to strings or wires running across rows. Lines of strings are strung between the stakes in order to provide support to the plant. A stake of 5–6 feet high is required for the

staking of an indeterminate variety, while in case of a determinate variety, 3–4 feet high stake is needed.

Method and time of potato planting

Fig. 3.8: Potato crop in a field

Potato crop is raised by planting tubers or pieces of a tuber directly in the main field at required spacing (Fig. 3.8). After the preparation of the land, the potato seeds are planted in ridge and furrow system. In the manual method of planting, potato seed tubers are planted on the north side of each ridge, whereas, furrows are made with the help of a tractor drawn 2–4 row planter-cum-fertiliser drills. Care is taken that seed tubers do not come in contact with fertilisers.

Potato is taken as a winter season crop in plains. The best temperature required for growing the crop is 30–32 °C and the minimum is 10–20 °C. In plains, September–October is the best time for planting potatoes. In hills, a temperature range of 20–22 °C (maximum) and 12–15 °C (minimum) is suitable for potato cultivation.

Spacing

Appropriate spacing to get the optimum plant population is important for getting the maximum yield and better quality produce, without unduly increasing the cost of production. Closer spacing gives higher yield but the tuber size is reduced. Besides, it increases the incidence of pests and diseases. The spacing for the transplanting of solanaceous crops is given in Table 3.5.

Table 3.5: Spacing for solanaceous crops

Crops	Spacing in cm (row-to-row x plant-to-plant)
Tomato	60 x 45 (determinate varieties/hybrids) 90 x 60 (indeterminate varieties/hybrids)
Brinjal	60 x 45 (long fruits) 90 x 90 (round fruits)
Chilli	45 x 45
Potato	60 x 20

Cropping system

Intercropping

This is a cropping system, wherein two or more crops are grown simultaneously in alternate rows or otherwise on the same land, showing significant amount of intercrop competition.

Selection of intercrop

- Short duration and shallow-rooted crop is selected as an intercrop with a deep-rooted crop.
- The prevailing climatic conditions should be favourable for the selected crops.
- The selected crops, preferably, should not have common insects, pests or diseases.
- The growing habit of one crop does not affect the growth of the other.
- The selected intercrop flourishes well in the space between two rows of the crop.

Suitable intercrop(s) with solanaceous vegetables

(a) Brinjal + Radish
(b) Tomato + Radish + Lettuce
(c) Tomato + Spinach
(d) Brinjal + Cauliflower

Advantages

(a) Intercropping increases production from a land without reducing the yield of the main crop.
(b) It provides better utilisation of land, labour and other resources.
(c) It provides additional income to farmers.
(d) Intercrops maintain a soil's fertility as nutrient uptake is obtained from different layers of the soil.
(e) Intercropping reduces soil erosion and helps in weed control.
(f) Intercrops provide shade and support to other crops planted on the same land.

Disadvantages

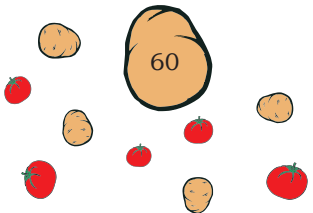
(a) Intercropping may require more agricultural inputs.
(b) Machines are needed for intercultural operations.
(c) There may be allelopathic effect (direct or indirect harmful effect of one plant on another).
(d) Disease, and insects or pests may harbour more on the preferred host crop as compared to intercrops.

Crop rotation

It is a system of growing crops in recurrent succession on the same land either in a year or over a longer period of time.

Selection of crop for rotation

Companion crops are chosen with due care so that the soil's health is not impaired. Here, the cycle of cropping



sequence takes more than one year to complete. Crops with different types are included in rotation, so the chances of harbouring of insects and pests can be checked. A shallow-rooted crop is rotated with a deep-rooted crop in order maintain the soil's productivity.

Suitable crop rotation with solanaceous vegetables

- Early cauliflower (July to September) – brinjal (October to March) – *amaranth* (March to June)
- Green manure crop (June to July) – early tomato (August to December) – onion (December to May)
- Brinjal (May to October) – pumpkin (October to February) – okra (February to May)
- Okra (June to October) – cauliflower (November to February) – tomato (February to June)
- Okra (June to October) – potato (October to February) – tomato (February to June)
- Tomato (June to November) – onion (December to May)
- Potato (October first week to December) – wheat – maize
- Potato (October first week to December) – wheat – paddy
- Potato (November to January) – okra (February to May) – soybean

Advantages

(a) Crop rotation improves and maintains soil fertility.
(b) It helps in preventing pests, weeds and soil-borne diseases.
(c) It also checks soil erosion.
(d) Crop rotation conserves soil moisture in a field.

What have you learned?

Now, I am able to:

- understand the transplanting process.
- assess the spacing of crops in transplanting.
- understand intercropping and crop rotation.

Practical Exercises

Activity 1: Demonstrate the transplanting of seedlings.
Material required: Khurpi, shovel and seedlings
Procedure

- Prepare a suitable layout (flat bed or ridges and furrows) for planting.

- Mark the location for planting seedings at suitable spacing.
- Make holes at the point of planting with the help of a *khurpi* or shovel.
- Place one uprooted seedling in each hole.
- Cover it with soil and press the soil around the seedling firmly.
- Water it immediately.

Check Your Progress

Fill in the Blanks

1. In plains, planting time of potato is _____.
2. The appropriate height of seedlings should be _____ at the time of transplanting.
3. The _____ facilitates to keep the fruits in hanging position above the ground.
4. _____ is a method of uprooting the selected seedlings from a nursery bed and planting them in the main field at suitable spacing.
5. Transplanting shock can be prevented by _____ of the seedlings.
6. Potato crop is raised by planting _____ directly in the main field.
7. The best temperature for planting potato is _____.
8. In intercropping, a _____ crop is selected with a deep-rooted crop.
9. _____ maintains and improves soil fertility.

Multiple Choice Questions

1. At the time of transplanting, a seedling must be _____.
   (a) vigorous and sturdy
   (b) having good root system
   (c) hardened in the nursery
   (d) all of the above
2. Transplanting is done when the weather is _____.
   (a) cloudy (b) cool
   (c) both a and b (d) hot
3. Solanaceous vegetable crops are also known as _____.
   (a) warm season crop
   (b) cool season crop
   (c) temperate crop
   (d) none of the above
4. The temporary growth retardation or subsequent mortality of seedlings after transplanting is called _____.
   (a) damping off
   (b) wilt
   (c) transplanting shock
   (d) none of the above

5. _____ means supporting the plant stem or branches by tying them to wooden or metal stakes (planks).
   (a) Rouging (b) Staking
   (c) Pruning (d) Intercropping
6. Potato crop is taken as _____ crop in plains.
   (a) summer season (b) rainy season
   (c) winter season (d) all the year round
7. Which of these system is followed when two or more crops are grown simultaneously in alternate rows?
   (a) mix cropping (b) intercropping
   (c) relay cropping (d) crop rotation
8. The system of growing crops in recurrent succession on the same piece of land either in a year or over a longer period of time is known as _____.
   (a) mix cropping (b) intercropping
   (c) relay cropping (d) crop rotation

Descriptive Questions

1. What is transplanting shock? How can it be minimised?
   _____
   _____
   _____
2. What is staking? Enumerate its advantages.
   _____
   _____
   _____
3. Write down the criteria for the selection of seedlings for transplanting.
   _____
   _____
   _____
4. Describe the method of potato planting.
   _____
   _____
   _____
5. Give the recommended spacing required for various solanaceous crops.
   _____
   _____
   _____

Match the Columns

Vegetables	Spacing
1. Tomato indeterminate type	(a) 60 × 20 cm
2. Long fruit bearing brinjal	(b) 45 × 45 cm
3. Chilli	(c) 60 × 45 cm
4. Potato	(d) 90 × 60 cm

Unit 4

Soil Nutrient Management in Vegetable Crops

Introduction

Plant nutrition is an important factor, which directly affects the growth, yield and quality of a crop. Soil contains many mineral nutrients, organic material and water, which are absorbed by plants. If any of these nutrients are deficient or not available in the soil, it affects crop development and a plant shows deficiency symptoms. Therefore, soil nutrient management is necessary for successful crop production. Most of the nutrients are absorbed by plants through their roots from the soil but leaves can also absorb nutrients, if applied in specific formulation as foliar sprays. Nutrients in the soil can be supplemented through the application of fertilisers or manures. Nutrient management includes the type of fertiliser to be applied, rate of application and method of application.

There are a total of 17 nutritive elements, which are necessary for the growth of plants. All elements are equally important irrespective of their requirement or presence in a plant. According to Arnon and Stout (1939), an element must meet the following three criteria:

- a plant cannot complete its life cycle in the absence of that mineral element
- the element is specific and cannot be replaced
- the element must be directly involved in plant metabolism

Session 1: Macro and Micro-nutrients in Soil System

Classification of plant nutrients

Nutrients can be classified according to their requirement and importance in plant life. They can be classified into basic nutrients, macro-nutrients and micro-nutrients. (Fig. 4.1).

Basic nutrients

The basic nutrients are — Carbon (C), Hydrogen (H) and Oxygen (O). These elements are obtained from air and water. Compounds made of these elements are called carbohydrates. Carbohydrates provide strength to cells. Therefore, they are called sources of energy for plants and for organisms who consume plants.

Macro-nutrients

This is further divided into:

- *Primary nutrients*: These consist of Nitrogen, Phosphorus and Potassium. These nutrients are supplied through fertilisers.
- *Secondary nutrients*: They include Calcium, Magnesium and Sulphur.

Micro-nutrients

They are also known as minor or trace elements. They include Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Chlorine (Cl), Boron (B) Molybdenum (Mo) and Nickel (Ni).

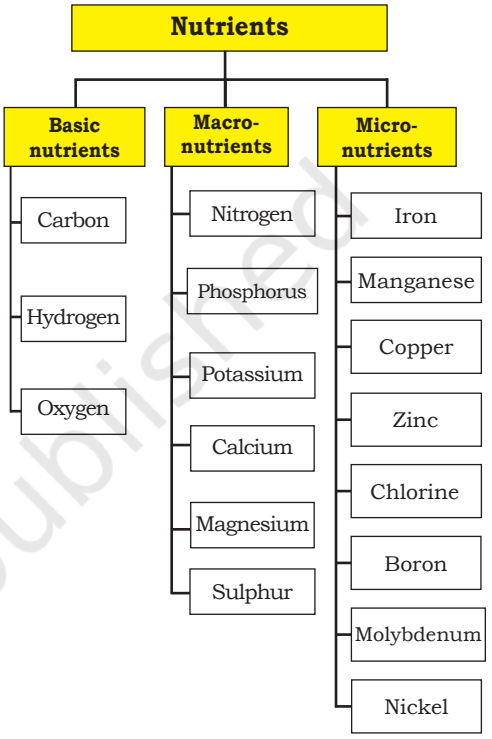


Fig. 4.1: Classification of plant nutrients

Nutrients, their functions and deficiency symptoms

- *Non-mineral elements*: Carbon (C), Hydrogen (H) and Oxygen (O)
- *Primary nutrients*: Nitrogen (N), Phosphorus (P) and Potassium (K)
- *Secondary nutrients*: Calcium (Ca), Magnesium (Mg and Sulphur (S)

Nitrogen (N)

Functions

(a) promotes the growth of leaves and stems
(b) enhances the dark green colour in plants and improves the quality of foliage
(c) necessary for the development of cell protein and chlorophyll
(d) improves the uptake and assimilation of other nutrients, like phosphorus, potassium, magnesium and sulphur

Deficiency symptoms

(a) loss of vigour and yellowing of green parts
(b) shortening of the stem, leaves become paler and remain small in size
(c) slow growth and a plant becomes dwarf

Phosphorus (P)

Functions

(a) stimulates root formation and healthy growth of roots
(b) vigorous growth and speedy maturity
(c) increases the number of tubers in tuber crops
(d) necessary for enzyme action in many plant processes

Deficiency symptoms

(a) growth of a plant is retarded at the early stage
(b) older leaves curl up and become purplish in colour
(c) sometimes, scorching of leaf margin is observed
(d) slow maturity and vegetative growth continues beyond normal time
(e) delayed tuber formation in tuber crops

Fig. 4.2: Potassium deficiency in cabbage

Potassium (K)

Functions

(a) helps in carbohydrates and protein synthesis
(b) helps in the transfer of carbohydrates from leaves to roots
(c) increases disease resistance, vigour and hardiness to drought and frost

(d) increases yield by increasing the size of tubers, hence, important for processing cultivars

Deficiency symptoms

(a) coincides with the onset of tuber initiation
(b) deficiency symptoms appear as dark bluish green leaves and shortened internodes
(c) terminal leaves show bronzing accompanied by necrotic spots (Fig. 4.2)
(d) in case of acute deficiency, leaf margins dry up and often premature death of a plant occurs

Sulphur (S)

Functions

(a) promotes root growth and vigorous vegetative growth
(b) essential for protein formation
(c) required in metabolic activities

Deficiency symptoms

(a) shoots become light green; veins on the leaves also turn paler
(b) yellowing of leaves and stunted growth of a plant
(c) yellowing starts from upper leaves and the plant shows chlorosis
(d) severe deficiency results in reddening of the stem and curling of leaves inwards
(e) growth of a plant is retarded

Calcium (Ca)

Functions

(a) improves plant vigour
(b) influences the intake and synthesis of other plant nutrients
(c) important constituent of cell wall
(d) increases the yield of large and medium-sized tubers
(e) improves specific gravity of tubers, and thus, enhances tuber quality for processing

Deficiency symptoms

(a) failure of development of terminal buds at apical tips
(b) small leaves

(c) leaves do not develop normally and have wrinkled appearance
(d) in mild deficiency, a light green band appears along the margin of leaves of terminal buds
(e) in severe deficiency, young leaves at the top remain folded and later their tips die

Magnesium (Mg)

Functions

(a) influences the intake of other essential nutrients
(b) helps in the assimilation of fats
(c) assists in the translocation of phosphorus and fats

Deficiency symptoms

(a) green parts between veins in leaves become pale, though the veins remain green
(b) leaf tips curl up
(c) slender and weak stalks
(d) plants become slightly pale, older leaves develop central necrosis and turn yellow or brown
(e) in severe deficiency, leaflets become thick, brittle, show bulging and roll upwards

Zinc (Zn)

Functions

(a) synthesis of *Tryptophan*
(b) helps in enzyme action
(c) essential for protein synthesis and seed production
(d) fastens the rate of maturity

Deficiency symptoms

(a) younger leaves become yellow
(b) shallow pits develop in the inter-veinal portion on upper surfaces of mature leaves
(c) leaves show inter-veinal necrosis, while midrib remains green
(d) in tomato, small narrow yellow leaves with black spots appear and there is stunted growth in plants

Iron (Fe)

Functions

(a) essential in the enzyme system of plant metabolism

(b) essential for the synthesis of enzymes responsible for chlorophyll synthesis in plants

Deficiency symptoms

(a) yellowing of younger leaf blades, while veins and petioles remain green
(b) affected plants remain small and do not respond well to normal fertiliser treatments

Manganese (Mn)

Functions

(a) helps in the oxidation-reduction process during photosynthesis
(b) essential element in respiration

Deficiency symptoms

(a) plants show a light inter-veinal chlorosis of leaves
(b) mature leaves when observed in light show netted veins
(c) appearance of chlorotic and necrotic spots in inter-veinal areas of leaves

Copper (Cu)

Functions

(a) essential for the synthesis of chlorophyll and other plant pigments
(b) helps improve the flavour and the content of sugar in vegetables
(c) increases the dark green colour of leaves and also the crop yield

Deficiency symptoms

(a) necrosis on the tip of young leaves along the margin
(b) defoliation
(c) leaves of deficient plants curl up and their petioles bend downwards

Molybdenum (Mo)

Functions

(a) involved in nitrogen fixation and nitrate assimilation
(b) required by some microorganisms for nitrogen fixation in soils

Deficiency symptoms

(a) chlorotic inter-veinal mottling of lower leaves followed by marginal necrosis and infolding of leaves
(b) wilting of leaves
(c) in cauliflower, the lamina of new leaves fails to develop and gives a whiptail appearance

Boron (B)

Functions

(a) helps in the synthesis of the bases of RNA (Ribonucleic acid)
(b) promotes root growth
(c) enhances pollen germination and pollen tube growth, thereby, improving fruiting

Deficiency symptoms

(a) loss of apical dominance
(b) leaf blades develop pronounced crinkling
(c) darkening and crackling of petioles
(d) syrupy exudation from leaf blades
(e) the leaves may have thick coppery texture and sometimes curl up and become brittle

Chlorine (Cl)

Functions

(a) has a direct role in photosynthesis
(b) necessary for shoot apex and root growth

Deficiency symptoms

(a) chlorosis and wilting of young leaves
(b) chlorosis of the inter-veinal area of leaf blade
(c) in severe deficiency, bronzing of the mature leaves on upper surface

What have you learned?

Now, I am able to:

- know about macro and micro-nutrients present in soil.
- understand the functions and deficiency symptoms of nutrients in plants.

Practical Exercises

Activity 1: Identify deficiency in the given sample of vegetable.
Material required: Sample of vegetables and picture showing symptoms

Procedure

- Observe the sample carefully.
- Identify the crop.
- Identify the symptoms.
- Match with the pictorial chart and confirm it.
- Write down the deficient elements.

Check Your Progress

Fill in the Blanks

1. Compounds made up of carbon, hydrogen and oxygen together are called _____.
2. Plants obtain carbon, hydrogen and _____ from air and water.
3. Micro-nutrients are also known as minor or _____ elements.
4. The function of _____ is to give dark green colour and improve the quality of foliage.
5. Stimulating root formation and their healthy growth are the functions of _____.
6. Calcium is an important constituent of the _____.
7. Magnesium helps in _____ assimilation.
8. Zinc fastens the rate of _____ in plants.
9. Manganese is involved in the _____ process of photosynthesis.
10. Nitrogen fixation and nitrate assimilation are the functions of _____.

Multiple Choice Questions

1. _____ essential elements are required for plant growth and development.
   (a) 15 (b) 16
   (c) 17 (d) 18
2. _____ are the micro-nutrients.
   (a) Ca, Mg, S (b) N, P, K
   (c) C, H, O (d) Zn, Cu, B

3. _____ helps in the synthesis of the bases of RNA.
   (a) Boron (b) Molybdenum
   (c) Chlorine (d) All of the above
4. Molybdenum in plant is necessary for _____.
   (a) protein synthesis
   (b) photosynthesis
   (c) chlorophyll
   (d) nitrogen fixation
5. Deficiency of boron results in _____.
   (a) loss of apical dominance
   (b) rosette appearance
   (c) syrupy exudation from the leaf blade
   (d) all of the above

Descriptive Questions

1. What are the criteria of essentiality of nutrients?
   _____
   _____
   _____
2. What are micro and macro-nutrients? Give examples.
   _____
   _____
   _____
3. What are the important functions of nitrogen. Write its deficiency symptoms.
   _____
   _____
   _____

Match the Columns

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

Session 2: Manures and Fertilisers

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 'fertiliser'.

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). The nutrients supplied by manures are given in Table 4.1.

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 fertilisers.

(d) There can be favourable 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)

Fig. 4.3: Farm Yard Manure

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. 4.3). 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.

Compost

Fig. 4.4: Compost

Compost is an organic manure produced by the decomposition of organic wastes (Fig. 4.4). 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.

Oil cakes

Fig. 4.5: Groundnut cake

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 fertilisers. 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. 4.5), linseed cake, rapeseed (*Brassica napus*) cake, cotton seed cake, safflower cake, sesame cake, etc., are examples of edible oil cakes.

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 4.1: Nutrients supplied by manures (%)

S. No.	Manure	N (%)	P_2O_5 (%)	K_2O (%)
1	**Manures of plant origin**			
	(a) Cotton seed cake	3.9–4.0	1.8–1.9	1.6–1.7
	(b) Green manure (avg.)	10.0–12.0	1.0–1.5	0.6–0.8
	(c) Groundnut cake	7.0–7.2	1.5–1.6	1.3–1.4
	(d) *Karanja* cake	3.9–4.0	0.9–1.0	1.3–1.4
	(e) Linseed cake	5.5–5.6	1.4–1.5	1.2–1.3
	(f) Neem cake	5.2–5.3	1.0–1.1	1.4–1.5
	(g) Rapeseed cake	5.1–5.2	1.8-1.9	1.1–1.2
	Wood ashes			
	(a) Ash babul	0.1–0.2	2.5–3.0	3.5–4.5
	(b) Ash coal	0.73	0.45	0.53
	Plant residue			
	(a) Groundnut husk	1.6–1.8	0.3–0.5	1.3–1.7
2	**Manures of animal origin**			
	(a) Bird guano	0.4–0.8	0.3–0.6	0.7–1.0
	(b) Bone meal	0.1–0.7	0.1–0.2	0.8–1.6
	(c) Cattle dung and urine mixed	5.2–5.3	1.0–1.1	1.4–1.5
	(d) Dried blood	0.5–1.5	0.4–0.8	0.5–1.9
	(e) Fish manure	1.2–2.0	1.0	1.5
	(f) Night soil	3.9–4.0	0.9–1.0	1.3–1.4
	(g) Settled sludge (dry)	3.9–4.0	1.8–1.9	1.6–1.7
3	**Composite manures**			
	(a) Compost (Rural)	0.4–0.8	0.3–0.6	0.7–1.0
	(b) Compost (Urban)	1.0–2.0	10–1.2	1.2– 1.5
	(c) Farm Yard Manure (FYM)	0.5–0.7	0.4–0.8	0.5–1.9

Green manure

Green manuring is a practice, wherein crops, like sunn hemp (*Crotalaria juncea*), *dhaincha* (*Sesbania aculeata*), pillipesara (*Phaseolu strilobus*) and cluster bean (*Cyamopsis te tragonoloba*) 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:

Fig. 4.6: Green manure crop (sunn hemp)

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. 4.7). 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. 4.7: Vermicompost

Advantages

(a) It can be used for all vegetable 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 an 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 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. When fresh FYM is used, it causes burning effect due to the presence of excess soluble nitrogen. An applicable dose of about 20–25 tonnes/ha is recommended for the cultivation of vegetable crops.

Bio-fertilisers

Bio-fertilisers are carrier-based preparation, containing beneficial microorganisms, such as bacteria, fungi and algae in sufficient quantities, 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-fertiliser includes microorganisms, which add, conserve and stimulate plant nutrients in the soil. Thus, their activities are helpful in increasing the soil's fertility. Bio-fertilisers should never be mixed with insecticide, fungicide, herbicide and fertilisers.

Classification of bio-fertilisers

Bio-fertilisers can be broadly divided into two groups:

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

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

Types of bio-fertilisers

Fig. 4.8: Rhizobium nodules in cowpea

Rhizobium

These bacteria fix nitrogen in the roots of leguminous crops. They colonise in roots of specific leguminous plants to form a tumour-like structure called 'root nodules' (Fig. 4.8). These nodules fix the atmospheric nitrogen symbiotically. *Rhizobium*–legume association can fix up to 100–300 kg of N per ha/year.

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 bio-fertilser 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.

Fig. 4.9: Azolla

Azolla

These are symbiotic in nature, suitable only for flooded rice and fix nitrogen symbiotically with *Anabaena azollae*. These contain chlorophyll and get energy from photosynthesis to fix atmospheric nitrogen (Fig. 4.9). These can fix 100–150 kg N per ha/year with about 40–60 tonnes of biomass.

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 Bio-fertilisers (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. The 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 bio-fertilisers

Seed treatment

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.

Fertilisers

Fertilisers are artificially 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 fertilisers used for vegetable crops *viz.*, nitrogenous, phosphatic and potassium. Fertilisers can also be classified into straight, compound and mixed.

Advantages

Fertilisers are readily available nutrients to plants. The exact amount of a given element can be calculated and applied to plants. Some of their advantages are:

(a) Fertilisers are easy to carry as they are packed in 50 kg plastic bags.
(b) They can be easily applied in different ways.
(c) Fertilisers are easily available in different formulations and concentrations.

Disadvantages

(a) A fertiliser costs much higher than organic fertilisers, 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 decomposes 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.

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

Type of fertilisers

Sole fertiliser or straight fertilisers

These fertilisers have only one chemical compound or supply only a single nutrient. It is sometimes accompanied by a minor element. Sole fertilisers are further grouped according to the nutrient they supply. The nutrient content of different fertilisers are shown in Table 4.2.

Nitrogenous fertilisers

These are prepared and applied as a source of nitrogen to the crop. These are decomposed fast and applied in split doses at the time of sowing and the rest as top dressing during flowering and fruit set. Commonly available nitrogenous fertilisers are — urea, calcium, Ammonium nitrate and Ammonium sulphate.

Phosphorus or phosphatic fertilisers

Phosphatic fertilisers 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 fertilisers are — Single super phosphate, Double super phosphate, Triple super phosphate, Dicalcium phosphate, etc.

Potassium fertilisers

These fertilisers 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 fertilisers are Potassium chloride or muriate of potash, Potassium sulphate, etc.

Mixed fertilisers

Fertilisers supplying more than one macro-nutrient to plants are known as mixed fertilisers. These are mixtures of nitrogen, phosphorus and potash (N, P and K) in various suitable proportions. Commonly used

mixed fertilisers are Nitrogen phosphate with potash (15:15:15), NPK (10:26:26) and NPK (12:32:16).

Compound fertilisers

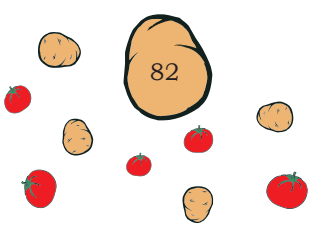
These fertilisers supply more than one plant nutrient, usually two, such as nitrogen and Phosphoric acid or nitrogen and potassium. The commonly used compound fertilisers are — Diammonium phosphate (18:46:0), Ammonium phosphate sulphate (16:20:0), Mono-ammonium phosphate (11:52:0), etc.

Table 4.2: Approximate nutrient content in different fertilisers

Fertiliser	N (%)	P_2O_5 (%)	K_2O (%)	Others (%)
Nitrogenous				
Ammonium chloride	25.0	–	–	–
Ammonium sulphate	20.5	–	–	–
Anhydrous ammonia	82.2	–	–	–
Calcium ammonium nitrate	25.0	–	–	–
Urea	46.0	–	–	–
Phosphatic				
Ammonium phosphate	20.0	20.0	–	–
Diammonium phosphate (DAP)	16	46	–	–
Double super phosphate	–	32.0	–	–
Rock phosphate	–	20.0–40.0	–	–
Single super phosphate	–	16.0	–	12% (S)
Triple super phosphate	–	46.0	–	
Potassium				
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)

Micro-nutrient fertilisers

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 fertilisers. Zinc sulphate ($ZnSo_4$),



Copper sulphate ($CuSo_4$), Ferrous sulphate ($FeSo_4$), Manganese sulphate ($MnSo_4$), etc., are commonly used micro-nutrient fertilisers. All are soluble in water and can be used as soil application or foliar spray.

Methods of fertiliser application

Soils react differently with the application of fertilisers. 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 (Table 4.3, see page 85).

Basal application

This method refers to the application of fertilisers 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 fertilisers in large quantities on the surface before ploughing (Fig. 4.10)

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

(c) fertilisers 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 fertilisers are applied with a drill below the surface of the soil before sowing or during seed sowing with a seed-cum-fertiliser drill

Fig. 4.10: Fertiliser broadcasting

Top dressing

The fertiliser is applied in the standing crop in case of top dressing. There are several methods of top dressing.

(a) broadcasting fertilisers in moist fields 2–5 days after irrigation

(b) applying fertilisers around individual plants
(c) applying fertilisers along rows

Fig. 4.11: Foliar application of fertiliser

Foliar application

Macro-nutrient fertiliser can also be applied through foliar spray (Fig. 4.11). 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.

Methods of micro-nutrient application

There are four ways of applying micro-nutrients.

Soil application

Micro-nutrient along with fertilisers 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 are dipped in a prepared solution before transplanting. Generally, 0.2–0.3% solution of Zinc sulphate is used 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 are 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 vegetables require specific doses of various nutrients in the form of nitrogen, phosphorus and potash (NPK). The recommended dose of the NPK is shown in Table 4.3.

Table 4.3: Recommended dose of NPK for vegetable crops

Vegetable crops	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Beans	60–120	50–80	50–80
Brinjal	100–200	60–80	50–100
Cabbage	100–200	80–100	50–100
Carrot	80–150	60–80	80–100
Cauliflower	100–200	60–80	50–100
Chilli	100–300	80–100	80–100
Cowpea	50–100	40–60	40–60
Cucumber	80–150	40–60	40–70
Garden pea	60–80	50–60	50–60
Garlic	100–200	60–80	60–80
Lettuce	120–180	40–80	50–80
Okra	100–150	50–80	50–80
Onion	120–300	60–80	50–80
Spinach	80–120	40–60	40–60
Potato	100–200	60–80	80–120
Snap bean	100–150	50–80	50–80
Tomato	100–200	60–80	50–100
Watermelon	100–160	40–60	60–80

What have you learned?

Now, I am able to:

- distinguish between different types of manures and their methods of application.
- distinguish between different types of fertilisers and their methods of application.
- know NPK dosage for different vegetable crops.

Practical Exercises

Activity 1: Identify various fertilisers.

Material required: Fertiliser samples, water, container, litmus paper (both red and blue), etc.

Procedure

- Collect fertiliser samples in a small polybag.
- Record the following observations.

Characteristics of fertilisers

Names of fertilisers	Hygroscopicity	Colour	Granules or powder	Solubility in water	Reaction on litmus paper
Nitrogenous					
(a) (b) (c)					
Phosphatic					
(a) (b) (c)					
Potassic					
(a) (b) (c)					

Activity 2: Identify different types of manures.

Material required: Manure of different types, dish

Procedure

- In a dish, keep a manure for identification.
- Write down its name.
- Write the class of the manure.
- Write the percentage of nutrients present in it.

S. No.	Name of manure	Class/source
1.	FYM	Decomposed organic waste of plants and animals
2.	Compost	Decomposed organic waste of plants and animals
3.	Cotton cake	Edible oil cake
4.	Branch of glyricidia	Green manure
5.	Vermicompost	Earthworm

Activity 3: Compost making using waste material in school

Material required: Pick axe, spade, measuring tape, baskets, stick or bamboo, other waste material

Procedure

- Dig a pit of 2 × 2 × 0.8 m size at a selected site in a school. Make its bottom complete or partial *pucca*.
- Collect organic waste material daily. Deposit it in the pit in layers of 20–25 cm.
- When 2 or 3 such layers are deposited in the pit, spread cow dung slurry (1:10 ratio) and spread soil over them in a thick layer of 2–2.5 cm. Continue in the same way till the pit is filled.
- Add water to the pit to maintain enough moisture for the decomposition of the waste material.
- Cover the pit with soil and cow dung again.
- After one month, remove a small portion of the soil to check the moisture content.
- Check again after three months. The compost is ready for use.

Observations

The students need to observe the compost for following properties and determine the quality of the compost prepared.

Properties	Undecomposed	Decomposed
(i) Odour		
(ii) Texture		
(iii) Colour		
(iv) Pliability		

Check Your Progress

Fill in the Blanks

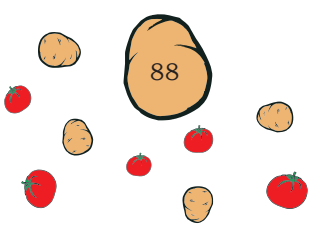
1. The _____ can be applied at any stage of crop growth.
2. For applying fertilisers into the soil before or at the time of planting, _____ method is used.
3. Urea is highly suitable for _____ application because of its high solubility, ease and quick absorption.
4. FYM contains _____ % N, _____ % P_2O_5, and _____ % K_2O_5.
5. For root dipping, _____% Zinc sulphate solution is used.
6. The _____ fixes nitrogen symbiotically with leguminous crop.

Multiple Choice Questions

1. Which is a non-edible oil cake?
   (a) Groundnut cake
   (b) Cotton seed cake
   (c) Neem cake
   (d) Linseed cake
2. Which of the following is a compound fertiliser?
   (a) Calcium ammonium nitrate
   (b) Double super phosphate
   (c) Nitro phosphate with potash
   (d) Diammonium phosphate
3. Identify the crop which is used as whole for green manuring.
   (a) *Glyricidia* (b) *Sesbania*
   (c) *Dhaincha* (d) *Karanja*
4. Organic manures should be best applied _____.
   (a) 15–20 days before transplanting
   (b) at the time of transplanting
   (c) 15–20 days after transplanting
   (d) all of the above
5. Recommended NPK dose per hectare for tomato is _____.
   (a) 100–200; 60–80; 50–100
   (b) 50–100; 100–150; 60–80
   (c) 60–80; 100–200; 50–100
   (d) 70; 90; 100–200
6. Vermicompost is applied in vegetables at the rate of _____.
   (a) 2–3 tonnes/ha
   (b) 5–6 tonnes/ha
   (c) 10–12 tonnes/ha
   (d) 20–22 tonnes/ha
7. Manures are organic nutrients in complex form derived from _____.
   (a) Animals (b) humans
   (c) plant residues (d) all of the above
8. Which of the following is a bulky manure?
   (a) FYM (b) Compost
   (c) Green manure (d) All of the above

Descriptive Questions

1. Write down the advantages of organic manure.
   _____
   _____
   _____



2. Write a brief note on vermicompost and its application.

_____

_____

_____

3. What is a green manure crop? What are its advantages and disadvantages?

_____

_____

_____

4. What are the different methods for the application of fertilisers in vegetable crops?

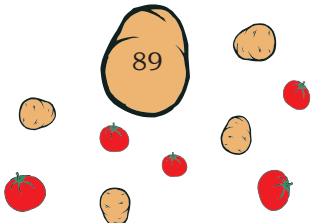
_____

_____

_____

Match the Columns

Column A	Column B
1. Basic nutrients	(a) Secondary nutrients
2. Ca, Mg, S	(b) Urea, DAP and MOP
3. Hollow heart of legumes	(c) Faecal matter of earthworms
4. Tuberisation	(d) Nitrogenous fertilisers
5. Bulky organic manures	(e) Boron
6. Vermicasting	(f) FYM and Compost
7. Chemical fertilisers	(g) Potassium
8. Split application	(h) C,H,O



Unit 5

Occupational Health, Hygiene and First Aid Practices

17902CH05

Introduction

Occupational health deals with the control of health hazards that may arise while doing an agricultural work in a farm or a laboratory. It relates to recognising, anticipating, evaluating and controlling those environmental factors at a workplace, which may be a reason of some health issues. Despite taking all precautions and care, often accidents occur while handling and applying chemicals and bio-agents. It is essential for students to know about immediate medical aid that must be administered, in case a chemical or mechanical accident occurs in a farm or a lab, and learn about the safety measures that they need to adopt in order to prevent such hazards.

Session 1: Prevent Hazardous Conditions at Workplace

Hazard

A hazard may be defined as a condition that has the potential to cause an injury to human beings and adversely affect the environment. A hazard can lead to adverse health effects and physical damage under certain situations at a workplace. Fig. 5.1 shows the different types of hazards.

Types of hazards

Natural hazards

These hazards occur because of natural incidents, which may include meteorological (e.g., heavy rains and floods), geological (e.g., landslides and earthquakes), and biological (e.g., gas leaks) factors. Examples of natural hazards are cyclone, earthquake, tsunami and volcanic eruption. Landslide, drought, flood and fire are socio-natural or hybrid hazards as their causes may be both natural and manmade. The natural hazards threatening India include earthquakes (usually, in the Himalayan region), floods, including tsunamis (usually, in river deltas and coastal areas), and landslides (usually, in hilly areas during heavy rains).

Fig. 5.1: Types of hazards

Mechanical hazards

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

Hazards related to pesticides and chemicals

Pesticides are solutions meant for destroying, mitigating and controlling pests. Accidental death from pesticides is a rarity but skin infections and disorders, and health issues may occur, if timely precautions are not taken (Fig. 5.2). Careless handling or use of pesticides can cause harmful effects to the environment and human beings. Precautions must be taken during the selection of pesticides, their transportation, loading, mixing, application, storage and container disposal (Fig. 5.3 and 5.4).

Fig. 5.2: Safety measures being adopted while preparing a pesticide solution

Pesticides may enter our food in the following ways:

- extensive use in growing crops
- frequent and unwanted application by a grower in a crop
- application of poor quality pesticides by the grower
- a pesticide dealer cheats farmers by giving wrong advice and supplying poor quality of pesticides
- continuance of banned pesticides
- liquid waste from pesticide manufacturing units

Fig. 5.3: Signage indicating pesticide spraying in progress

Fig. 5.4: Signage indicating pesticide application in a field

Fig. 5.5: Colours showing toxicity labels of pesticides

- unsafe disposal of leftover pesticides and cleaning of plant protection equipment
- pesticide production and marketing

Precautions

Toxicity labels marked on the pesticide packing, as shown in Fig. 5.5, must be taken into account while using pesticides.

- Chemicals should not be sprayed in foggy and windy weather.
- A person spraying chemicals should not have an open injury on his/her body.

Accidents

Accidents are unfortunate incidents attributable to various factors that a person faces during work, causing physical injury, death and acute poisoning when exposed to a toxic product even for a short duration.

Occupational hazards at agricultural farm

Farmers and workers, while working in an agricultural farm, can suffer from a number of occupational hazards. These include hazards related to farm machinery, biological and chemical hazards, and stress. The hazards may cause injuries, health disorders or diseases. Some of the reasons for injuries and accidents at agricultural farms are as follows:

- being hit by a moving vehicle
- falling from height
- contact with large animals
- contact with a heavy falling object or material
- contact with a farm machinery
- drowning
- musculo-skeletal injury (aches, sprains or strains)
- effects of toxic chemicals through inhalation or exposed body parts

Hazards related to animals

Injuries inflicted by animals include bites, kicks, crushing and transmission of certain infectious diseases. If a farmer or a person working in a field gets injured by a farm animal, immediate first aid must

be administered to him/her and required medical procedures be followed. Injuries from cattle relate to a number of factors, including lack of trained workers, unsafe work practices, weight of an animal, stress and sometimes the behaviour of the animal.

- Hazards by animals may vary as per their age, breed, sex, weight, temperament, horn status and training imparted to them.
- It is also in look, heifers can be dangerous at the time of weaning.
- Cattle, kept isolated, are likely to be more aggressive when approached.
- Cattle with sharp and pointed horns are dangerous, therefore, dehorning is recommended.

Ergonomic hazards

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

Hazards related to electricity

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

In some severe cases, it can even lead to electrocution, causing permanent disability or death of a person.

Fig. 5.6: Electricity hazard sign

Hazards related to heights

Hazards related to heights include falls from ladders, rooftops, farm machinery, tractors and windmills. These are major causes of injury. The following precautions must be taken to prevent hazards due to heights (Fig. 5.7):

- Always wear safety and protective devices, such as headgear, while working on rooftops.
- Climbing ladders should be strong, unbreakable and non-slippery.
- An attendant must always hold the ladder.

Fig. 5.7: Height hazard sign

- A worker must hook an elastic rope around his waist that has one end locked while working at heights.

Hazards related to water

Floods, droughts and other water related hazards have major impacts on the socio-economic status of farmers. Lakes, ponds, wells, rivers, channels, tanks, etc., — all are hazardous, especially for young children. Children playing on farmland should be cautioned not to go near water bodies.

Hazards related to extreme weather

Hazards due to extreme weather conditions in an agricultural farm may occur due to sunburn, heatstroke, dehydration and extreme exposure to cold.

Risk

Risk may be defined as the danger of loss from unforeseen circumstances. It is a measure of the potential danger associated with an activity. Understanding the kind of harm that a machinery may cause a farm worker or assessing the risk helps design and implement strategic and operational plans for the mitigation of hazards. For example, the main hazard of a power-driven machine is that of its getting trapped or entangled in wires, ropes, etc. The risk may be high if one does not fit guards to the machine or train the staff in handling it. If the machine is properly handled and timely maintained, the risk automatically gets reduced.

Risk assessment is a careful lookout at what could be the cause of harm to workers or other people present on a site. There are no fixed rules to conduct a risk assessment, even though some well-defined norms must always be taken into account, such as legislation, regulations, technical norms, codes of practice, principles of risks prevention, etc. These, along with the following measures, can help avert an accident in a farm.

- identification of dangers in every aspect of a work
- identification of people who may be exposed to particular risks
- the reliability and adequacy of existing precautionary or preventive measures

- decision on new measures that should be introduced to eliminate or reduce risks

Disaster

Besides hazards, the farming community also has to face various types of natural and manmade disasters. A disaster can be termed as as "a sudden misfortune that causes a great damage to life". In other words, it can be explained as "an unexpected event whose consequences are seriously destructive".

A disaster can be a combination of a hazard, vulnerability and insufficient capacity of individuals or a community to minimise the potential probability of a risk. It can either be natural, i.e., floods, cyclones, droughts, earthquakes, etc., or manmade, such as riots, fires, conflicts, epidemics, industrial accidents, environmental fallouts, etc.

What have you learned?

Now, I am able to:

- differentiate between risk and hazard.
- understand the common hazards that can occur in an agricultural farm.

Practical Exercises

Activity 1: Prepare a flow chart on types of hazards at a workplace

Material required: Chart paper, pencil, scale and sketch pens

Procedure

- Take a chart paper and draw a flow chart depicting the different types of hazards at a workplace.
- Discuss it in the class with other students.

Check Your Progress

Fill in the Blanks

1. Substances intended for preventing and mitigating pests are called _____.
2. Hazards related to agricultural machinery are called _____.
3. Keep electrical equipment away from _____.
4. Risk is defined as the danger of loss from _____ circumstances.

Multiple Choice Questions

1. Ergonomic hazards are caused by _____.
   (a) poorly designed tools
   (b) machinery
   (c) chemicals
   (d) electricity
2. The use of dangerous substances comes under _____.
   (a) ergonomic hazard (b) extreme weather hazards
   (c) chemical hazards (e) natural hazards
3. Hazards due to agricultural machinery are _____.
   (a) electrical (b) mechanical
   (c) chemical (d) none of these
4. Electrical hazards arise due to _____.
   (a) faulty switches
   (b) spray chemicals
   (c) farm animals
   (d) all of the above
5. Extreme toxic label for pesticide is denoted by _____.
   (a) blue (b) green
   (c) yellow (d) red
6. Pesticides should be sprayed during _____.
   (a) rainy and windy days
   (b) sunny and clear days
   (d) foggy days
   (e) any weather

Descriptive Questions

1. Define hazards.
   _____
   _____
   _____
2. List the various types of hazards related to agriculture and discuss them in brief.
   _____
   _____
   _____
3. Discuss the ways in which pesticides enter our food items.
   _____
   _____
   _____
4. Give one example each of hazards related to height, extreme weather, chemicals and animals.
   _____
   _____
   _____

5. Differentiate between the following:
   (a) Hazard and disaster
   (b) Hazard and risk
   (c) Natural and manmade disaster
   (d) Chemical and biological disaster

_____

_____

_____

Session 2: First Aid, Treatment and Safety Equipment

Despite all precautions and care, often accidents take place while handling and applying chemicals. It is essential for students to know about the immediate medical aid that needs to be administered in case of a chemical accident and learn about the safety and protective devices to be put in place to prevent them.

Chemical poisoning and first aid measures

Chemical poisoning may result from continuous contact, absorption of a chemical through the skin, inhalation of toxic vapour, or swallowing a chemical directly during handling or applying. The common symptoms of pesticide poisoning are — headache, vomiting, nausea, tremors, convulsion, difficulty in respiration, etc. A first aid kit with necessary antidotes should be available at the work site for all types of poisoning.

Fig. 5.8: First aid kit

Treatment for simple chemical poisoning

Swallowed poison

If poison is taken internally, vomiting must be induced immediately. Table salt or mustard oil in a glass of warm water is given to the victim for intake. Touching the throat internally with a finger or any blunt and hard

material will also induce vomiting when the stomach is filled with liquid. The process must be continued till a clear liquid starts coming out as in the case of swallowed chemicals, like Carbon disulphide, petroleum products, such as kerosene or petrol, and corrosive acids, or caustic alkalis. If a patient is in coma, convulsion, or in an unconscious state, vomiting must be induced even then. The patient needs to be given large quantities of milk or egg white beaten in water. If poisoning is due to ingestion of mercury compounds, egg white and milk must be given first, and then, vomiting must be induced. After vomiting, soothing substances, like raw egg white mixed with water, butter or cream milk must be given.

Skin contamination

Contaminated clothes must be put off immediately, if you feel like itching or there is smell of a chemical. The contaminated skin must be thoroughly washed with detergent and clean water. Rapid washing is needed to minimise the intensity of the injury.

Eye poisoning

In this case, the eyes of a victim must be washed with plenty of water, keeping the eyelids open. A delay of few seconds may intensify the extent of the injury. Immediate medical aid must be provided.

Inhaled poison

A patient must immediately be shifted to an open area, so that s/he can inhale fresh air. S/he must be asked to be quiet. Loosen her/his clothes and wrap her/him in a blanket to avoid chilling. Artificial breathing must be arranged if the patient is unable to breathe. Artificial respiration technique through the mouth can also be used.

Safety and protective devices

Hazards due to pesticide poisoning can be prevented by using protective and safety devices. The various kinds of pesticide poisoning and their first aid treatment have already been discussed. The safety and protective

equipment (Fig. 5.9 and 5.10) essentially consists of gas mask, gloves, shoes, eye shields, headgear, protective clothing, respiratory devices, etc.

Fig. 5.9: Gloves and headgear

Gas mask

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

Gloves

Never use gloves made of leather, cotton or any other fluid-absorbing material for handling chemicals. Always use rubber gloves.

Shoes

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

Fig. 5.10: Protective clothing

Eye shields

These must be worn to prevent eye poisoning due to pesticides.

Protective clothing

Apron is used while working with treated crops. The skin must be protected entirely. The clothing needs to be washed before re-use.

General health and safety measures

Follow these health and safety measures at a workplace.

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

Health and safety awareness at workplace

- Awareness campaign may be organised for workers.
- Demonstrate various commitments related to the health and safety of workers by adopting safe work practices.
- Encourage workers to report about health issues, if any, immediately.
- Always wear the required protective equipment and safety gear while working with toxic substances and conduct time-to-time checks if they need to be replaced.
- Ensure that children are always away from high-risk areas, such as tractors, quad bikes, plunge dips, machinery access roads, dams, toxic substances, channels and feed mills.

Amenities and environment

- Ensure that workers have access to toilets.
- They must have access to potable, clean and cool drinking water.
- The work site must have a first aid kit and trained workers who can administer first aid in case of an accident or emergency.
- Maintain ground surrounding near a building to minimise the presence of dangerous creatures (e.g., snakes, spiders, etc.) and reduce fire fuel loads.
- Provide hand wash and face wash to workers.

Emergency response

- Workers must be aware about the procedures that need to be followed in case of an emergency situation.
- Install emergency response equipment at the workplace.
- In case of an emergency, trained workers must be involved in administering the first aid to patients.

Manual tasks

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

Chemicals and hazardous substances

- Safety data sheets (SDS) must be available for all hazardous substances.
- Read the label and safety data sheets carefully and follow the instructions.
- Store the chemicals at a safe place and keep them away from ignition sources.
- Minimise exposure to workers by adopting preventative measures and train them in safe handling techniques.
- Never store toxic chemicals in food and drinking containers.
- Make sure that the chemicals are labelled correctly with relevant instructions.

Plants and machinery

- Supply appropriate plants and equipment.
- Make sure that fixed and mobile plants, and vehicles are in a working condition and have the required safety guards.
- Workers must be trained about the safe use and maintenance of an equipment.
- Train the workers in safety measures in case of falls from heights on fixed plants (e.g., silos and windmills, etc.).

Electricity

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

Precautions to be taken in a farm

- Approach cattle quietly as animals feel your presence.
- To avoid kick injuries, try to work either outside an animal's kicking range or directly against it.
- When leading the cattle on a halter, rope must not be wrapped around your arm or hand because the animals may get angry and become out of control.
- While doing grooming, washing, clipping of the cattle, first train the animals to accept intensive handling through gradual familiarisation.
- While preparing a solution, one's face must never be just above the container, in which it is being prepared.
- While using chemicals, one must always wear rubber gloves and mask to avoid direct physical contact or inhalation of chemical fumes.
- Clean the sprayer with a detergent after spraying is completed.
- Follow the instructions mentioned on a pesticide bottle before using it.
- Take bath and wash your clothes after spraying.
- Do not smell, taste or touch a chemical.
- Keep pesticides and other chemicals away from children's reach.

What have you learned?

Now, I am able to:

- explain the first aid treatment that needs to be administered in case of chemical poisoning.
- understand the importance and use of safety and protective devices.
- understand the measures that need to be followed for general health and safety.
- understand the precautions that must be taken in an agricultural farm.

Practical Exercises

Activity 1: Demonstration of safety devices and measures to be followed

Material required: First aid kit, gas mask, protective clothing, eye shields, gloves, shoes and pictorial charts

Procedure

- See the different types of protective devices used while handling and applying chemicals. Have a discussion about each device.
- Understand their usage through pictorial charts. Demonstrate their use in class.
- Look at the first aid box. Identify each item kept in the box and understand their usage.
- Discuss the different types of chemical poisoning and their immediate symptoms.
- Understand the treatment for each type of poisoining through pictorial charts. Do some of the treatments through class demonstrations, if possible.

Activity 2: First aid induction and training for students

Material required: First aid kit, pictorial charts and training manuals

Procedure

- Get all students undergo induction in the beginning of the class.
- Ensure that only experienced trainers are involved in the training process.
- Assess the competence of the students.
- Use only standard procedures, which are recommended by agricultural industries.
- Regularly review the training needs.
- Keep records of training and completed inductions.
- Ensure that all students are aware of the accepted safe work procedures.
- Plan the approach before starting the activity and document the safe work procedures that need to be followed.
- Ensure that the first aid kit and emergency response equipment are in place.

Check Your Progress

Fill in the Blanks

1. Vomiting can be induced by using _____.
2. On contaminated skin, _____ must be done.
3. Gas mask is used to protect eyes and respiratory tract from _____.
4. Gloves made of _____ must be used to handle chemicals.
5. _____ is the first aid given in case of inhaled poisoning.

Multiple Choice Questions

1. Common symptoms of pesticide poisoning are:
   (a) headache
   (b) vomiting and nausea
   (c) difficulty in respiration
   (d) all of the above
2. To prevent hazards at workplace, the following material should be put in place:
   (a) SDS
   (b) first aid kit
   (c) protective clothing
   (d) all of the above
3. Protective and safety equipment comprise:
   (a) gas mask (b) gloves
   (c) both a and b (d) none of the above
4. Potential dangerous creatures around house and office buildings include:
   (a) lizards
   (b) snakes
   (c) spiders and scorpions
   (d) all of the above

Descriptive Questions

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

   _____
   _____
   _____

2. What are the devices used for protection while working in an agriculture field?

   _____
   _____
   _____

GLOSSARY

Acidic soil: *Soils having pH below 7.*

Adventitious roots: *Such roots arise from an organ of a plant other than the root, like stem.*

Aesthetic: *Concerned with beauty and art, and appreciation of the same.*

Anaemia: *A medical condition characterised by the deficiency of Red Blood Cells.*

Apical dominance: *It is a phenomenon, wherein the central system of a plant is stronger than the side stem.*

Arka: *Prefix of varieties developed at the Indian Institute of Horticultural Research, Bengaluru.*

Aromatic plants: *Plants that exude aroma, and are used in making perfumes and cooking.*

Assimilation: *Absorption or digestion of food or nutrient in a biological system.*

Autoclave: *Equipment used for the sterilisation of soil.*

Bronzing: *Development of yellowish brown colour on the tissues of a plant.*

Beri beri: *A disease causing inflammation of nerves and heart failure.*

C:N ratio: *A ratio of the mass of carbon and nitrogen in a plant or soil.*

Chlorosis: *Loss of the normal green colour in leaves.*

Condiments: *These are used to add flavour to food.*

Cotyledons or endosperm: *These are the organs having reserve food material of the seed.*

Crinkling: *Covered with many small lines and folds (wrinkles).*

Curd: *The edible part of a cauliflower and brocolli.*

Deficiency: *The state of not having enough or lack of something that is essential.*

Deficiency symptoms: *Symptoms that arise in plants and other living beings due to the lack of one or more essential element or nutrient.*

Dehorning: *The process for removing fully grown horns in cattle.*

Depletion: *Exhaustion or reduction in quantity*

Diet: *The kind and amount of food available to or consumed by a person.*

Dietician: *A person trained to give advice on diet and nutrition.*

Dilation of heart: *The chamber of heart, which is enlarged.*

Drained: *To withdraw or drawing of liquid (here water).*

Earthling up: *Making heaps of soil around the stem of a plant to provide support.*

Electrical Conductivity (EC): *The capacity of a substance to conduct or transmit electrical current.*

Embryo: *A young animal or plant in the very early stages of development before birth, or before coming out of its egg or seeds.*

Exudation: *Secretion*

First aid: *Immediate medical treatment given to a person suffering from a sudden illness or injury before the arrival of a doctor or her/him being taken to a hospital.*

Fumigant: *A gaseous or readily volatilisable chemical capable of destroying insects, bacteria and moulds, like Carbon disulphide, Methyl bromide, etc.*

Growth hormones: *A regulatory substance that stimulates specific cells or tissues into action.*

Harbour: *To nourish*

Hardiness: *The character of a plant to survive in unfavourable conditions.*

Harm: *Physical injury or damage to health*

Hazard: *A thing that can be dangerous or cause damage.*

Heifer: *A young cow before it gives birth to its first calf.*

Herbaceous: *Plants having non-woody stem (tender).*

Hydroscopicity: *The character of absorbing moisture from the atmosphere.*

Indeterminate: *A tomato plant that terminates in a vegetative bud.*

Innoculation: *Artificial introduction of microorganicms into a growing medium or living system.*

Intercropping: *The growing of two or more crops together on the same land or raising any crop in the alleys of an orchard.*

Kufri: *Varieties developed by the potato research station at Kufri in Himachal Pradesh.*

Lanky: *Ungracefully thin and tall*

Macro-nutrients: *A chemical, element or substance that is required in large quantity.*

Medicinal: *A substance or plant having healing properties.*

Medium: *The supporting substance on which a plant, fungi, bacteria, etc., are grown or cultured.*

Micro-nutrients: *Essential nutrients required in small quantities.*

Midrib: *The central, thick linear structure that runs along the length of the lamina in a leaf.*

Mortality: *Death*

Motting: *Spots or blotches of different colour interspread with the dominant colour.*

Necrosis: *Death of cells or tissues due to severe injury, disease or deficiency.*

Nutrition: *The process of obtaining or providing food.*

Occupational hazards: *Hazards experienced at a workplace.*

Oedema: *Abnormal accumulation of fluid in certain tissues.*

Ornamental plants: *Plants that are grown for decorative purposes in gardens.*

Osteoporosis: *A condition, in which bones become weak and brittle.*

Pellagra: *It is characterised by dermatitis, diarrhoea and mental disturbance.*

Perlite: *An amorphous volcanic glass that has relatively high water content.*

Pesticides: *Chemicals used to control pests.*

Petiole: *The stalk that joins a leaf to the stem.*

Photosynthesis: *A process by which plants manufacture their own food from Carbon dioxide and water in the presence of sunlight.*

Plant nutrients: *Chemical elements and compounds necessary for plant growth and metabolism.*

Plantation: *A large-scale farm specialised in cash crops, including coconut, arecanut, oil palm, cashew nut, coffee and rubber.*

Plumule bud: *Part of a seed that grows into shoots and branches.*

Poison: *A substance capable of causing illness or death, if swallowed or absorbed by the body.*

Polyhouse: *Structure used for controlled farming.*

Polythene mulching: *Covering the exposed area between plants with polythene.*

Propagation: *Method of multiplication of a plant.*

Protective food: *Food that prevents the body from diseases.*

Pusa: *The Indian Agricultural Research Institute (IARI) at Pusa in New Delhi*

Radicle: *Part of a seed that grows into the roots of a plant.*

Recurrent succession: *Consecutively, one after the other*

Rickets: *Softening of the bones*

Rotavator: *A machine with rotating blades used for breaking or tilling the soil.*

Roughage: *Fibrous indigestible component in vegetables that aids the passage of food and waste products through the gut.*

Scorching: *Burning*

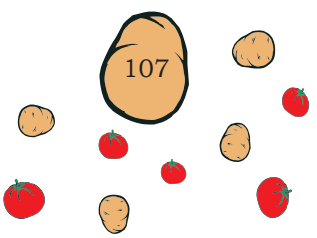
Seed coat: *Outer protective covering of a seed.*

Soil fertility: *The capacity of a soil to supply nutrients.*

Soil reclamation: *It is a process to modify the soil properties for the growth of crops by the application of soil amendments, like gypsum, lime, etc.*

Solanaceous: *Crops belonging to the family 'solanaceae'. The solanaceae family of vegetables includes potato, tomato, brinjal and chilli.*

Solarisation: *Use of solar (Sun) energy*



Spices: *Substances primarily used for flavouring, colouring or preserving food.*

Stumps: *The remaining stem part of harvested crop.*

Sturdy: *Strong*

Subtropical crops: *Crops that require hot and dry climate.*

Succulent: *Juicy*

Symptom: *It is the subjective indication of a disease or a disorder.*

Tanning: *Making lea*

Temperate crops: *Crops that require severe winters to grow and can tolerate freezing temperatures.*

Top-dressing: *It is the application of fertilisers in standing crops.*

Tropical crops: *Crops that require hot and humid climate conditions to grow.*

Uprooting: *Pulling out the seedlings without damaging the roots.*

Vermiculite: *A group of hydrated laminar minerals (aluminum, iron and magnesium silicates), which look like mica.*

Viable seed: *A seed that is capable of germination.*

Water holding capacity: *Total amount of water a soil can hold at field capacity.*

Weaning: *Seperation of a calf from a cow or buffalo, and feeding them artificially.*

Suggested Readings

Chadha, K.L. 2010. *Handbook of Horticulture*. ICAR, New Delhi. p. 1069.

Das, P.C. 2004. *Manures and Fertilisers*. Kalyani Publishers, New Delhi.

Premchand, Krishan Pal Singh and Beena Nair. 2014. *Fundamentals of Vegetable Crop Production*. Scientific Publishers. p. 302.

Singh, Jitendra. 2002. *Basic Horticulture*. Kalyani Publishers, New Delhi.

Thamburaj and Narendra Singh. 2015. *Textbook of Vegetables, Tuber Crops and Spices*. ICAR Publication, New Delhi.

http://nhb.gov.in/statistics/PublicationHorticultureAtGlance 2017fornetuplod(2).pdf

http://www.manage.gov.in/publications/farmerbook.pdf

Answer Key

UNIT 1: Introduction to Horticulture

Session 1: Horticulture and its Importance

Fill in the Blanks

1. Second
2. Garden and *cultura*
3. Horticulture
4. India
5. First
6. Sloppy lands

Session 2: Branches of Horticulture and Special Horticultural Operations

Fill in the Blanks

1. Biennial crop
2. Curd
3. Annuals
4. October
5. Summer

Multiple Choice Questions

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

Match the Columns

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

Session 3: Olericulture and its Importance in Human Nutrition

Fill in the Blanks

1. Olericulture
2. Calcium
3. Vitamin A
4. Vitamin A and C

Multiple Choice Questions

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

Match the Columns

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

UNIT 2: Seed Selection and Seedling Production

Session 1: Seed

Fill in the Blanks

1. Determinate type
2. Tomato

3. Arka Shirish
4. Pant C1
5. Kufri Chipsona 1

Multiple Choice Questions

1. (a) 2. (d) 3. (b) 4. (c)
5. (d) 6. (d) 7. (d) 8. (a)

Match the Columns

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

Session 2: Nursery Bed Preparation and Seed Sowing

Fill in the Blanks

1. Potato
2. Raised
3. 1.20
4. Solarisation
5. *Trichoderma* species
6. 13 to 21°C
7. 2
8. 5
9. Coco peat

Multiple Choice Questions

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

Match the Columns

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

Session 3: Nursery Raising in Soilless Medium

Fill in the Blanks

1. 36 or 24
2. Maturity
3. Space
4. Light
5. 238
6. Vermiculite
7. Algae
8. Plugs

Multiple Choice Questions

1. (d) 2. (d) 3. (a)

UNIT 3: Field Preparation and Transplanting in Solanaceous Crops

Session 1: Soil and Field Preparation

Fill in the Blanks

1. *Solum*
2. Weathering

3. 7.2 to 8.5
4. Kerala and Tamil Nadu
5. Asparagus and beet root

Multiple Choice Questions

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

Match the Columns

1. (b) 2. (g) 3. (e) 4. (f)
5. (c) 6. (d) 7. (a)

Session 2: Transplanting of Seedlings

Fill in the Blanks

1. September-October
2. 10–15 cm
3. Staking
4. Transplanting
5. Hardening
6. Tuber
7. 30–32 °C
8. shallow rooted
9. Crop rotation

Multiple Choice Questions

1. (d) 2. (c) 3. (a) 4. (c)
5. (b) 6. (c) 7. (b) 8. (d)

Match the Columns

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

UNIT 4: Soil Nutrient Management in Vegetable Crops

Session 1: Macro and Micro-nutrients in Soil System

Fill in the Blanks

1. Carbohydrates
2. Oxygen
3. Trace
4. Nitrogen
5. Phosphorus
6. Cell wall
7. Fats
8. Maturity
9. Oxidation-reduction
10. Molybdenum

Multiple Choice Questions

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

Match the Columns

1. (i) 2. (h) 3. (g)

4. (f) 5. (d) 6 (e)
7. (c) 8. (b) 9. (a)

Session 2: Manures and Fertilisers

Fill in the Blanks

1. Vermicompost
2. Basal
3. Foliar application
4. 0.5, 0.2 and 0.5%
5. 0.2–0.3
6. *Rhizobium*

Multiple Choice Questions

1. (c) 2. (d) 3. (c) 4. (a)
5. (a) 6. (c) 7. (d) 8. (d)

Match the Columns

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

UNIT 5: Occupational Health, Hygiene and First Aid Practices

Session 1: Prevent Hazardous Conditions at Workplace

Fill in the Blanks

1. Pesticide
2. Mechanical hazards
3. Water
4. Unforeseen

Multiple Choice Questions

1. (a) Poorly designed tools
2. (c) Chemical hazard
3. (b) Mechanical
4. (a) Faulty Switches
5. (d) Red
6. (b) Sunny and clear days

Session 2: First Aid, Treatment and Safety Equipment

Fill in the Blanks

1. Table Salt and mustard oil
2. Rapid washing
3. Toxic gases
4. Rubber
5. Artificial respiration

Multiple Choice Questions

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

Credits for Illustrations

Shital Hi-Tec Nursery

Unit 1

Fig.1.3, 1.10;

Unit 2

Fig. 2.2, 2.6, 2.7, 2.8, 2.9, 2.10;

Unit 3

Fig. 3.5, 3.6, 3.7;

Unit 4

Fig. 4.11

Books

Fundamental of Horticulture — Practical Manual for Class IX (Unit 1: 1.6, 1.7, 1.8)

Individuals

Uadal Singh

Unit 2

Fig. 2.11, 2.12, 2.13, 2.14;

Unit 3

Fig. 3.4

Unit 4

Fig.4.10)

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Unit 1

Fig 1.2	https://goo.gl/HRZoz6
Fig 1.4	https://goo.gl/W4YJ55
Fig 1.9	https://goo.gl/wWGzwS

Unit 2

Fig 2.1	https://goo.gl/rrCalf
Fig 2.3	https://goo.gl/iCKXBE
Fig 2.4	https://goo.gl/MkztSz
Fig 2.5	https://goo.gl/tQha84

Unit 3

Fig 3.1	https://goo.gl/HdpgjL
Fig 3.2	https://goo.gl/1N3hLH
Fig 3.3	https://goo.gl/pBLLyD
Fig 3.8	https://goo.gl/Qkh3L6

Unit 4

Fig 4.2	https://goo.gl/6zZDoD
Fig 4.3	https://goo.gl/rxnYTm
Fig 4.4	https://goo.gl/4swsR2
Fig 4.5	https://goo.gl/WRXPmi
Fig 4.6	https://goo.gl/FEGd3A
Fig 4.7	https://goo.gl/VBXLCE
Fig 4.8	https://goo.gl/ZSvHXe
Fig 4.9	https://goo.gl/ikY9ma

Unit 5

Fig 5.2	https://goo.gl/nUK73m
Fig 5.3	https://goo.gl/gYYfCW
Fig 5.4	https://goo.gl/ygxajB
Fig 5.5	https://goo.gl/uixDC7
Fig 5.6	https://goo.gl/XzFfqn
Fig 5.7	https://goo.gl/nWpfBV
Fig 5.8	https://goo.gl/BLyejx
Fig 5.9	https://goo.gl/ZvGFsn
Fig 5.10	https://goo.gl/mzBA2Q