Solanaceous Crop Cultivator

(Job Role)

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

Textbook for Class X

विद्यया ऽमृतमश्नुते
एन सी ई आर टी
NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

Foreword

The National Curriculum Framework (NCF)–2005 recommends bringing work and education into the domain of the curricula, 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 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 the society. Work involves interaction with material or 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 workplace. The NCF–2005 also emphasises Vocational Education and Training (VET) for all those children, who wish to acquire additional skills and seek livelihood through vocational education after either discontinuing or completing 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 subject areas and 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 the levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learners 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 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 Education, erstwhile Ministry of Human Resource Development.

This textbook has been developed as per the learning outcomes based curriculum, keeping in view the National Occupational Standards (NOSs) 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 institutions and organisations, which have supported in the development of this textbook. NCERT welcomes suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

HRUSHIKESH SENAPATY
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New Delhi
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About the Textbook

Agriculture is an important part of India's economy, which accounts for about 18% of the country's GDP and occupies almost 43% 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. Skilled manpower for various job roles, such as solanaceous crop cultivator, floriculturist (open cultivation), floriculturist (protected cultivation), gardener, micro irrigation technician, etc., are in demand.

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 contributions by 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/N0402: weed control and management in vegetable crops
2. AGR/N0403: integrated pest and disease management in vegetable crops

3. AGR/N0404: irrigation management in vegetable crops
4. AGR/N0410: harvest and post-harvest management in solanaceous crops
5. AGR/N9901: basic farm management
6. AGR/N9902: assimilating market information

Unit 1 of this textbook introduces irrigation management in vegetable crops. Unit 2 focusses on weed control and management in vegetable crops. Unit 3 deals with integrated pest and disease management in vegetable crops, while, Unit 4 focusses on harvest and post-harvest management in solanaceous crops. Unit 5 deals with basic farm management.

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Gratitude is also due to the Publication Division, NCERT, for transforming the manuscript into an attractive textbook. Special thanks are due to Shveta Uppal, *Chief Editor*, Shilpa Mohan, *Assistant Editor* (Contractual) for copy editing the manuscript. The efforts of Pavan Kumar Barriar, *DTP Operator*, Publication Division, NCERT, and Sachin Tanwar, *DTP Operator* (Contractual) are acknowledged for flawless layout and design of the textbook.

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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

Irrigation Management in Vegetable Crops

Introduction

Vegetable crops require frequent irrigation for better growth and development. Irrigation requirement may vary from crop to crop. If water is the limiting factor, then proper management and conservation practices can be fruitful to grow vegetables round the year. Conservation, management and use of irrigation water are critical to successful vegetable production, especially when the fields are under drought condition. A well-organised water management plan and irrigation scheduling is the key to water management in vegetables crop production. Leafy vegetables require frequent irrigation. Fruiting vegetables and root and tuber vegetables have different critical stages of water requirement. This unit will help you understand about the water sensitive or critical stage of vegetable crops.

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Role of Water in Plants

- Water is an essential element for plants.
- It helps in the growth and development of plants.
- It helps plants to absorb and transport minerals from soil.
- It is essential for the conduct of biochemical reactions.
- It is integral for making food through photosynthesis.

- It helps plants to manage heat or frost stresses.
- It is necessary for seed germination and seedling establishment.

Sources of Water for Plants

Rainfall and irrigation are the two main sources of water for plants.

Rainfall is a natural source of water and the quality of water is also good. But, it is a limited and unpredictable natural source. Whereas, the artificial application of water to the soil in order to maintain a proper soil moisture regime for plant growth is called irrigation. Irrigation is the practice of planning and applying water artificially to maintain soil moisture. It can be made an assured source.

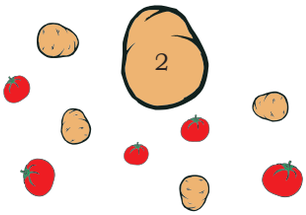
The irrigation requirement of crop plants depends on

- the type of vegetable crop. Shallow-rooted crops need light but frequent irrigation as compared to deep-rooted vegetable crops.
- the growing season. Summer vegetable crops need more frequent irrigation than the winter crops. Occasionally the rainy season crops also need irrigation.
- the climate. Crops should be irrigated less frequently during the cool climate and more frequently in tropical or hot climate.
- the soil type. Frequent but light irrigation should be done in sandy soil and deep but less frequent irrigation is required in clayey soil.
- the type of irrigation system. Regular irrigation is needed in the drip system and less frequently in the surface, sub-surface and sprinkler irrigation system.

Session 1: Irrigation and Water Quality

Importance of Irrigation

- Since vegetable crops contain 80–90% water they require a large amount of water and frequent irrigation for proper growth and development.



- In water shortage conditions the yield and quality of vegetable crops suffer. Hence, irrigation is essential for higher yield and good quality vegetables.
- Vegetable crops grow fast, hence, they require frequent and more water.
- A sufficient amount of water in the roots is a pre-requisite for better yield and quality produce.
- Irrigation reduces dependence on rainfall because it can be done as and when required.
- If irrigation is scheduled properly, it can save water and minimise weed problems.
- Irrigation helps in growing more crops in a year in the same field.

Sources of Irrigation Water

1. **Surface water sources** are found on the surface of the land. These sources are rivers, canals, ponds, lakes, dams, etc. Generally the quality of water from these sources is quite good and fit for irrigation.
2. **Groundwater** is underground water lifted through dug wells, tube wells and bore wells. This water quality varies from poor to good.

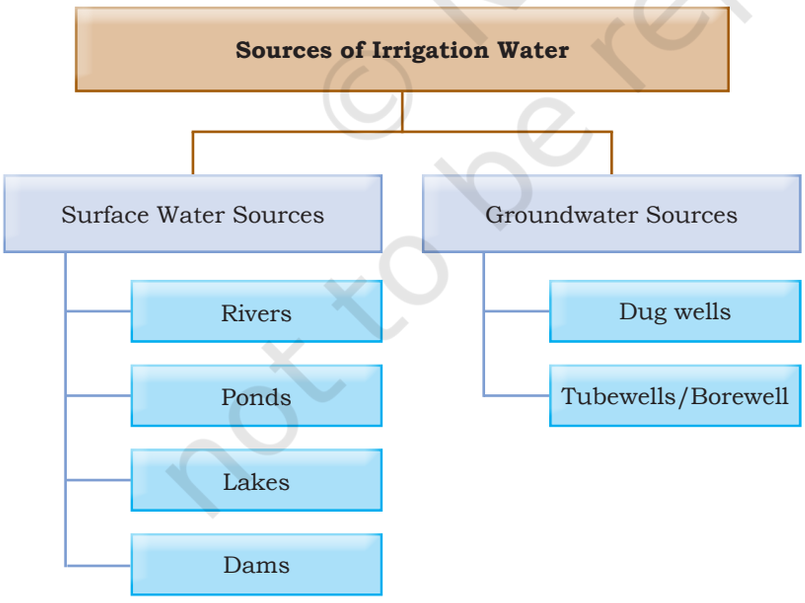


Fig. 1.1: Sources of irrigation water

Do you know?

- India has very few water resources and the groundwater level is also depleting at an alarming rate. Therefore, it is essential to conserve rainwater. Also, mulching in crops can save water and increase irrigation interval.
- In some areas, poor quality water full of toxins, heavy metals and microbes is used in the cultivation of vegetables. It can be used but only after proper treatment.

The quality of water is as important as the quantity for successful vegetable cultivation. In India, water quality concerns have often been neglected because of the availability of good quality water but nowadays this situation is changing in many areas. Poor quality water from urban-industrial areas and the salinity of groundwater need to be properly treated before using for irrigation.

Good quality water is a crucial factor for soil to remain productive for long. It allows growing of any kind of vegetable crop and also gives a high yield and better quality of vegetable crops.

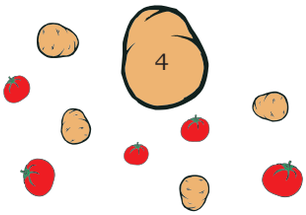
Various regions in the country use poor quality water to irrigate the crops. Untreated water from urban-industrial areas is of poor quality. In some areas, groundwater is very deep and poor in quality.

Using poor quality water for irrigation may

- deteriorate the soil health.
- deposit excess salt in the root zone.
- reduce uptake of minerals and affect crop yield.
- reduce soil permeability and increase water runoff.
- show toxicity of metals in some plants.

Criteria of Suitable Water for Irrigation

1. **pH** of water being used for irrigation should range between 6.5 to 8.5.
2. **Water salinity** is an indicator of total dissolved salts present in the water. It is of prime concern for both the soil structure and crop yield. Salt concentration is measured by electrical conductivity (EC) in mili Siemens per meter (mSm^{-1}) or micromhos per cm. Water having EC below 1500 micromhos/cm is good for irrigation.



3. **Sodium adsorption ratio (SAR)** is a measure of the relative proportion of sodium (Na+) to calcium (Ca^{+2}) and magnesium (Mg^{+2}) in water. High sodium causes breaking of soil aggregates and sealing of the soil pores. Sodium weakens the binding capacity of soil. A small SAR value indicates low sodium content in water. It should be below 10 in irrigation water.
4. **Residual sodium carbonate and bicarbonate concentration** content in water increases the pH. This can have an alkalising effect and raise the SAR index. Residual sodium carbonate below 1.5 mg/litre in irrigation water is safe. The following measures can be adopted for the management of this water quality.
   (i) Addition of gypsum in low calcium soil + leaching
   (ii) Addition of sulphur + lime + leaching
   (iii) More frequent irrigation
   (iv) Avoid the sprinkler method of irrigation
   (v) Avoid using fertilisers containing chloride and boron
   (vi) Select tolerant crops
5. **Boron** is the most common element found in toxic concentrations in water. It cannot be easily removed from water. The only remedy is to dilute high boron water. Below 1.0 ppm boron content is acceptable level in irrigation water.

Quality Testing Instruments

It is important to test the suitability of water quality for its intended purpose. Water testing will help to know whether the quality of water is fit for irrigation or not. If it is not, then one needs to find out what is the specific reason for the poor quality of water. Generally, the pH and electrical conductivity (EC) are the two most important parameters for water quality analysis. When a pH colour strip is dipped into alkaline or acidic water the colour changes as shown in Fig. 1.2.

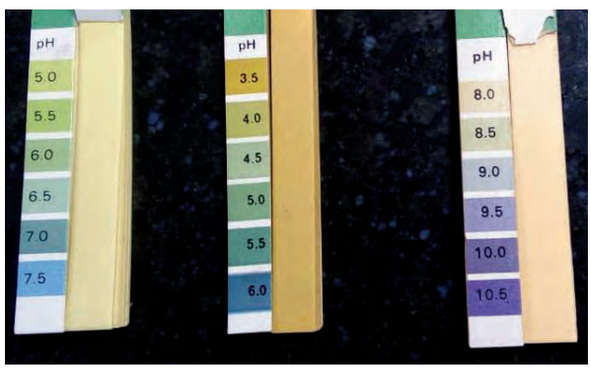


Fig.1.2: pH colour strip scale

1. **pH meter** is an equipment by which we can measure the pH level of any solution. It consists of a display unit and electrode. When the electrode is

Fig.1.3: Digital pH meter

Fig.1.4: Digital Electrical Conductivity (EC) meter

inserted into the solution the display unit shows the pH value. Ideally, the pH of the soil and water has to be 6-6.5 and that of the nutrient solution should be 5.6-6.5. For accurate data collection, the pH meter, like all other equipment, should be calibrated beforehand. It is more accurate than the pH colour strip. (Fig. 1.3)

2. **Electrical conductivity (EC) meter** is used to measure the total dissolved salts in irrigation water. It is reported in terms of millimhos per centimetre (mmhos/cm), deci Siemens per metre (dS/m), micro Siemens per centimetre (µS/cm) or milli Siemens per centimetre (mS/cm), which gives information on the degree of salinity in water. Micro Siemens per centimetre is the standard unit to represent EC value of freshwater measurements. They are all similar on numerical count. The numerical value remains the same per unit area, only the reference varies. Electrical conductivity of irrigation water is more when it contains more soluble salts and vice versa. The temperature of water affects conductivity and it is usually reported at 25°C. The EC measurement is the easiest and a rapid method to analyse the salinity level of water, but it is non-specific. It measures only the combined effect of all ions present and cannot distinguish between the different types of ions (Fig. 1.4).

Practical Exercises

Activity 1

Collection of water samples for quality testing

Material required

Plastic sample bottle (500 ml)

Procedure

a. Tubewell or handpump

- Start the tubewell or handpump and let it run for about 15-20 minutes. It is necessary to drain out all the water retained in the pipe of the well or pump to avoid 'pipe effect' (metals, salts deposited in the pipe).

- Take a water sample in sample bottles (500 ml–1 litre) just before the water falls into the channel.
- To analyse the quality of water from a tubewell or handpump, never collect the water sample once it falls into the channels because it affects the water quality.

b. Ponds or tanks
- Sample water from a pond or tank should be taken at least 5-10 metres inside the boundary area to avoid boundary effect.
- Take a properly washed plastic container for sampling.
- Displace the surface water of the pond or tank gently and take the sample from the intermediate depth.

c. Collect the water in a sample bottle immediately and close the bottle cap tightly.

d. Label the sample by writing name, address, source, place and date of sampling.

e. Submit the collected samples to the water quality testing laboratory within 2-3 days.

Precautions

- Avoid possibility of any external contamination.
- Don't wash the bottle with detergents or soap.
- Don't take water from the pond surface because it may contain organic material and affect the correct representation of water quality.
- Gently shake the pond surface to collect the water sample more accurately.

Activity 2

Measure pH by using litmus paper or pH meter

With litmus paper or pH paper

Material required

Litmus or pH paper strip, water from different sources, writing material, practical file, etc.

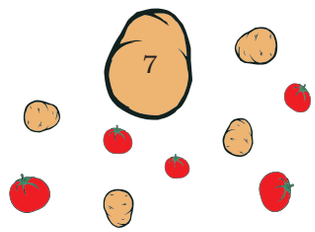
Procedure

1. Collect the water from different sources and places.
2. To observe the pH of the water sample, take the sample in a beaker (100 ml).
3. Dip the litmus paper in the sample and observe the colour change.
4. The litmus or pH paper changes colour based on the pH of the water sample.
5. Match the colour change with the help of a colour strip.
6. Note down the pH of water.

With a pH meter

Procedure

1. Collect the water sample.
2. Take 40 ml (5 ml more or less) of the water sample in a beaker.



3. Stabilise the temperature of the water sample.
4. Insert the pH meter electrode in the water beaker and turn the beaker to adjust for good contact between the pH meter electrode and water.
5. Before taking a recording, stabilise the pH reading of the sample for 20-30 seconds (automatic pH meter provides signals).
6. After reading, wash the electrode with distilled water to remove any film on it.

Precautions

- Calibrate the pH meter by using a pH 7 buffer solution before noting the observations.
- Insert the electrode into water. It should not touch the bottom of the beaker.
- During the electrode storage, keep it in pH 7 buffer.

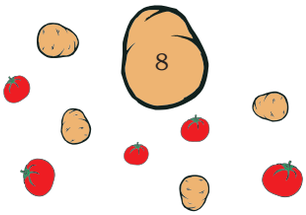
Check Your Progress

A. Fill in the blanks

1. Water is an essential _____ for plant life.
2. Vegetable crops grow fast, hence they require _____ and _____.
3. The untreated water from urban-industrial areas is _____ in quality.
4. _____ pH range of water is considered safe for irrigation.

B. Multiple choice questions

1. Irrigation is a practice of_____.
   (a) only artificial application of water
   (b) watering through rainfall
   (c) recharging groundwater
   (d) storing rainwater
2. Irrigation water suitable for most of the crops contains _____ boron.
   (a) below 1.0 ppm
   (b) 1.0 ppm - 1.5 ppm
   (c) 1.0 ppm - 2.0 ppm
   (d) above 2.0 ppm
3. The most common surface water source is a _____.
   (a) tube well
   (b) dug well
   (c) river
   (d) bore well



4. Total dissolved salt in water is measured with a _____.
   (a) Hygrometer
   (b) Lux meter
   (c) pH meter
   (d) EC meter
5. Electrical conductivity in irrigation water should be_____.
   (a) below 1500 micromhos/cm
   (b) 2000-3000 micromhos/cm
   (c) 2500-3500 micromhos/cm
   (d) above 3000 micromhos/cm

C. Short answer questions

1. Define irrigation and enlist the role of irrigation water.
2. Point out the criteria for suitability of irrigation water.
3. When is water suitable for irrigation?
4. Classify irrigation sources with proper examples.
5. How is water testing helpful for a farmer?

D. Match the columns

A	B
1. Quality test	(a) Mulching
2. Poor quality water	(b) Frequent watering
3. Increase water pH	(c) Deposit salts in root zone
4. Increase irrigation interval	(d) Suitability of water
5. Shallow rooted crops	(e) Carbonate and bicarbonate

SESSION 2: WATER REQUIREMENT AND IRRIGATION METHODS

Water Requirement

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

When the entire water requirement is supplied by irrigation, then both WR and IR are the same. It is expressed as the unit of absorbed water required for the production of one unit of dry matter.

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

Where,

Evapo-transpiration (ET) = Total loss of water by transpiration from crop and evaporation from soil

Application losses = Water loss during the application of irrigation water

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

How much to irrigate

If the water requirement of a particular crop is 6 mm per day, it means every day we need to give 6 mm of water to the crop. In field condition practically, it is not possible so it can be given as 30 mm for every 5 days or 60 mm for every 10 days. The frequency of irrigation varies with the growing season, types of crop and types of soil and its condition.

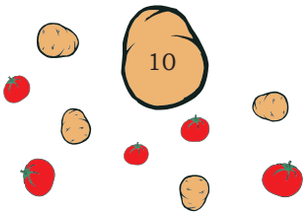
Water requirement of vegetable crops

- Tomato: 600-800 mm
- Chili: 450-500 mm
- Brinjal: 1000 mm
- Potato: 500-700 mm
- Onion: 640-700 mm
- Watermelon:500 mm
- Pea: 350-500 mm
- Cauliflower: 350 mm
- Bean: 300-500 mm
- Cabbage: 380-500 mm

Source: Reddy, 1999

Points to understand

- The water requirement of a crop is expressed in mm/season.
- The crops require more water in summer than in winter.
- Long duration crops have more water requirement.
- Shallow rooted vegetable crops need light but frequent irrigation.



- Timely irrigation means higher yield and better quality of produce.
- Only a few vegetables, such as brinjal, chili, watermelon, amaranthus, can tolerate partial drought.
- Unlike clayey soil, sandy soil requires low but more frequent depth of water.
- Avoid over flooding otherwise it will cause poor aeration and poor germination.
- With regular irrigation, keep the ridges and fields moist but not wet, for better crop growth and development.

Vegetable crops are divided into three major categories depending upon the rooting depth.

Table 1.1: Rooting depth of various vegetable crops

Rooting depth category	Root depth	Vegetable crops
Shallow rooted	45-60 cm	Onion, cabbage, cauliflower, celery, potato, radish, cowpea, lettuce, broccoli
Moderately deep-rooted	90-20 cm	Beans, beetroot, turnip, cucumber, brinjal, chili, sweet pepper, muskmelon, tomato
Deep-rooted	(More than 120 cm)	Asparagus, pumpkin, winter squash, sweet potato, watermelon

(Source: Swarup, 2014)

When to irrigate?

While growing vegetable crops, some stages of the plants are very sensitive to water stress. If it is not irrigated at this stage, the growth and yield of the crop can be adversely affected. This is known as the critical stage.

Water shortage in early crop stages delay crop maturity and reduce the yield, while moisture stress in the later stages of the crop reduce the quality of the produce. Hence, adequate moisture is essential for a high yield and good quality produce.

The frequency of irrigation and the amount of water to be given depend on a number of factors, such as the depth of the root system, water use efficiency, growth stage, soil type, prevailing weather conditions and the actual consumptive use of the vegetable crops.

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

The decision on 'when to irrigate' can be taken on the basis of visual plant indices, soil appearance and climatic parameters. Visual symptoms, such as dropping and rolling of plants in mid-day are used to determine the time of irrigation. When soil samples from the root zone do not form a 'soil ball' properly, irrigation can be planned. Critical periods of water needs have been identified in most crops, the stage when they must be irrigated to maintain adequate moisture in the root zone (Table 1.2).

Table.1.2: Critical stages of vegetable crops

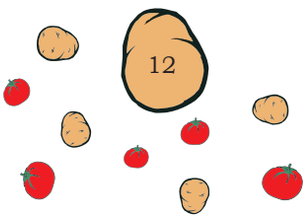
Crop	Critical Stages
Tomato, chili, brinjal	Flowering, fruit set and fruit development
Potato	Tuber initiation and tuber development
Okra	Flowering and pod development
Radish, carrot, turnip, beetroot	Root enlargement/development
Onion, garlic	Bulb formation and enlargement
Pea, beans	Flowering, pod set and pod development
Cabbage, cauliflower	Head formation and enlargement
Leafy vegetables	Entire crop duration

(Source: Swarup, 2014)

Methods of Irrigation

The system of irrigation water application into a crop field is called method of irrigation. The selection of suitable irrigation method mainly depends on the soil characteristics, cropping system, land topography, quantity and quality of irrigation water and the nature and availability of inputs like labour and energy. There are four principal systems of irrigation: surface, sub-surface, aerial or overhead or sprinkler irrigation and drip irrigation.

An efficient method aims at the proper use of irrigation water in conjunction with other inputs to enhance yield. Land topography, soil and crop types, water quality and quantity, availability of labour and energy are factors for deciding the irrigation method.



The system of irrigation and common methods are given in Fig. 1.5.

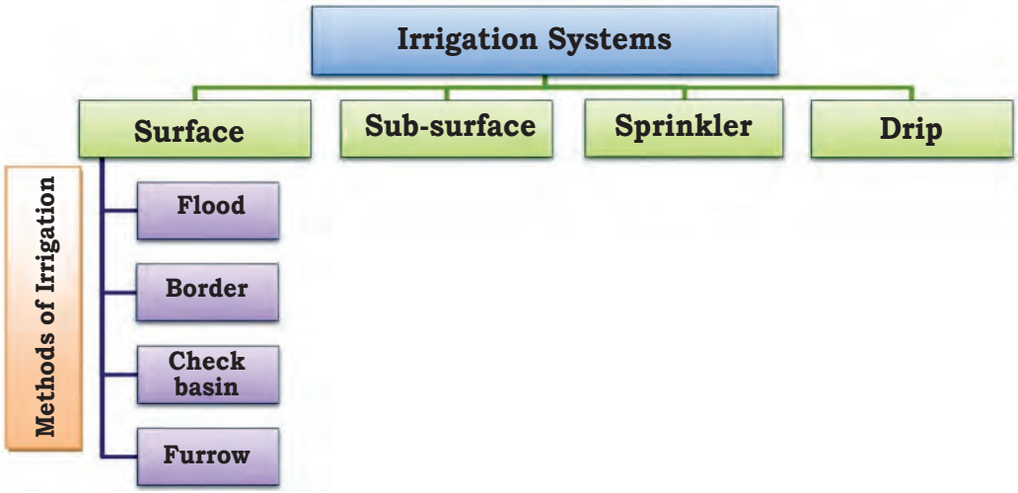


Fig.1.5: Irrigation systems and methods

Surface irrigation system

It is the most common and cheapest method of irrigation and is also known as gravity irrigation method. In this method the field is usually watered by introducing a stream of water through channels, pipes or ditches at the head of the field and allowing gravity and hydrostatic pressure to spread the flow over the surface of the entire field. Land leveling and smoothing are essential operations. The important surface irrigation methods are: (i) flooding; (ii) bed or border method; (iii) basin (ring and basin) method; and (iv) furrow (ridge and furrow, broad ridge or raised bed) method.

Flood

It is an ancient irrigation practice, where a water channel is opened into a field and water is allowed to flow freely in all directions to cover the land surface like a sheet. This is practiced in an area where water is abundant and the topography is leveled. The flooding method is still practiced in vegetable crops, such as onion, garlic, pea, spinach, coriander, fenugreek and amaranthus, grown by the broadcasting method on a well-levelled field. (Fig. 1.6)

Fig.1.6: Flood irrigation method

Advantages

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

Disadvantages

1. It is an unscientific and inefficient method of irrigation.
2. Maximum loss of irrigation water occurs in this method.
3. It requires more water per unit area than all other methods of irrigation.
4. Unsuitable for spacious crops and crops sensitive to waterlogging. It spreads soil borne diseases.
5. It results in wetting of the entire field surface. Hence, it increases weed population in the field.
6. Variability in infiltration rate of soil in the field causes non-uniformity of water distribution in the root zone.
7. There is more loss of nutrients.

Border irrigation method

In this method, the land is leveled and divided into different strips of appropriate size by making the borders 30 cm high between each strip. Strips of 3-10 m width and 30-90 m length with up to 0.5% slope are formed. This is suitable for growing vegetable crops (Fig. 1.7).

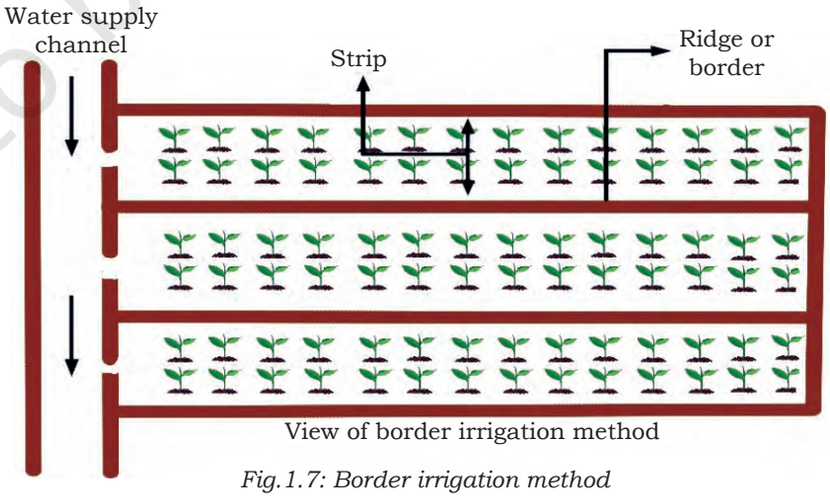


Fig.1.7: Border irrigation method

Advantages

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

Disadvantages

1. It requires a flat and smooth topography.
2. More water flow is required to irrigate border strips.
3. Not suitable for sandy soil.
4. To avoid waterlogging a proper drainage system is required.

Check basin irrigation method

In this method, the field is divided into square or rectangular checks or plots surrounded by ridges for irrigation (Fig. 1.8). The plots are generally leveled or have a mild slope. It is used successfully for both field and row crops. A modification in the basin method is the ring and basin method in which a circular basin of about 45-60 cm width is made around the plant for irrigation of the crop. In this method, water is impounded to irrigate a single tree or vine vegetables (Fig. 1.9). In vegetable crops, this method is practised for bitter gourd, bottle gourd, ridge gourd, melons, etc. This method is not used for solanaceous vegetable crops.

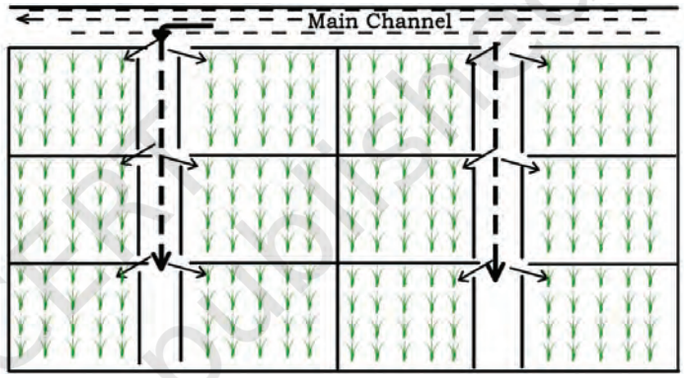


Fig.1.8: Line diagram of check basin irrigation method

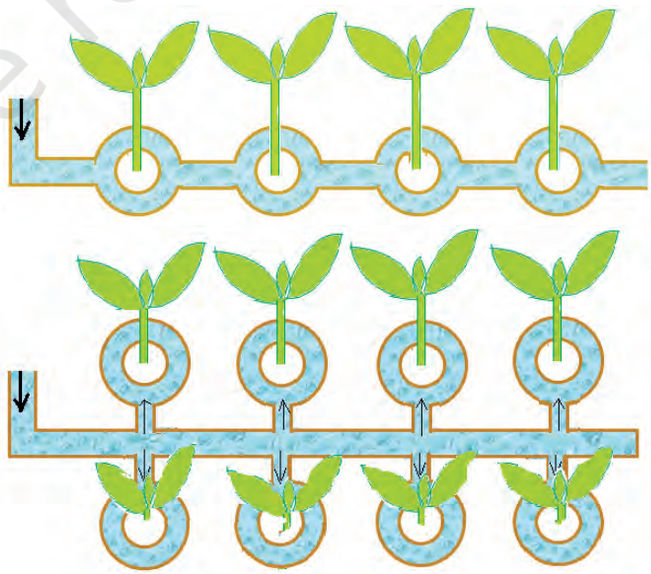


Fig. 1.9: Line diagram of ring and basin irrigation methods

Advantages

1. It can be used to irrigate irregular shaped fields.
2. Water application and distribution efficiencies are generally high.

Disadvantages

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

Fig. 1.10: Furrow irrigation method

Furrow irrigation method

In this method, water is moved to the field in furrows between two ridges. These furrows are lined among rows of the crop according to the slope of the land (Fig. 1.10). Furrows are channels with continuous and nearly uniform slope in the direction of irrigation. Furrows, 3-6 m in length are spread in such a way that water reaches every nook and corner of the field. Planting is done on the side of the ridges or raised beds (about 15-22 cm high) and water is given in 15-20 cm deep furrows of 30-50 cm width. This method is commonly adopted in vegetable crops like tomato, brinjal, potato, chili, radish, carrot, cauliflower, etc.

Advantages

1. Water efficiency is high due to less wastage because irrigation is done in furrows only.
2. The entire land surface is not covered with water therefore the problem of weeds is minimised.
3. It is more suitable for vegetables grown on rows or beds.
4. Relatively easy to operate and requires less labour, hence it is not expensive.
5. Evaporation losses are less because it exposes a smaller area of open water.
6. It is adapted to most soils.

Disadvantages

1. Labour requirement is more for making ridges and furrows and streaming irrigation water.
2. Furrows interfere with farm machinery during weeding, spraying and crop harvesting.

3. Not suitable for sandy soils because of poor stability of furrows, land leveling problem and high infiltration rate.
4. Not applicable on uneven lands because a leveled field is required for proper flow of water.

Sub-surface irrigation

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

Advantages

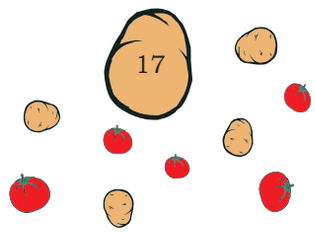
1. Reduces water loss due to less evaporation.
2. Do not create any interference with the farm operations.
3. Easy to maintain water level at optimum depths as per crop requirements.

Disadvantages

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

Sprinkler or overhead irrigation

In the sprinkler system, water is sprinkled over the crop and the soil in a circular manner similar to rain. With the help of revolving sprinkler nozzles, water is forced out with pressure through pipes fitted with a stand. The nozzles rotate due to the water pressure and spread water in the form of a thin spray. Water can be applied in a controlled way and distributed uniformly. Compared to the other method, this is a much more efficient system. It is ideal for hilly and undulating regions where



other systems cannot be used Fig. 1.11(a-d). The major components of the sprinkler system are the pump, main line, lateral pipe and sprinkler.

Advantages

1. It can be used to irrigate undulating land.
2. There are no obstacles when farm implements are being used.
3. Water saving is around 30–35%.
4. Fertilisers and pesticides can also be applied by this method.
5. The amount of water can be controlled as per the crop requirement.
6. More land area can be covered for irrigation.
7. This system is useful to control frost during freezing temperature.

Disadvantages

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

a

b

c

d

Fig. 1.11(a-d): View of the sprinkler or the overhead irrigation system

Drip irrigation system

This is also known as trickle irrigation or micro irrigation, which supplies water in the form of discrete, continuous drops at a slow rate through emitters, either onto the soil surface or directly to the root zone. There is direct and continuous wetting of the root region. Fertilisers and chemical amendments can also be applied using this method. It is a highly water use efficient system with little irrigation water requirement. Thus, it is suitable for water scarce areas. It saves 40-60 % of water over the other conventional methods (Figs 1.12 and 1.13).

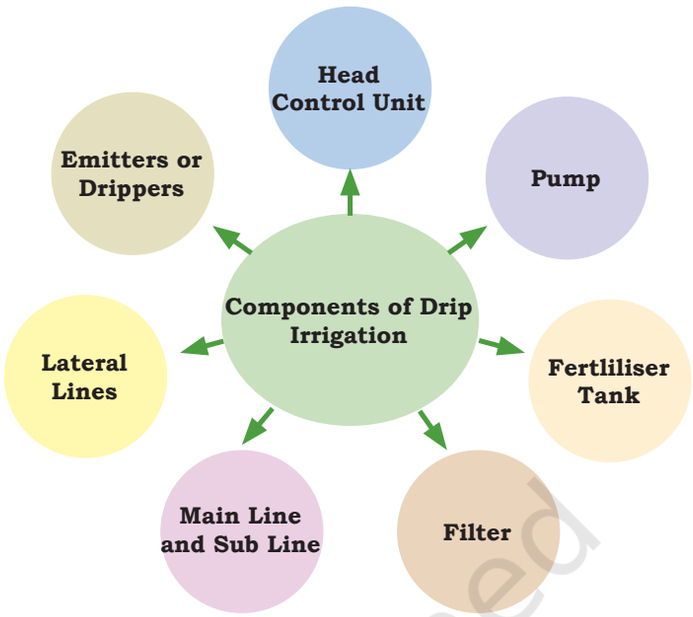


Fig.1.12:Components of a drip irrigation system

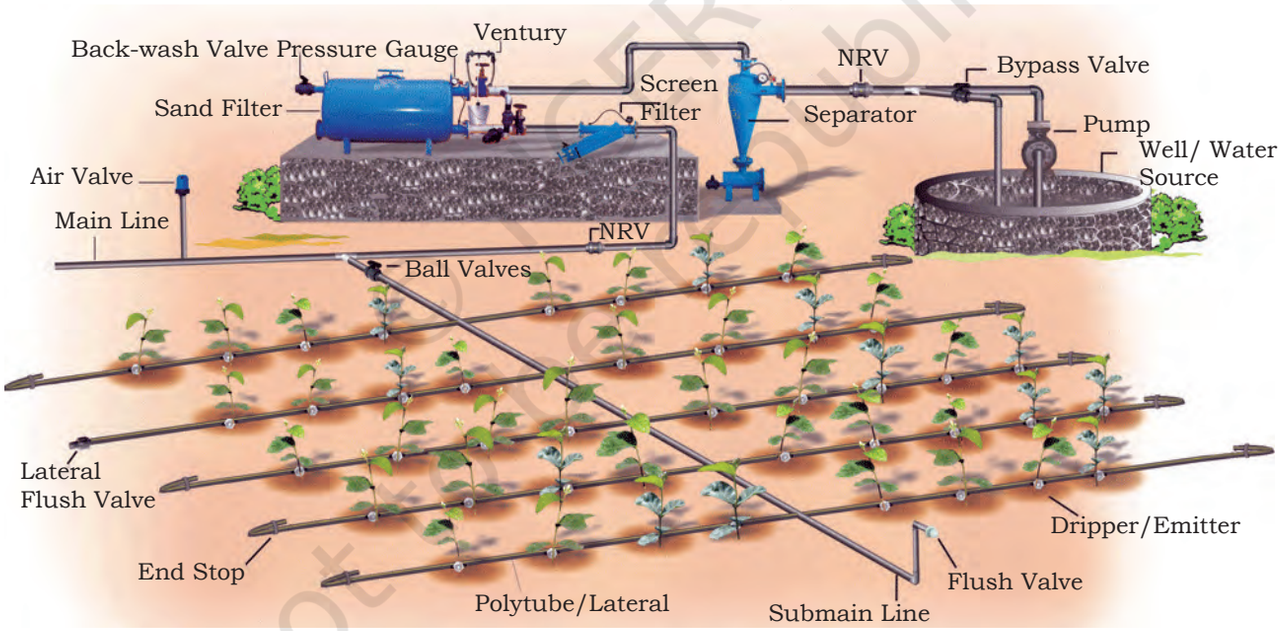


Fig. 1.13: Component and layout of a drip irrigation system

Components of a drip irrigation system

Based on the system's requirements, the head control unit consists of the following equipment.

- **Pump** provides pressure to lift water from the source and distribute through the nozzles.

- **Fertiliser tank** is used when fertilisers are applied along with irrigation.
- **Filter** is used to clean the suspended impurities in water.
- **Main line and sub line** are flexible black poly vinyl chloride (PVC) pipes used for distribution of water to laterals from the water source.
- **Lateral lines** are 1 to 1.25 cm diameter black flexible PVC tubes that take of from the mains or sub mains. Laterals are normally laid parallel to each other.
- **Emitters or drippers** are fixed at regular intervals in the laterals. It is the most important component in the drip system and regulates the discharge rate of water.

Advantages

1. It is a highly efficient system with 80 to 90% water use efficiency.
2. It saves up to 40 to 60% water.
3. This system also facilitates the supply of liquid fertilisers directly to the root zone.
4. Increases plant yield up to 10 to 25%.
5. Problem of weeds and cost of labour is minimised.
6. Ideal for slopes or undulating land, especially in the hills.

Disadvantages

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

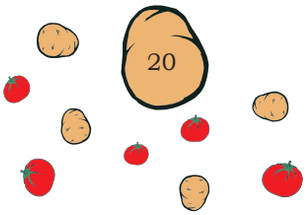
Practical Exercise

Activity 1

Identification of different components of drip irrigation system and their function

Material required

Sketching and writing material and different components of a drip system



Procedure

1. Visit a nearby farm where a drip system has been installed.
2. Observe the types of drip system.
3. Note down the different components of a drip unit.
4. Identify different components, such as drippers, laterals, valves,etc.
5. Draw a figure of the drip system and write the functions of its different components.

Activity 2

Demonstrate the border irrigation method

Material required

Sketching and writing material.

Procedure

1. Visit a nearby farm where border irrigation method is being followed.
2. Select a piece of land and prepare a layout.
3. Transplant the seedling of the given crop.
4. Irrigate and observe the performance of the crop.

Check Your Progress

A. Fill in the blanks

1. Applying irrigation water in the crop at definite frequency is known as _____.
2. A particular stage of the plants that is sensitive to water stress is known as _____.
3. Land, levelled and divided into different strips of appropriate size by making borders, is called the _____ method.
4. Sprinkler irrigation is also known as _____.
5. The critical stage of irrigation in onion and garlic crops is _____.
6. In drip irrigation system, water is let out through devices called _____.
7. A highly efficient irrigation system with 80–90% water use efficiency is _____.

B. Multiple choice questions

1. The critical stage of irrigation in cabbage is _____ _____.
   (a) head formation
   (b) flowering stage
   (c) seed germination
   (d) harvesting stage

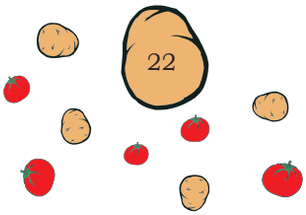
2. Irrigation water spread over the crop as well as on the soil in a circular manner is called _____.
   (a) flood
   (b) border
   (c) overhead irrigation
   (d) check
3. The process of applying liquid fertilisers through an irrigation system is known as _____.
   (a) fertigation
   (b) drip irrigation
   (c) sprinkler irrigation
   (d) furrow irrigation
4. The irrigation method, which is suitable in undulating lands is _____.
   (a) flood irrigation
   (b) furrow irrigation
   (c) sprinkler irrigation
   (d) basin irrigation
5. Drip irrigation helps in _____.
   (a) saving water
   (b) increasing yield
   (c) increasing quality
   (d) All of the above

C. Short answer questions

1. Define irrigation and its methods.
2. How is a drip irrigation system useful?
3. Write the advantages and disadvantages of the furrow method of irrigation.
4. If you are a farmer with undulating land but good quality water, which method of irrigation will you prescribe? Justify.
5. Among the surface irrigation methods,which method is good? Explain.

D. Match the columns

A	B
1. Sprinkler system	(a) Cucurbitaceous crops
2. Furrow irrigation	(b) Drip system
3. Check basin irrigation	(c) Nozzles
4. Bulbous crop	(d) Vegetable crop
5. Highest water use efficiency	(e) Onion



Unit 2

Weed Management in Vegetable Crops

Introduction

Weeds are wild plants growing where they are not wanted, especially among crops or garden plants. Weed propagules remain viable for a long time and survive in the field even under odd conditions. Based on their life cycle, weeds can be classified as annuals, biennials or perennials. They can be reproduced by seeds or through cuttings, bulbs, corms, rhizomes or tubers. Weeds are harmful as these compete with the main crop for nutrients, water, light and space and badly affect the growth and production of the main crop. They also play an important role as alternative hosts for various stages of insect-pests and pathogens.

They may also produce certain toxins and chemicals that are harmful for the crop as well as to humans and animals in the vicinity. Weeds occupy land, spread fast and hence, require regular eradication. It requires a lot of energy and resources to control them.

Session 1: Weeds in Vegetable Crops

Weeds may be defined as a plant that grows in another plant's space and uses mineral and fertiliser that is meant for the desired crop. It is an unwanted plant in the crop field or its surrounding areas.

Characteristics of weeds

- Weed seeds germinate early, grow fast, and being hardy compete with the main crop for light, moisture and nutrients.
- Weeds are unwanted plants that are harmful to crops, livestock and human beings.
- Weeds can survive under unfavourable conditions.
- They have a very high and prolific capacity to reproduce.
- Even under a deeper layer of the soil, the weed seed can remain viable.
- Some specific structures like wings, hooks, spines, sticky hairs, etc., are present in the seeds, which can help in easy dissemination over longer distance.

Types of weeds

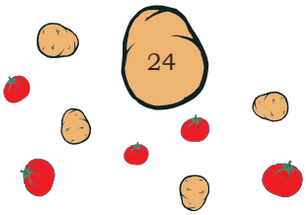
Some of the most common weeds are as given below.

- **Monocot weeds** have a hollow and round stem, internodes are short and hard, and the leaves are slender, long and have parallel veins. Most of the grasses, such as *doob* grass (*Cynodon dactylon*), *motha* (*Cyperus rotundus*) and crab grass (*Digitaria sanguinalis*) belong to this group.
- **Dicot weeds** have a taproot system with broad leaves. The veins on its leaves are netted and they produce flowers, such as *bathua* (*Chenopodium album*), Amaranth (*Amaranthus* spp.).
- **Sedges** have hard triangular stems and look like grass. The leaves extend from each side of the stem in three directions. Sedges have sharp edges.

Also, weeds can be categorised as follows:

Broadleaf weeds

These weeds have two seed leaves (first leaves or cotyledons) when they emerge from the soil. The leaves of this type of weeds are generally wider than the grassy weeds. The veins on the leaves are netlike or branched. Stems of this weed are oval, round or



square and are often branched. They may have showy flowers (Fig. 2.1).

Grassy weeds

They have only one seed leaf and are also called narrow leaf weeds. The leaf blades of this type of weeds are narrow and have parallel veins. The stems are oval or round. The ends of the stems may develop seed heads and have unseen flowers (Fig. 2.2)

Fig.2.1: Broadleaf weeds
Camphor grass (Chromolaena odorata)

Fig.2.2: Grassy weeds
Johnsongrass (Sorghum halepense)

Difference between broadleaf weeds and narrow leaf weeds

Broadleaf Weeds	Narrow Leaf/Grassy Weeds
They have two seed leaves (cotyledons).	They have only one seed leaf.
The leaves are broad.	The leaves are narrowing.
The veins on the leaves are branched or netted.	The leaves have parallel veins.
The stems are often branched.	The stems are unbranched.
They have showy flowers.	They have inconspicuous flowers.

There are some parasitic weeds, which absorb nutrients and water through the roots of the crop plants. For example, broomrape (*Orobanche cernua* and *Orobanche indica*), dodder (*Cuscuta*) and witchweed (*Striga*).

Classification of weeds

Based on their life cycle weeds can be classified into three groups: annuals, biennials and perennials (Fig. 2.3).

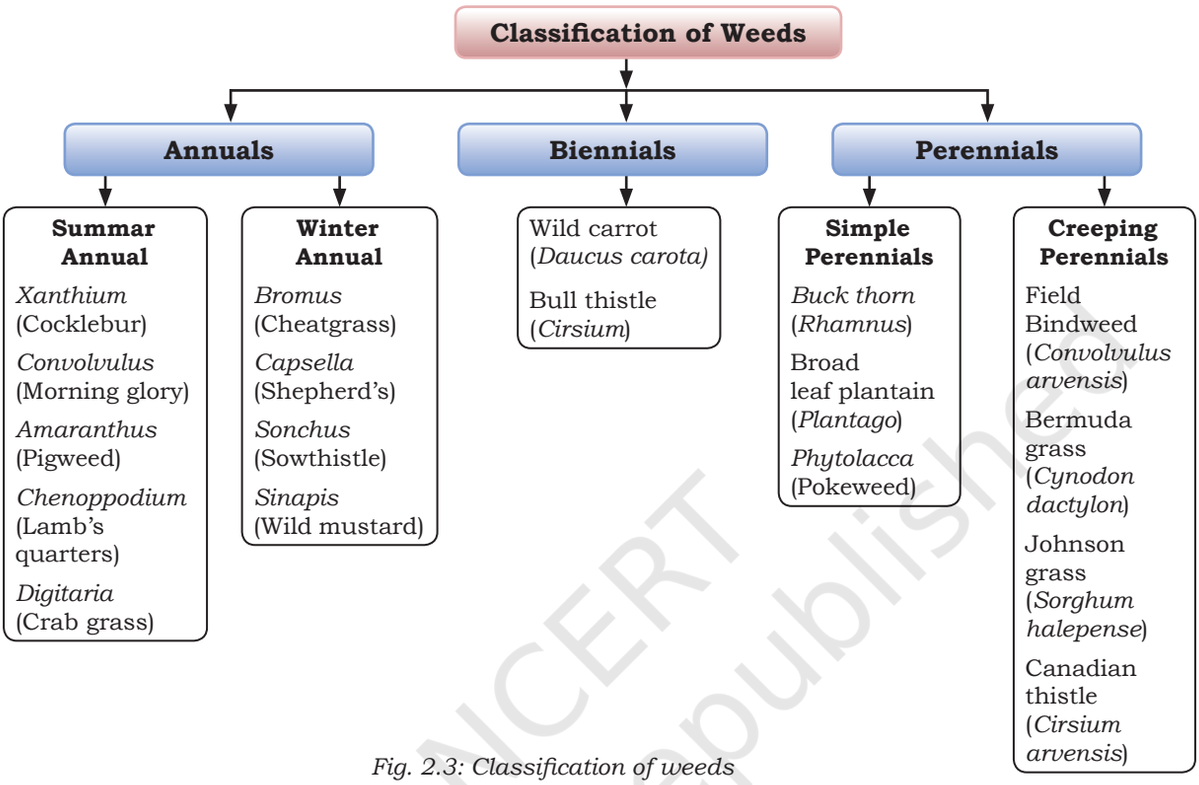


Fig. 2.3: Classification of weeds

Annuals

In annuals, a weed grows from a seed and completes its life cycle within one year. Generally, such weeds are considered comparatively easy to control. However, due to their large numbers and large quantity of seeds and fast growth, these are very constant. They incur higher cost to control than perennial weeds. Vegetable crops are largely affected by these weeds. These are further grouped into:

Summer Annuals

These annual weeds germinate during the spring season and make most of their growth during the summer. A summer annual usually flowers, produces seed and dies. The seeds remain dormant in the soil until the next spring. The common summer annual weeds include *Xanthium* (cocklebur), *Convolvulus* (morning

glory), *Amaranthus* (pigweed), *Chenopodium* (lamb's quarters) and *Digitaria* (crab grass). These weeds are most problematic in summer cropslike tomato, okra, peppers, cucurbitaceous crops and other spring planted vegetable crops.

Winter Annuals

They germinate during late summer and winter, usually flower and produce seeds in the spring or early summer before dying.

During summer months, the seed remains dormant in the soil because the high temperature of the soil restricts their germination.

The winter annual weeds include *Bromus* (cheatgrass), *Capsella* (shepherd's purse), *Sonchus* (sow thistle) and *Sinapis* (wild mustard). These weeds are mostly problematic in winter and early spring for grown crops like carrots, radish, beetroot, onion, garlic, cole, lettuce, etc.

Biennials

These weed plants complete their life cycle in more than one year but do not take over two years. The troublesome weeds that fall in this group are wild carrot and *Cirsium* (bull thistle), etc.

Perennials

These weeds take more than two years to complete their life cycle and may live for many years. They reproduce by seed and also spread vegetatively. They are further classified into:

- Simple perennials spread only by seed and not by vegetative means. However, the cut pieces of plants may also produce new plants. The roots of these weeds are fleshy and may grow very large, for example, *Rhamnus* (buckthorn), *Plantago* (broadleaf plantain) and *Phytolacca* (pokeweed).
- Creeping perennials multiply through creeping roots (creeping above the ground stems, stolens, or creeping below ground stems, rhizomes) and seeds. The examples are *Convolvulus arvensis* (field bindweed), *Cynodon dactylon* (doob grass), *Sorghum halepense* (Johnson grass) and *Cirsium arvense*

(Canadian thistle). Some weeds also propagate by means of tubers, which are modified rhizomes, such as *Helianthus tuberosus* (Jerusalem artichoke) and Cyprus (nut sedge or nut grass). Once a field is infested with these weeds, it becomes very difficult to control them. The weeds associated with different vegetable crops are given in Table 2.1.

Table 2.1: List of common weeds associated with different vegetable crops

S.No.	Name of Weed	English Name	*Botanical* Name	Crops Associated
1.	*Chulai*	Slender amaranth	*Amaranthus viridis*	Chili, onion and garlic
2.	*Satyanashi*	Mexican prickly poppy	*Argemone mexicana*	Chili and potato
3.	*Bathua*	Lamb's quarter	*Chenopodium album*	Tomato, brinjal, chili, cabbage, cauliflower, potato and radish
4.	*Kandai/Lehli*	Canadian thistle	*Cirsium arvense*	Tomato, potato and chili
5.	*Doob*	Bermuda grass	*Cynodon dactylon*	Tomato, brinjal, chili, onion, garlic, potato and radish
6.	*Motha*	Nut grass/Nut sedge	*Cyperus rotundus*	Tomato, cabbage, cauliflower, onion, garlic andcarrot
7.	*Takri Ghas*	Crab grass	*Digitaria sanguinalis*	Cabbage and cauliflower
8.	*Badi Dudhi*	Garden spurge/ Asthma plant	*Euphorbia hirta*	Chili, potato and cassava
9.	*Hiran Pug*	Field bindweed	*Convolvulus arvensis*	Radish and sweet potato
10.	*Sabuni*	Horse purslane	*Trianthema portulacastrum*	Potato, carrot and tomato

Figs 2.4–2.13 show weeds associated with major vegetable crops.

Fig.2.4: Common Crabgrass (Digitaria sanguinalis)

Fig.2.5: Asthma Plant (Euphorbia hirta)

Fig. 2.6: Field bindweed or Hirankhuri (Convolvulus arvensis)

Fig. 2.7: Amaranth (Amaranthus viridus)

Fig.2.8: Satyanashi or Mexican poppy (Argemone mexicana)

Fig.2.9: Bathua or Pigweed (Chenopodium album)

Fig.2.10: Creeping thistle (Cirsium arvense)

Fig.2.11: Doob grass or Bermuda (Cynodon dactylon)

Fig.2.12: Purple nut sedge or Motha (Cyperus rotundus)

Losses caused by weeds

In India, weeds cause the highest loss followed by pathogens, insects, storage pests, rodents and others. The various losses caused by weeds have been described below.

Increase in cost of cultivation

Tillage operations are required to remove the weeds from vegetable fields, which is about 25-30 per cent of the total expenditure of crop production. In case of severe infestation of weeds, more labour is required for manual weeding to remove the weeds. This increases the cost of cultivation and reduces the net return from the crop.

Reduction in quality of crop produce

Weed infestation reduces the quality of crop. Especially leafy vegetables suffer a lot from the infestation of weeds as the seeds of *Euphorbia hirta* (leafy vegetables) are very small, which increases chances of seed mixing.

Fig.2.13: Bishkhapra (Boerhavia difusa)

High infestation of pests and diseases

Weeds serve as an alternative host for diseases and pests. When a particular host dies, the pests and diseases remain and survive on weeds. When the season becomes favourable again, they start their life cycle and damage the main crop.

Reduction in crop vigour and health

Weeds compete for space, light, nutrition, moisture, etc., with the main crop. They deprive the main crop from essential elements required for growth and development. Once the main crop growth is affected, the yield obtained from infested field is very low.

Interference in agricultural operations

Heavy weed infestation in vegetable fields creates problem in field operations like tillage, earthling up, bed preparation, preparation of irrigation channel, etc. All these factors affect crop performance, ultimately reducing the yield.

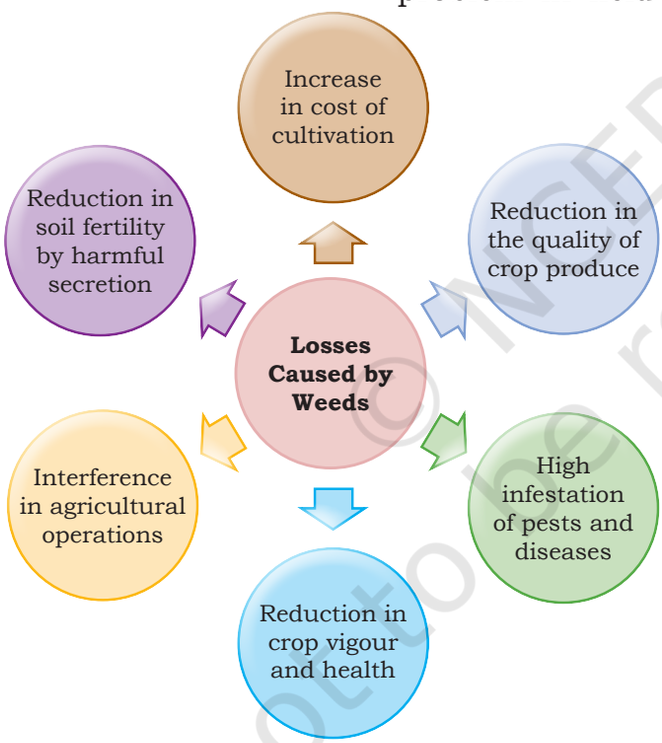


Fig. 2.14: Losses caused by weeds

Reduction in soil fertility

The root exudates of *Cyperus rotundus* (*Motha*) reduce the germination of seeds and causes great losses in terms of yield as well as degradation of soil fertility by harmful secretion.

Critical stages of weed control

Vegetable crops are sensitive to weed infestation. Therefore, critical stages must be kept in mind for effective weed management. Critical stages of vegetable crops for control of weeds are given in Table 2.2.

Table 2.2: Critical stages of vegetable crops for control of weeds

S. No.	Crop	Critical stages of weed control in vegetable crops
1.	Tomato and brinjal	2–6 weeks after transplanting
2.	Potato	3–6 weeks after planting

3.	Onion	2–9 weeks after transplanting
4.	Chili	4–6 weeks after transplanting
5.	Radish, turnip and beetroot	2–4 weeks after sowing
6.	Cabbage	2–4 weeks after transplanting
7.	Okra	2–4 weeks after sowing
8.	Carrot	2–8 weeks after sowing
9.	Garlic	2–8 weeks after planting
10.	French bean	2–6 weeks after sowing

Practical Exercise

Activity 1

Prepare a chart of weeds associated with vegetable crops

Material required

Writing material.

Procedure

1. Visit a nearby vegetable field to collect weeds.
2. Note down the crop associated with the weed collected.
3. Note down the local names of the collected weeds.
4. Note whether the weed has broad or narrow leaves.

Observations: The students should prepare a chart like the one given below and record their observations.

General familiarity chart of weeds

Date of collection _____

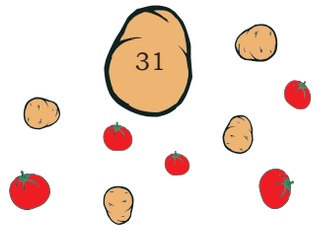
Site of collection _____

Specific vegetable plot from which weed is collected	Vegetable crop	Local or common name of the weed collected	Whether weed is broadleaved or narrow leaved

Activity 2

Collection of weeds and the preparation of a herbarium

A herbarium is a perennial collection of the most representative specimen of weeds. It is very good learning material not only for students who prepare it, but also for others who want to know the flora of a particular area.



Material required

field notebook, blotting paper, collection bag, herbarium sheets, pressing device, adhesive or cello tape, scissors or knife, magnifying lens, forceps

Procedure

1. Select a fresh specimen of a plant with all the important parts.
2. Spread the specimen in its natural form on a sheet of paper that can absorb moisture (blotting paper) and place under a press (or tightly press between two smooth surfaces).
3. Change the paper frequently to avoid fungal attack and keep the specimen pressed.
4. Repeat the operation till the specimens are dry.
5. Paste the specimen on a herbarium sheet.
6. Note down the following information on the right side of the bottom of the herbarium sheet.
   - Common/local name
   - Botanical name
   - Family
   - Growth habit
   - Date of collection
   - Site of collection or crop association or soil type
   - Name of the crop associated

Check Your Progress

A. Fill in the blanks

1. Unwanted plants that grow in the crop field or its surrounding areas are called _____.
2. Broad leaved weeds have _____ as they germinate.
3. A weed that completes its life cycle in less than a year is known as _____ weed.
4. _____ weeds spread only by seed and vegetative means.
5. Parallel veins on the leaves are found in _____ weeds.

B. Multiple choice questions

1. Dodder (*Cuscuta*) is _____.
   (a) an annual weed
   (b) a parasitic weed
   (c) a narrow leaf weed
   (d) a road leaf weed

2. The botanical name of nut grass is _____.
   (a) *Argemone mexicana*
   (b) *Euphorbia hirta*
   (c) *Chenopodium album*
   (d) *Cyprus rotundus*
3. The most common weeds found in vegetable crops are _____.
   (a) annual
   (b) biennial
   (c) perennial
   (d) None of the above
4. Bermuda grass is also known as _____.
   (a) doob grass
   (b) field bindweed
   (c) lamb's quarter
   (d) crab grass
5. The critical stage of weed control for potatoes is _____.
   (a) 1-2 weeks after planting
   (b) 3-6 weeks after planting
   (c) 7-9 weeks after planting
   (d) 10-12 weeks after planting

C. Subjective questions

1. Define weed. How are weeds harmful for a crop?
2. Classify weeds based on their life cycle and morphological features.
3. Distinguish between broad leaved and narrow leaved weeds.

D. Match the columns

A	B
1. Monocot weeds	(a) Consists of/ has a hard triangular stem
2. Dicot weeds	(b) Completes life cycle in more than two years
3. Sedges	(c) Leaves are slender, long and have parallel veins
4. Perennial weeds	(d) Completes life cycle within two years
5. Biennial weeds	(e) Has taproot system with broad leaves

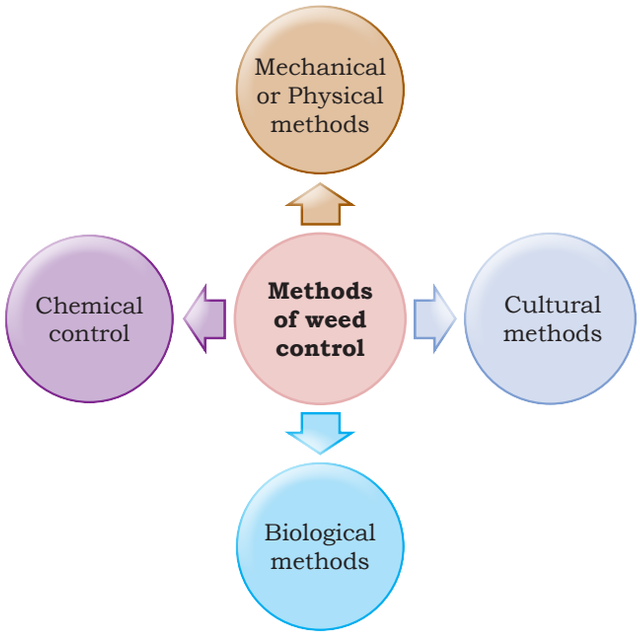


Fig. 2.14: Methods of weed control

Session 2: Weed Management

Methods of Weed Control

Minimising infestation so that the crop can be cultivated successfully is called weed control. The various methods of controlling weeds are given in Fig. 2.14.

Mechanical or physical methods

Mowing the weed is superficial trimming of succulent and herbaceous weeds. This inhibits the formation of seeds on the weed. Mowing keeps the growth of weeds under check,especially in a lawn. It should be followed by other methods of weed control to stop spread of perennials or the low-growing weeds can become a problem. **Mulching** the field is a practice of covering the open soil between the rows and plants of the crop. The soil is covered by organic matter, crop residues, polythene or paper. The exposed areas between the crops get no sunlight when they are covered with mulch. Due to this the weeds are unable to germinate. **Hoeing** is effective in controlling weeds in row crops. It has been widely used as a weeding tool for centuries.

Hand weeding is effective against annual and biennial weeds. Pulling out weeds from the field with the help of a *khurpi* is called hand weeding. This facilitates the loosening of soil and improves its drainage and aeration.

Cultural methods

Various agronomic practices, such as crop rotation, intercropping, soil solarisation, etc. have been found to be effective on weed management.

Crop rotation

It is growing different types of crops in the same field in sequenced seasons. In mono culture, a particular type of weed grows with a particular type of crop. Crop rotation helps to break the life cycle of weeds and prevents any weed species from becoming dominant.

Intercropping

It is growing of two or more crops next to each other at the same time. Intercropping suppresses weeds better than the mono cropping system. It provides the advantage of utilising crops themselves as tools for weed management.

Transplanting

It is when healthy and disease free 4-6 weeks old seedlings are transplanted from one area to another. They have the ability to compete with weeds.

Soil solarisation

It is the method of increasing soil temperature through absorption of sunlight, so that it destroys the seed and other propagules of a weed. Solarisation is done by covering the soil with black polythene during extreme summer for 4 to 6 weeks. The soil temperature may reach up to 40–55°C depending upon the intensity of sunlight. Many annual weeds can be controlled by this method.

Biological method of weed control

Living organisms, such as fungi, bacteria and insects are used to control weed population. Such herbicides are broadly known as bio-herbicides. When fungal spores or fungi are used to control the weeds it is known as myco (fungi) herbicide. The fungi, such as Pythopthora sp., Colletotrichum sp. and Bipolaris sp. are used as myco-herbicide. Insects, such as pallister beetles and flea beetles also damage weeds by feeding on the tender parts. Cochineal insects eradicate the weeds in the prickly pear. Sometimes the pests used for controlling weeds may remain in dormant stage in soil for a longer period. Root borers, stem borers or fruit borers are more destructive than foliage feeders. This method is uncommon as it needs technical knowledge. Bio-herbicides and weed insect-pest may infect or infest the main crop along with weeds.

Chemical control

Labour being uneconomical and also because hand weeding takes longer time, certain chemicals are

used to control the weeds. These chemicals are called herbicides. Chemical control of weeds is an economical method, requires less time and labour and controls weeds uniformly. There are ample pre-emergence, post-emergence, selective and non-selective herbicides available.

Types of Herbicides

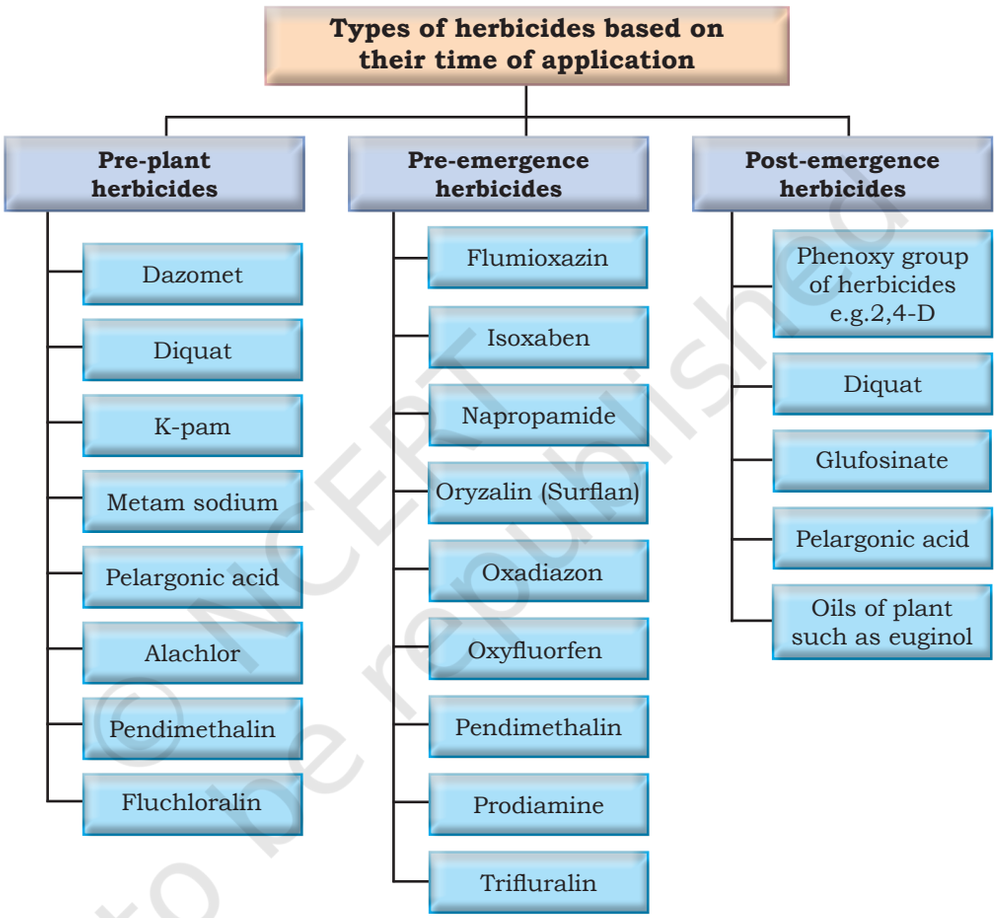


Fig. 2.15: Types of herbicides

Pre-plant herbicides

This is a group of herbicides that is applied before planting the main crop. These herbicides may be fumigants or non-selective chemicals and are lethal to all the plants that come in their contact. These are useful in controlling pre-emerged as well as emerging weeds. Most of these are applied to the soil. Some may be sprayed onto the weeds,

in case of perennial weeds. Pre-plant herbicides include Dazomet, Diquat, K-pam, Metam sodium, Pelargonic acid, Alachlor, Pendimethalin, Fluchloralin, etc.

Pre-emergence herbicides

This is another group of herbicides that attack the weeds at the seedling stage. These herbicides are generally selective. These are applied to soil after removing the existing weeds. Pre-emergence herbicides must be applied before the germination of weed seeds. Since there are various germination periods of weed species and a selection of herbicides, it is generally essential to use different herbicides at different times of the year to achieve best control. For example, Flumioxazin, Isoxaben, Napropamide, Oryzalin (Surflan), Oxadiazon, oxyfluorfen, Pendimethalin, Prodiamine and Trifluralin are included in this group.

Post-emergence herbicides

Post-emergence herbicides are applied onto weeds at the seedling stage. These are very selective and control only a narrow range of weed species. Fluazifop-p-butyl and Sethoxydim control most annual grasses and Clethodim controls annual bluegrass as well as other grasses.

These products include the phenoxy group of herbicides, such as 2,4-D, which selectively control broad leaved weeds. The group of non-selective herbicides includes diquat, glufosinate and pelargonic acid, and oils of plants, such as euginol.

Selective herbicides

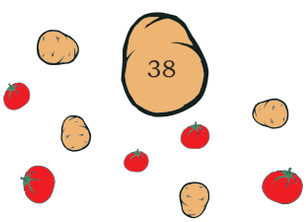
These are used against specific group of weeds and do not prove harmful for other crops. Pendulum, Surflan, Treflan, etc., 2,4–D, etc., kill broad leaved weeds but do not harm the monocots, while Fusilade (fluazifop) controls monocot weeds and not the broad leaved plants.

Non-selective herbicides

These prove lethal to almost all monocot and dicot weeds when they come in its contact, for example diquat.

Table 2.3: Chemical weed control in vegetable crops

S.No.	Crop	Herbicide formulation	Dose (kg/ha)	Time of application
1.	Potato	Fluchloralin	1.0	Pre-plant
		Pendimethalin	2.0	Pre-emergence
		Metribuzin	0.2-0.3	Post-emergence
2.	Cabbage and cauliflower	Fluchloralin	0.75-1.5	Pre-plant
		Pendimethalin	1.0	Pre-emergence
		Alachlor	2.0-3.0	Pre-emergence
		Isoproturon Alachlor	0.75-1.0 1.0-2.0	Post-emergence
3.	Onion and garlic	Fluchloralin	1.0-1.5	Pre-transplant (soil incorporation)
		Alachlor Pendimethalin	1.5-2.0 0.5-1.0	Pre-transplant (surface application)
		Oxyflurofen	0.62	Post-transplant
4.	Carrot	Fluchloralin	0.75-1.5	Pre-plant (soil incorporation)
		Pendimethalin Nitrofen	1.0 1.0	Pre-emergence
		Nitrofen	1.0	Post- emergence
5.	Radish	Benthiocarb Fluchloralin	1.0 0.5	Pre-emergence Pre-emergence
6.	Peas	Linuron Pendimethalin	0.5 1.0	Pre-emergence Pre-emergence
7.	Tomato	Trifluralin	1.0	Pre-plant (soil incorporation)
		Alachlor	1-1.25	Pre-transplant (surface application)
		Fluchloralin	1.25	Pre-transplant (surface application)
		Alachlor	1-2	Pre-emergence
8.	Okra	Fluchloralin Alachlor	0.5-1.0 1-2	Pre-plant (soil incorporation) Pre-emergence
9.	Brinjal	Fluchloralin Pendimethalin	1-1.25 1.0	Pre-plant (soil incorporation) Pre-emergence
10.	Bottle guard and cucumber	Fluchloralin Butachlor	0.5-1.0 1-1.25	Pre-plant (soil incorporation) Pre-emergence
11.	Spinach	Benthiocarb	1.0	Pre-emergence



Application of Herbicide

The success of weed control depends on the method of application of the herbicide. The important factor in the application of herbicide is that it should target the foci accurately and in measured quantity only. Different equipment is used for herbicide as per the formulation and area to be covered. On small holdings or in a greenhouse it can be applied through a backpack handpump sprayer or duster, whereas, in big fields or farms, a tractor unit is more desirable. In large nurseries, over-the-top sprayers are used, which cover full beds will be best. Flat fan nozzles, equally spaced on a boom, are used to get the most uniform distribution of pre-emergence liquid herbicidal formulations.

Hollow or cone nozzles on a boom are used in case of spraying post-emergence herbicides on weeds. Granular herbicides can be applied through common types of spreaders. Herbicide granules can be spread with drop-type or side-throw-type of spreaders.

Equipment used to spray weedicide

Sprayers are of two types – knapsack and foot sprayer. They are used to spray not only herbicides but also insecticides, fungicides, soluble fertilisers etc. in vegetable crops.

Duster is used for dusting fungicides, insecticides, herbicides, etc. in a powder form.

Fig. 2.16: Knapsack sprayer

Precautions to keep in mind while applying weedicides

1. Before application read and follow the directions written on the label.
2. Calibrate your spray equipment and keep it in good working order.
3. Always wear gloves, cap and mask during the spraying of weedicides.
4. Do not apply on a hot sunny day or during strong wind conditions.
5. Do not apply just before and after a rainfall.
6. Stop entry of animals and workers in the spraying area.

7. Post-emergence herbicides should be sprayed when the weeds are at the initial stage.
8. Make a record of major weed species in the vegetable field and use it for planning the spraying schedule for the next season.
9. Competitive crops should be grown in weedy areas and non-competitive crops in the cleaner areas of the field.
10. After spraying weedicides, wash your hands properly with soap in running water.
11. Clean the sprayer or duster by removing the remaining weedicides.
12. Properly oil or grease the sprayer or duster, before and after spraying, to check faulty application.

Practical Exercise

Collect information about herbicides commonly used in your locality

Material required: Writing material.

Procedure

Collect information about commonly used herbicides in your locality either from the farmers or from the agro service centre and prepare the following chart.

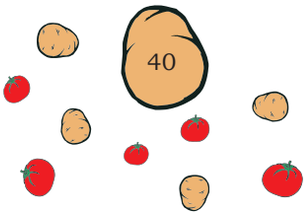
S. No.	Name of herbicide	Formulation dry/wet	Concentration	Time of application	Effective against (weed)

- Formulation may be dry or wet.
- Time of application means pre-planting, pre-emergence or post-emergence.

Check Your Progress

A. Fill in the blanks

1. Growing two or more crops next to each other at the same time is called _____.
2. Soil temperatures must reach above _____°C to facilitate solarisation.



3. The different types of crops that grow in the same field in sequenced seasons are known as _____.
4. Pulling out weeds from the field by hand with the help of a *khurpi* is called _____.
5. Diquat is a _____ herbicide.

B. Multiple choice questions

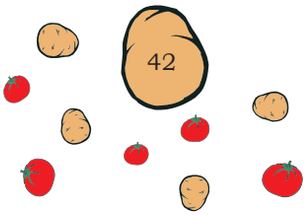
1. Herbicides applied prior to the emergence of the weed seed is known as _____
   (a) pre-plant application.
   (b) pre-emergence application.
   (c) post-emergence application.
   (d) All of the above
2. Pendimethalin can be used in potato as a pre-emergence spray and the dosage is _____.
   (a) 1 kg/ha.
   (b) 2 kg/ha.
   (c) 3 kg/ha.
   (d) None of these
3. Which of the following herbicides can be used as a pre-plant/transplant?
   (a) Alachlor
   (b) Pendimethalin
   (c) Fluchloralin
   (d) All of the above
4. Living organisms, such as fungi, bacteria and insects that are used to control weed population are known as _____.
   (a) myco-herbicides
   (b) persistent herbicides
   (c) bio-herbicides
   (d) herbigation
5. Herbicides applied before planting the main crop are _____.
   (a) pre-plant herbicides
   (b) pre-emergence herbicides
   (c) post-emergence herbicides
   (d) All of the above

C. Subjective questions

1. Explain different methods of weed control in vegetable crops.
2. Classify the various types of herbicides used in weed control.
3. Discuss the chemical method of weed control in solanaceous vegetables.
4. Write various precautions to be followed during the spraying of weedicides.

D. Match the columns

A	B
1. Soil solarisation	(a) Covering exposed surface of soil
2. Mowing	(b) Use of chemicals
3. Mulching	(c) Biological control
4. Herbicide	(d) Superficial trimming
5. Myco-herbicide	(e) Raised soil temperature



Unit 3

Integrated Pest and Disease Management in Vegetable Crops

Introduction

Solanaceous vegetables are more susceptible to different types of pests like insects, nematodes and mites. In India, upto 50–80% yield loss of vegetable crops incurs due to various diseases. The crop loss caused by diseases, such as early blight of brinjal is 78%, wilt is 10–60%, Begomovirus is 100%, phomopsis blight is 30–50% and chili anthracnose is 30-80%.

The use of fungicides and insecticides in vegetables to control diseases and insect-pests is increasing because of intensive farming practices and expanding cultivation into new areas and in seasons beyond the traditional range of crops. Pesticides are synthetic compounds and are hazardous for the environment and also for non-target insects. Indiscriminate use and improper application of pesticides create ecological imbalances due to the destruction of beneficial insects and the emergence of pesticide resistant species and strains.

The increasing use of pesticides is a major factor for the rising cases of pesticide residue in vegetables. In the past, a single approach to control pests and diseases was in practice, which was neither economical nor safe. Therefore, a systematic approach of integrated pest or disease management (IPM or IDM) was adopted.

IPM includes all types of control measures, such as physical, mechanical, biological and chemical as per the suitability of application, that control the pest population below the economic injury level.

It is a multidisciplinary approach, which includes different tactics, such as analysis of habitat, knowledge of crop husbandry, soil tillage, healthy seeds, balanced fertilisers, well-timed irrigation, sanitation, recommended spacing, tolerant and resistant varieties, use of natural enemies, release of parasitoids and predators and the use of need-based biological and chemical pesticides or fungicides. In this unit, you will learn about insect-pests and diseases that damage solanaceous crops. You will also learn about the control measures for various pests and diseases including the IPM and IDM approach.

SESSION 1: MAJOR INSECT-PESTS OF SOLANACEOUS CROPS

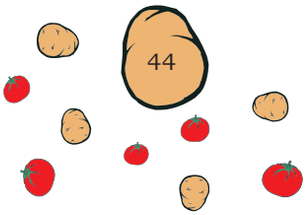
Insect-pests are a menace to vegetable production. They generally attack crop at all its stages. It is essential to adopt control measures for insect-pests at the right time to manage the pest population and minimise the yield loss. Knowledge about the insect-pests of the crop, the characteristics of the insects, their nature and the damage they cause helps to identify and manage the pest effectively.

Tomato Fruit Borer

Tomato fruit borer *(Helicoverpa armigera)* caterpillars are greenish in colour with dark brown and grey outline along the body. A caterpillar is the most active stage of tomato fruit borer. At a young stage, the larva feeds on tender foliage while at the advanced stage it bores circular holes in the fruit and feeds inside the pulp.

Control

- Use tolerant varieties like Punjab Kesari, Punjab Chhuhara, BT-1 and BT-32.



- Deep summer ploughing can expose the larvae and pupae to sunlight and predation of birds.
- Plant marigold (40 days old) as a trap crop with every 16 rows of tomato (25 days old) to attract the larvae. Collect the larvae from the marigold flowers and destroy them.
- Place 15-20 T-shaped bird perches per ha to invite insectivorous birds.
- Use HaNPV (*Helicoverpa armigera* nuclear polyhedrosis virus) @ 250 LE (larval equivalent)/ha during evening hours.
- Periodically release egg parasitoid, such as *Trichogramma chilonis or T. pretiosum* @ 1,00,000 egg /ha.
- In the early stages, spray 4% NSKE (neem seed kernel extract) to kill the larvae.
- Apply Novaluron 10 EC/1.5ml/l or Quinalphos 25 EC/2ml 40 SP/1g/l.

Aphids

Aphids or *Aphis gossypii* are soft bodied insects. They are also known as plant lice. The tiny insects may be green to black in colour and are found in a cluster on the tender parts of the plant. Tomato aphid adults are fragile, slender and minute with fringed wings. They harm the crop constantly by sucking sap from the lower leaves and the tender shoots of the plant. Aphids exude honey dew, which attracts ants and develops a sooty mold. The leaves curl up. They act as a vector for transmission of disease causing viruses.

Control

Spray the crop with dimethoate @ 0.03% or methyl demeton @ 0.025% or phosphomedon @ 0.04% for effective control of aphids.

Whitefly

Whitefly or *Bemisia tabaci* adults are white tiny scale-like insects covered with a white waxy bloom. Nymphs and adults both feed on the upper surface of

the leaves by sucking cell sap. The affected parts of the plant show yellowing and wrinkling of leaves. It also transmits leaf curl viral disease.

Control

- Remove weed hosts, which harbour the white flies to reduce the incidence of whiteflies and associated viral diseases.
- Treat seeds with imidacloprid 70 WS @ 2.5 g per kilogram to provide protection for 25–30 days.
- Use a nylon net (200 mesh) covering for 25–30 days to avoid insect infestation in the nursery.
- An alternate spray of neem seed kernel extract (NSKE) 4 per cent or neem soap @ 10g/litre and triazophos 40 EC, 10, 20, 30 and 45 days after transplanting, is effective for the control of white flies.

Leaf Miner

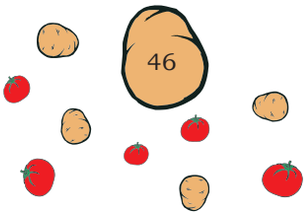
Leaf miner larvae are orange yellow and apodous. Maggots enter the leaf and eat the mesophyll of the leaves by making tunnels and zigzag structure on the leaves. Remove and destroy the severely infested leaves.

Control

- Spraying NSKE (neem seed kernel extract) @ 4.0 per cent along with sticker is effective. This pest can be controlled by spraying the crop with Cartap hydrochloride 50% SP @ 250–300 gram/acre.
- These natural enemies, particularly larval and pupal parasitoids, are active between the months of July-August.
- These parasitoids can be used to control leaf miner insect.

Leaf Hopper or Jassids

Leaf hopper or jassids (*Amrasca biguttula*) nymphs and adults are green and move diagonally when disturbed. They suck the sap from the leaves, leaving them yellow and curling upwards. In severe conditions, the leaves become brown, dry and fall down.



Control

- Treat the seeds with imidacloprid (3g/kg), which gives protection for up to 40-50 days after sowing. Also apply carbofuran @ 1.0kg/ha in the soil at the time of sowing.
- Dip the root of the seedling for one hour in imidacloprid17.8 SL @ 1ml/litre of water. This will protect the crop for 30 days after transplanting.
- Spraying NSKE @ 4% at an interval of 10 days is also effective.
- Applying imidacloprid 17.8 SL @ 0.35 ml per litre or thiamethoxam 25 WG @ 0.35 ml litre, after 25 days of transplanting, at an interval of 10-15 days is also effective.

Shoot and Fruit Borer

Leucinodes orbonalis have black and brown patches and dots show on the white forewings of the moth. The larvae are light pink in colour. Initially, the larvae bore into shoots and kill the growing point of the plant. The affected shoot wilts or droops. Adult caterpillars bore into the fruits. At the entrance hole, fecal pellets are visible.

Control

- Regularly clip and burn the affected and withered dead shoots and leaves.
- Spray Fenpropathrin 30 EC @ 0.75 ml/l or Emamectin benzoate 5 SC @ 0.35 G/litre, alternatively at 15-day intervals when the plant is in the vegetative and flowering stage. It is effective against shoot and fruit borer.
- Use sex pheromone lucilure @ 100 traps/ha at 20-25 days intervals.

Chili and Capsicum

Thrips

Scirtothrips dorsalis and Thrips palmi are minute insects with fringed wings. Both adults and nymphs damage the crop and lacerate leaf tissues and curl

the leaves inwards. This incidence is severe during dry periods.

Control

- Sow seed after treatment with imidacloprid 70WS @5-10 gram / kg seed.
- Cover the nursery with nylon net (200 mesh) to protect nursery plants from thrips till the plant is 25-30 days old.
- Foliar apply acetamiprid 20SP @ 0.2 ML / litre water or dimethoate 30 EC @1.5 ml / litre water or Emamectin benzoate 5SG @0.4 gram /litre water or imidacloprid 17.8SL @0.5 ml/litre water at an interval of 10-15 days.
- Avoid spraying same chemical repeatedly. Stop foliar spray of chemicals before 10 days of flowering.
- Trips can be controlled by blue polyethene coated with a sticky material like castor oil or grease (20-25polyethene/ hac) at equal distance.

Mites

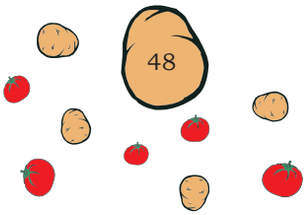
Polyphagotarsonemus latus, Tarsonemus translucens and Tetranychus cinnabarinus are very small and white in colour. They are difficult to see with naked eyes. They make the leaves curl downwards.

Control

Foliar Spray Buprofezin 25 SC @ 1.2 ml/litre water or Chlorfenapyr 10 SC @ 2ml/ litre water or Dimethoate 30 EC @ 2ml/ litre water or Fenpyroximate 5 EC @ 1.2 ml/litre water at 10-15 days interval is effective to control mites.

Green Peach Aphid

Green peach aphid or *Myzus persicae* are tiny, succulent, pear-shaped and vary in colour from yellow and green to black. They appear on newly emerging shoots and on the lower side of the leaves. They suck the sap from the tender parts and affect the plant's vigour. They secrete a sweet substance, which attracts ants and also form a sooty mould.



Control

Treat seeds with imidacloprid 70 WS @12 g/kg of seed. Foliar apply thiamethoxam 25WG @ 80 gm/acre or emamectin benzoate @0.5 ml/litre of water.

Insect Pests of Solanaceous Vegetables

Fig. 3.1: Whiteflies in tomato

Fig. 3.2: Aphids in tomato

Fig. 3.3: Leaf hopper in brinjal

Fig. 3.4: Aphids in brinjal

Practical Exercise

Activity 1

Identify the symptoms caused by mites and thrips in chili.

Material required

Infested specimen of chili

Procedure

1. Examine the sample carefully.
2. If the leaf shows upward curling (cupping) it has been infested by thrips.
3. If the leaf shows downward curling it is attacked by mites.
4. Suggest suitable control measures.

Activity 2

Identify the major insect pests in your nearby area.

Material required

Insect net, collection box and writing material.

Procedure

1. Visit a nearby farmer's field and note down the following information:
2. Crop grown in the field; and stage and age of the crop.
3. Collect insect pests from the crops.
4. Identify the insect pests.
5. Write control measures for the collected insect pests.

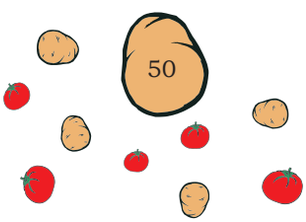
Check Your Progress

A. Fill in the blanks

1. Tomato's fruit borer can be kept away from the crop by growing _____ as trap crop.
2. Adults of _____ are fragile, slender and minute with fringed wings.
3. Maggots of _____mines into the leaf and feeds on the mesophyll of the leaves.
4. Leaf hopper or jassids' leaves become yellow and _____.
5. The leaves of the chili plant affected by _____show downward curling.
6. Larvae of _____bore into shoots and kill growing point of brinjal plant.

B. Multiple choice questions

1. The most active stage of insect of fruit borer of tomato is _____.
   (a) adult
   (b) caterpillar
   (c) Both (a) and (b)
   (d) None of the above
2. The number of pheromone traps used to control the moths of chili fruit borer are _____.
   (a) 5 trap/ha
   (b) 7 trap/ha
   (c) 9 trap/ha
   (d) 11 trap/ha
3. Which one of the following is an egg parasitoid?
   (a) *Tetranychus cinnabarinus*
   (b) *Epilachna*
   (c) *Trichogramma chilonis*
   (d) None of the above



4. In thrips infestation _____.
   (a) leaves curl upwards
   (b) leaves curl inwards
   (c) growing point kills
   (d) holes can be seen in the fruit
5. Aphids damage crop by _____
   (a) sucking cell sap
   (b) secreting sugary substance
   (c) vector of virus
   (d) All of the above

C. Subjective questions

1. Explain brinjal's fruit and shoot borer and its control measures.
2. What are the control measures of tomato's fruit borer?
3. Write about chili's fruit borer and its control measures.

D. Match the columns

A	B
1. Aphids	(a) Sex pheromone
2. LuciLure	(b) Yellowing and wrinkling of leaves
3. Whitefly	(c) Zig-zag pattern on leaves
4. Leaf miner	(d) Kills growing point of plant
5. Shoot and fruit borer	(e) Vectors

SESSION 2: MAJOR DISEASES OF SOLANACEOUS CROPS

What is a Disease?

A successful interaction between virulent pathogen and susceptible host in favourable conditions is called disease. Diseases are caused by fungi, bacteria and viruses. Disease causing organisms are called pathogens. Pathogens may be soil borne, carried through seeds or disperse through wind and water. Some viral diseases are transmitted by insect vectors. Some of the most common diseases of solanaceous crops are anthracnose, wilt, bacterial spot, bacterial blight, damping off, early blight, late blight, leaf curl, mosaic, powdery mildew, rots, and septorial leaf blight, little leaf, leaf curl, bacterial canker, buck eye rot, fruit rot, etc.

A few of the major diseases of solanaceous vegetables have been discussed below.

Damping off

This is a common disease among nursery plants, tomato seedlings, chili and brinjal that are generally attacked by the soil borne fungi. Fungi like *Phytophthora*, *Pythium* sp. are the causal organisms. Fungi infect seedlings in the collar region causing decay of tissues. Infected seedling cannot stand upright and collapse. It is commonly seen during the rainy season and under water stagnation conditions.

Control

- During the rainy season, the seedlings should be grown on a raised bed.
- Soil solarisation and sterilisation may reduce the soil borne inoculum of fungi.
- Soil drench with mancozeb or carbendazim (2-3g/ litre of water) also reduces infection.
- Treat the seed with trichoderma 5g/kg seed.

Early blight

It is a fungal disease commonly seen in tomato, brinjal and potato. The causal organism of this disease is *Alternaria alternata* f. sp. *lycopersici* and *Alternaria solani*. Irregular brown leaf spots appear on a marginal portion of leaves, which enlarge and become necrotic patches. Fungi is dispersed through air and favoured by high temperature.

Control

Two foliar sprays of mancozeb 2 gm/litre or zineb 75 WP @ 1.5-2 gm/litre of water are beneficial.

Phomopsis blight of brinjal

It is a fungal disease of brinjal caused by *Phomopsis vexans*. Clearly defined circular, light brown spots appear on the lower leaves. On fruits pale to light brown sunken spots develop, which later coalesce to form bigger patches.

Control

- Use disease-free seed material.
- Treat the seed with carbendazim 2.5 gm/kg of seed.
- Collect and burn the diseased twigs and plan material.
- Foliar spray with carbendazim 0.1% or 0.15% carbendazim + mancozeb (1.5 gm/litre of water) is found to be effective.

Anthracnose or die back of chili

It is a fungal disease caused by *Colletotrichum capsici*. Fungus is seed borne, which also disperse through wind. It starts from tender twigs from the top of the plant causing necrosis and withering. Drying starts from top to bottom, hence it is called die back. Small, irregular, sunken, light brown lesions with concentric rings can be seen on leaves, shoots and fruits.

Control

- Treat the seed with carbendazim @ 2.5 gram/kg seed.
- Remove and burn diseased parts of the plant.
- Foliar spray of Chlorothanonil 25 EC @1.5 gram/ litre water or propineb 3.5 gram/ litre water is found effective for control of the disease.

Bacterial wilt

It is a common disease of all solanaceous vegetable crops. Bacterium *Ralstonia solanocearum* is found associated with the disease. Sudden wilting of plant without yellowing and collapse of entire plant are primary symptoms. When an infected plant is cut and dipped in a glass of water, a thread like milky substance oozes out from the cut end of the stem.

Control

- Use disease resistance varieties.
- Adopt long-term crop rotation without solanaceous crops.
- pH of soil should not acidic.
- Before transplanting, treat the roots of the seedling with streptocycline 150 ppm (1 gram in 6 litre water) for 30 minutes.

Fusarium wilt

Leaves of the affected plants become yellow and droop. Later it may cause the death of the whole plant.

Control

- Avoid continuous solanaceous crop cultivation on the same piece of land.
- Treat the seed with carbendazim @ 2.5 gm/kg seed before sowing.
- Spraying tebuconazole @ 1 gram/ litre or carbendazim @ 0.2% at one week intervals is found to be effective.

Leaf curl disease

It is an important viral disease of the tomato and chili plant. The virus is transmitted by the whitefly. The leaves show downward rolling, curling, twisting and chlorosis. The plants show stunted growth with short internodes. It gives a bushy appearance to the plant. Such plants do not bear flower or fruit at a later stage.

Control

- To avoid whitefly attack, the nursery should be covered with a nylon net (40 mesh) or sprayed with insecticide @ 4-6 days interval to check the transmission of the disease.
- Uproot and destroy the infected plant as soon as it is seen, otherwise it could cause further infection and spread of disease.
- Use barrier crops like maize, bajra and sorghum.
- Place yellow sticky traps (20 traps/ha) to control the vectors.
- Spray the crop with imidacloprid (3 ml/ 10 litre water) to avoid infestation of whiteflies.
- At the time of transplanting, dip the roots of the seedlings in imidacloprid 17.8SL@0.5 ml/litre water for 2 hours to control the disease.

Little leaf of brinjal

The characteristic symptoms of this disease are excessive shortening of leaves. Numerous leaves aggregate in a bunch giving a bushy appearance. Due to shortening of internodes the plant becomes a dwarf. The infected

plants are totally unproductive and do not bear flower or fruit. Organisms like Mycoplasma are responsible for this. The pathogen is transmitted by vector leafhopper.

Control

- Uproot infected plants and burn them as soon as the first sign of initial symptoms appear.
- Avoid early transplanting to escape leafhopper population.
- Spray imidacloprid 3 ml/10 litre water to avoid the secondary infection of the disease.

Root knot nematode

Soil borne nematode *Meloidogyne incognita* infests almost all solanaceous vegetables through the roots. Nematode develops inside the root, causing swelling and knots. This affects the uptake of water and minerals from the soil, ultimately affecting the growth of the plant.

Judicious or need based application of nematicides is recommended. Application of Carbofuran 3G @ 1 kg ai/ha is found effective for vegetable crops under field condition.

Diseases of Solanaceous Vegetables

Fig.3.5: Early blight of tomato

Fig.3.6: Late blight of tomato

Fig.3.7: Leaf curl in tomato

Fig.3.8: Root knot in tomato

Fig.3.9: Phomopsis blight in brinjal

Fig.3.10: Little leaf in brinjal

Fig.3.11: Cercospora leaf spot in brinjal

Fig.3.12: Fusarium wilt in tomato

Practical Exercise

Activity 1

Identify the symptoms caused by bacterial wilt in brinjal and chili crops.

Material required

Infected chili or a brinjal plant, knife, glass and water, etc.

Procedure

1. Observe the infected plant.
2. Select the plants that show wilting in the field.
3. Fill a glass with water.
4. Cut the stem of the affected plant with the help of a knife.
5. Put the cut end into a glass of water.
6. Observe the milky secretion oozing out from the cut end of the stem.
7. Bacterial wilt affected plants will show symptoms of a thread like milky ooze.

Activity 2

Identify disease specimens of solanaceous crops.

Material required

Magnifying glass, disease specimens, pen, notebook, etc.

Procedure

1. Visit a nearby vegetable field and identify the crop.
2. Collect diseased samples from the field.
3. Observe the disease sample or specimen carefully.
4. Observe the symptoms with the help of magnifying lenses.
5. Write down the name of the disease.
6. Write down the name of the causal organism.
7. Write down the control measures.

Check Your Progress

A. Fill in the blanks

1. _____ is a disease at nursery stage.
2. _____ is a disease caused by coplasma like organisms.
3. In _____ disease, wilting is observed from top to bottom.
4. Knotting on roots is caused by _____.
5. Leaf curl in chili is caused by _____.

B. Multiple choice questions

1. In which disease is formation of a concentric ring found?
   (a) Anthracnose
   (b) Late blight
   (c) Wilt
   (d) None of the above

2. Irregular brown spots on the leaves during the early period of growth is observed in _____.
   (a) late blight
   (b) damping off
   (c) leaf curl
   (d) early blight
3. Damping off is a disease of _____
   (a) leaves
   (b) fruits
   (c) seedling
   (d) flowers
4. Milky white ooze from a cut stem is the sign of _____ infection.
   (a) nematode
   (b) bacterial
   (c) fungal
   (d) viral

C. Subjective questions

1. Write short notes on the following
   (a) Early blight of tomato
   (b) Late blight of potato
   (c) Leaf curl disease in chili
   (d) Little leaf of brinjal
   (e) Root knot nematode in solanaceous crops
2. What are the major differences between late blight and early blight?
3. Write the symptoms of damping off with its effective management practices.

D. Match the columns

A	B
1. Root knot	(a) Streptocycline
2. Leaf hopper	(b) Reduce nematode population in the soil
3. Soil drenching	(c) *Meloidogyne incognita*
4. Bacterial wilt	(d) Transmitted little leaf of brinjal
5. Marigold	(e) Carbendazim

SESSION 3: INTEGRATED PEST AND DISEASE MANAGEMENT OF SOLANACEOUS CROPS

Integrated Pest Management (IPM)

Integrated pest management is an efficient and economical approach to controlling pests in crops.

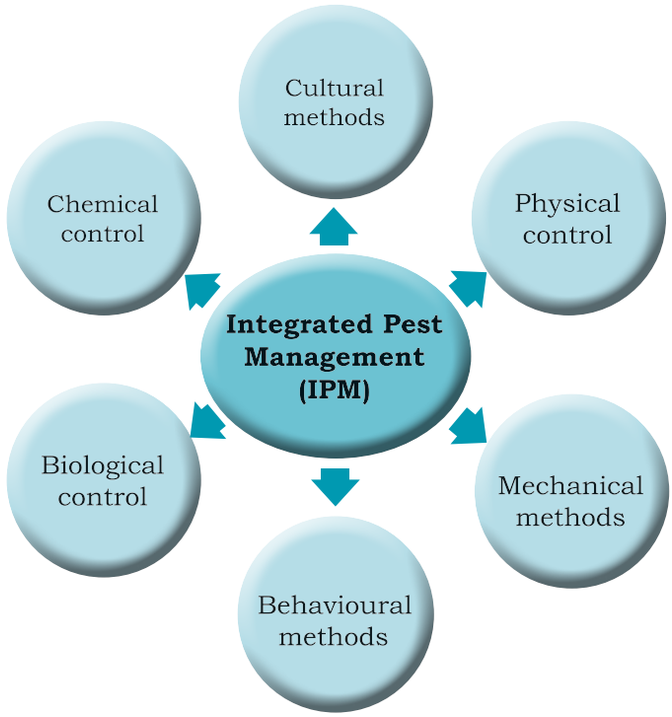


Fig.3.13: Integrated Pest Management (IPM)

It makes use of virtually all methods of pest control, including natural pesticides, beneficial insects, special cultivation practices, and even chemical pesticides in the right measure at the right time. Some practical techniques of IPM are described below. (Fig. 3.13)

Cultural methods

Routine agronomic practices can be utilised for minimising pest infestation by slight modification in timing or method of their application. These functions are preventive methods. The field operations right from field preparation to harvesting or post harvesting can reduce the population of one pest species or the other.

Resistant cultivars

Grow insect and disease resistant varieties recommended for specific regions. Chilli, Pusa, Sadabahar variety is resistant to mites and thrips, Kashi Gaurav variety is tolerant to thrips and resistant to fruit rot. Tomato, Kashi Aman variety is resistant to leaf curl and Kashi Abhay is a hybrid tolerant to leaf curl. Brinjal, the fruits of Pant Samrat variety is moderate against stem borer insect.

Clean cultivation

Destroy unwanted crop stubble after the crop is harvested. Destruction of cucurbit vines and stubbles of rapeseed mustard after the crop season kills the population of pumpkin beetle and painted bug, respectively.

Tillage

Deep ploughing and intercultural operations expose pests, such as army worm, cut worms, borers and white grubs, termites, and mole cricket to the vagaries

of nature. Thus, this helps to reduce pest infestation in crops.

Sowing time

The change in sowing or planting time is aimed to disturb the synchrony between the host and pest populations. Early sown cucurbits and rapeseed-mustard escape the attack of pumpkin beetle and aphids, respectively.

Intercropping

It helps in reducing the incidence of certain pests by making microclimate less favourable for them. It also hinders free movement of pests among plants of the same species. Intercropping of cabbage with tomato reduces the infestation of diamond black moth, while that of tomato with marigold is useful in checking fruit borer and nematodes.

Crop-rotation

It means altering the category of crop grown on a specific area of land from year to year. Crop rotations are mostly done in a span of 3 to 7 years. Avoid growing the same crop, or crops of the same family, over and over again in the same field. Ratooning should be avoided as it promotes the survival of brinjal shoot and fruit borer. Avoid sequential cultivation of vegetable cultivars as they are more prone to attack by insect pests and needs effective protection for profitability.

Trap crops

A 'trap crop' is grown as a companion to the main crop to attract pests away from the main crop. To reduce the incidence of diamond black moth, leaf webber, web worm and aphids, grow mustard as a trap crop with cabbage. Marigold planted with tomato as a trap crop is highly effective against fruit borer.

Nutrient and water management

Fertilisers should be applied in a balanced manner. Excessive use of nitrogenous fertiliser intensifies the incidence of sucking pests, such as jassids, whiteflies and aphids. Likewise, excess use of water should also be avoided as humidity increases pest population.

Physical control

It is the method of reducing pest population with the help of devices that influence them physically or adjust their physical environment. Manipulation of temperature, humidity and light is used for this purpose, for example, the use of light traps, pheromone lures, hot water treatment,etc.

Mechanical methods

This reduces pest control by manual devices. Mechanical methods along with physical and cultural methods are effective in reducing pest populations.

Behavioural methods

Use insect traps to monitor or directly reduce the population of insects. In this method visual lures, chemical attractants, sticky bands and pheromones are installed to attract insects.

Pheromone trap

- Pheromones may attract only the male insect.
- Use of Helilure for tomato fruit borer, Erivitlure for lady finger fruit borer, and *Leucine lure* for brinjal shoot and fruit borer is recommended as female sex pheromones are beneficial.
- Use methyl eugenol traps against fruit flies.
- Pheromone traps can be used either for monitoring (5 traps/hectare), mass trapping or mating disruption (25 or 100 traps/ha).

Biological control

Insects have some natural enemies. Predators, parasitoids, microbes, birds and other animals are useful in minimising insect pests.

- **Predators** are organisms that feed on other insects. The organism is called predator and the insect is known as the prey. For example, a lady bird beetle feeds on aphids. Birds like crow, egret, cuckoo, woodpecker, stork, warbler and babbler feed on insects. Owls, bats and peacocks help to control rat and mice population.

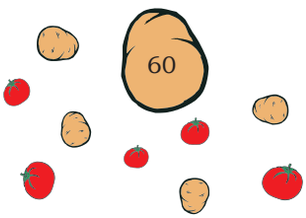


Fig.3.14: Biological pest control A spotted lady beetle(Adalia bipunctata) feeding on an aphid colony

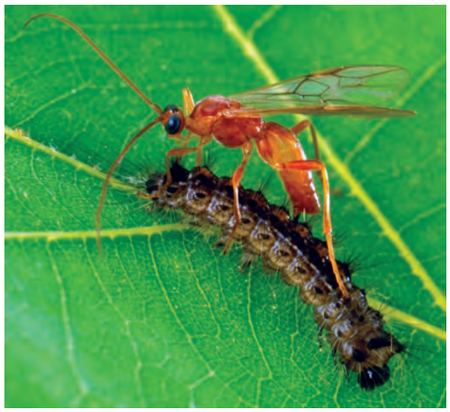


Fig.3.15: Biological pest control A parasitoid wasp (Aleiodes indiscretus) laying eggs on a caterpillar

- **Parasites** feed on other insects' body parts, internally or externally. For example, *Trichogramma chilonis* feeds on the eggs of *Helicoverpa armigera* (fruit borer of tomato).
- **Pathogens** are microorganisms developed to help in the killing of pests. This includes bacteria, viruses, fungi, etc.
- **Virus** Ha-NPV (*Helicoverpa armigera* Nuclear polyhedrosis virus) is used against tomato fruit borer.
- **Botanical insecticides** are naturally occurring chemical substances (insect toxins) extracted or derived from plants. They are also called natural insecticides.
  - **Neem** contains many active compounds like azadirachtin, which acts as feeding deterrents. It is effective on several types of insects, mites and nematodes. Neem oil (2-5 per cent)is found effective and neem cake (250 kg/ha)helps control fruit and shoot borer.
  - **Nicotine** is derived from tobacco and is used to control insects, such as aphids and mites in greenhouses.
- Use pesticides judiciously, that is, the right pesticides, in the right amount, at the right time, in the right place.
- Apply chemical pesticides only when other effective methods are not available.
- Choose less toxic and less persistent pesticides.

- Choose selective pesticides which control the pest species but leave beneficial species and neutral species unharmed.

Integrated Disease Management (IDM)

IDM involves timely use of various combined measures to reduce the pathogenic invasion. This involves site selection and preparation, altering the planting practices, use of resistant cultivars, modifying the environment, pruning, thinning shading, etc., and use of pesticides, if required. Along with this, following conventional techniques, monitoring environmental factors, disease forecasting and establishing economic thresholds are also important. The disease incidence can be minimised or eliminated by adopting the following tactics.

Cultural methods

- **Tillage**— soil-borne fungi, bacteria and nematodes that serve as sources of infection, perpetuate in the soil. When the soil is ploughed they get exposed to the sun's high temperature. This reduces their population or activity within the soil.
- **Field sanitation**— plant pathogen (fungi, bacteria, and virus) that survives on previous crop residues and weeds in the field can serve as a major source of inoculum. Clean cultivation means the removal of crop residues and keeping the bunds clean to minimise pest population in the field. Plant disease can be controlled by regularly destroying diseased plants or weeds. This disrupts the disease cycle and is an effective source of control.
- **Crop rotation**— availability of susceptible hosts every season or year after year increases the survival or persistence of diseases. Crop rotation with crops of other groups or different families breaks their persistence. Starving pests by making susceptible hosts unavailable for a long time makes it difficult for the pests to survive.
- **Resistant varieties**— such varieties of flower crops provide one of the most successful approaches to the control of plant pathogens in many crops,

especially those that cannot be controlled by other means. Some cultivars are resistant to a particular disease and are, therefore, inherently less damaged than other genetically related plants growing in the same area.

- **Alteration in sowing time**— manipulation of sowing time and selection of early or late varieties also dodges the pathogens. Certain diseases, such as early blight and late blight are time-bound and require a particular stage of growth of the plant to infect. Unavailability of susceptible stage keeps the infection at bay.
- **Seed treatment**— most of the seed and soil borne diseases, such as damping off, wilt, rots, dieback, anthracnose, etc. attack the crop through seed or soil. Seed treatment reduces the chances of infection.
- **Crop density**— high density of crop means incidence of many diseases. Infections can move easily from diseased to healthy plants in a dense field. It is, therefore, desirable to plant the crop with proper spacing.

Mechanical methods

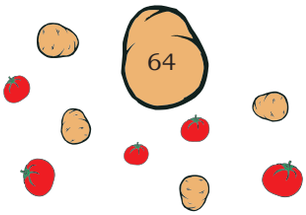
It includes uprooting or pruning of diseased plants or parts so that the infected plants or parts do not transmit pathogens to healthy ones. Training and staking the crop helps the plants so that their leaves do not come in contact with the soil and thereby controlling infection or infestation. Erecting nets, sticky bands and mechanical traps control insect-vectors that may transmit viruses.

Bio-control of plant diseases

Soil-borne diseases of tomato, brinjal, chilli and capsicum caused by *Pythium, Phytophthora, Rhizoctonia, Fusarium, Alternaria* and *Colletotrichum* species can be parasitised by *Trichoderma harzianum, Trichoderma viride and Gliocladium virens*. These bio-agents are effectively used either as soil application or seed treatments. The *Aspergillus niger* has been proved useful against *Fusarium* spp.

Chemical control

- **Use of fungicides**— chemical or a combination of chemicals lethal to the fungi that saves the host from infection is called fungicide. Fungicides, according to their movement in the plant system, are of two types. The first one is systemic,which when applied on plants dissolves on the cell sap and is effective for the whole plant irrespective of where it is applied. For example, benlate, carbendazim, metalaxyl, thiobendazol, propiconazole, etc. The second one is contact fungicide whose action is restricted to the area of the plant where it is applied. The examples are sulphur, mancozeb, zineb, etc
- **Fungicide application**— soil drenching should be undertaken when plants have a case of soil-borne infection of fungi (wilt, damping off, root rot) or nematodes (root-knot). Such fungicides are carbendazim, maneb, etc., and the Formaldehyde used for sterilization of seed bed.
- **Seed treatment**— this is a simple way to avoid infection in the soil and the seed. Generally, seeds are treated @ 2.0–2.5 g fungicide/kg of seed. A seed dressing drum or earthen pitcher can be used for treating the seeds. Fungicides used are carbendazim, carboxin, oxathin, etc.
- **Foliar application**— the aerial parts affected by foliar disease can be controlled by the foliar sprays of the fungicidal formulations. Specialised sprayers are available for the treatment. Generally, fungicides are sprayed along with compatible insecticides. This reduces the cost of application. These fungicides are sulphur, copper oxichloride, maneb, zineb, nabam, etc.
- **Dip method**— in this method, before planting, seedlings and cuttings are dipped in the fungicidal solution for a certain period to avoid infection. The solutions could be carbendazim, maneb, sulphur, zineb, etc.



Practical Exercise

Activity 1

Managing aphids and whiteflies by using yellow sticky cards.

Material required

Yellow and blue sheet of plastic, thermocol sheets, a wooden stick, cello tap, and adhesive (gum)

Procedure

1. Arrange the above items to prepare a sticky yellow or blue card or trap.
2. Cut the plastic sheet and thermocol 9×6 inch in size.
3. Fix the yellow or blue plastic sheet on both sides of the thermocol with the help of cello tap.
4. Attach the wooden stick on one side of the thermocol for support and make a board.
5. Paste gum on both the sides of the plastic sheet.
6. Place the board in the field of any crop just 6 inch above the crop height.
7. Next day, visit the field and observe the sticky trap cards.
8. You will find many insects on the board.
9. Identify the insects and count them.
10. Follow control measures according to the population of a particular insect.

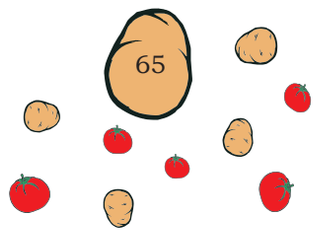
Check Your Progress

A. Fill in the blanks

1. Intercropping of cabbage with tomato reduces infestation of _____.
2. Ratooning encourages shoots and fruit borer in _____crop.
3. A crop grown as a companion that attracts pests away from the main crop is called _____.
4. Excess use of _____intensifies the incidence of sucking pests.
5. A pheromone trap attracts only_____ insects.
6. Methyl eugenol traps are useful against _____.
7. A lady bird beetle is a kind of _____.

B. Multiple choice questions

1. Organism that feeds on other insects is called _____
   (a) antagonist
   (b) predators
   (c) parasitoids
   (d) None of the above



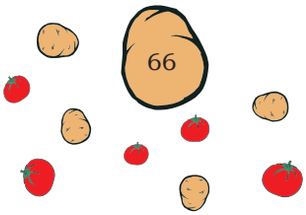
2. Botanical pesticides are obtained from _____
   (a) animals
   (b) fungus
   (c) plants
   (d) bacteria
3. Which of the following is not a sucking pest?
   (a) Fruit and shoot borer
   (b) Aphid
   (c) Mites
   (d) White fly
4. Damping off disease by using Carbendazim is a_____
   (a) chemical control
   (b) biologicalcontrol
   (c) mechanical control
   (d) cultural control
5. Trichoderma sp. can be used to control _____ disease.
   (a) soil borne
   (b) water borne
   (c) air borne
   (d) viral

C. Subjective questions

1. Write a brief note about integrated disease management.
2. Describe the cultural methods of pest management.
3. Discuss the mechanical and behavioural methods of pest management.

D. Match the columns

A	B
1. Systemic fungicide	(a) Tobacco plant
2. HA-NPV	(b) Plant extract
3. Neem	(c) Benlate
4. Botanical insecticides	(d) Tomato fruit borer
5. Nicotine	(e) Azadirachtin compound



Unit 4

Harvest and Post-harvest Management in Solanaceous Crops

Introduction

Solanaceous vegetables are delicate and perishable. In order to prevent deterioration and maintain quality, utmost care is essential right from the time of harvesting till it reaches the consumer. The post-harvest life of vegetables depends upon the judgements of maturity, the right stage of harvesting and careful handling of the produce. Harvesting of immature or over mature vegetables leads to deterioration of quality and early decay. If harvested at improper stages, the vegetables may not grow into attractive sizes, colours, and flavours and could be rejected by the consumers. Hence,the correct maturity indices have to be observed along with the right stage of harvesting with a proper method. Post-harvest handling is equally important to maintain the quality of produce and to enhance the storage life. Post-harvest technology works on the principle 'to save means to produce'. Proper management of harvested produce reduces losses after harvest, and makes the harvested produce more nutritive and acceptable. Besides eliminating spoilage and other food problems, it also boosts the country's economy by creating rural industries. Different factors like pre-cooling,

washing, treatments, packaging, storage and careful transportation are important in the maintenance of harvested produce. These post-harvest factors influence the shelf life and price of the vegetables in the markets. It is essential for a cultivator, seeking maximum returns from their produce, to have knowledge of harvesting, and post-harvest handling of solanaceous vegetables.

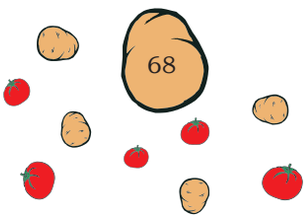
Session 1: Maturity Standards and Harvest of Solanaceous Crops

Maturity of Solanaceous Vegetables

Maturity is the attainment of the final stage of biological development of a plant, fruits or other plant parts. It is also called physiological maturity. Maturity stage differs from crop to crop and also depends on the purpose for which the produce is harvested. The stage of maturity at which the produce is in the most desirable form and is harvested as per the consumers' preference, is called horticultural maturity. In most of the vegetable crops, horticultural maturity comes prior to physiological maturity. Brinjals and chilies are harvested at horticultural maturity when the crop is still tender and under development stage. Solanaceous vegetables are non-climacteric and ripen on the plant itself. In most cases, physiological maturity overlaps the ripening process therefore the produce is harvested after ripening. Tomatoes, potatoes and dry chilies are harvested at physiological mature stage when the crop is fully mature. Solanaceous vegetables are mostly harvested depending on the distance to the markets and the choice of the consumers.

Role of respiration in shelf life

Vegetables are classified in two groups–climacteric and non-climacteric, based on their respiration rate. In climacteric vegetables, ripening is associated with a rapid increase in respiration. This sudden rise in respiration is called 'climacteric rise'. On ripening, the climacteric vegetables produce more ethylene than non-climacteric vegetables. The ripening process in climacteric vegetables will continue while attached



to the plant or even after harvest. Non-climacteric vegetables ripen on the plant itself and must be harvested at the appropriate maturity stage. Tomato and musk melon are climacteric vegetables, whereas, cucumber, brinjal, pepper, summer squash, etc., are non-climacteric vegetables.

Maturity Indices

Maturity indices indicate the stage of maturity of vegetables to be harvested for fresh consumption, storage or marketing to distant places. In vegetables, it is very difficult to standardise the appropriate stage of maturity. Growing experience (harvesting and marketing) of a particular vegetable with important parameters is the most excellent method to measure optimum maturity.

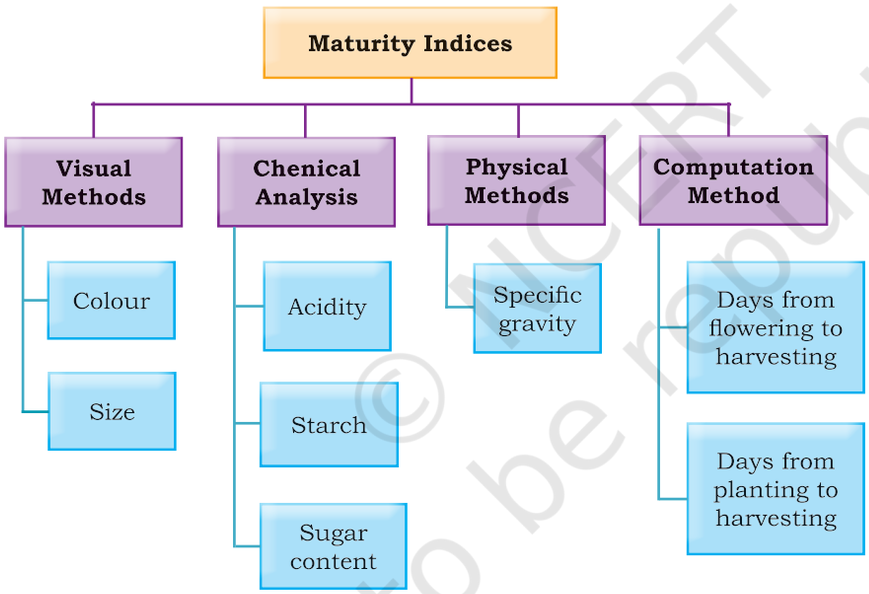


Fig. 4.1: Maturity indices of solanaceous vegetable crops

Importance of maturity indices

1. To ensure the sensory (flavour, colour, aroma, texture) and nutritional quality.
2. To ensure a sufficient post-harvest shelf life
3. To facilitate scheduling of harvest and packing operations.
4. To ensure market price.

Determination of Maturity in Solanaceous Vegetables

Visual method

The colour of the produce changes with maturity. Colour is an important index that indicates the stage of maturity. Most tender vegetables are green in colour, which turn paler as they mature. Tender fruits are glossy. Tomato and chili are harvested after ripening on the plant so they are red in colour.

As for size, some vegetables reach a certain size. This can be used as an index to determine the time of harvest.

Fig. 4.2: A view of maturity stages in tomato

Chemical analysis

Starch, acidity and sugar content are measured in chemical analysis. More sugar content in the samples indicates maturity. Acidity decreases with maturity. Thus, low acid content indicates maturity of the produce.

Physical method

A pressure tester is used to measure the softness of a fruit.

A fruit's specific gravity increases, as it matures. During harvesting, specific gravity to determine the right time of harvesting is rarely used. It can be calculated by dividing the weight of the produce in air by the weight in water.

Computation method

This method involves calculating the days from flowering to harvesting and from planting to harvesting.

Harvesting of Solanaceous Vegetables

Tomato

(a) Maturity indices: the harvesting stage in tomato depends upon the purpose for which the tomatoes are being used. Generally, there are four types of maturity stages found in tomatoes for harvesting.

(i) Green stage fruits are green in colour but are fully mature. They are harvested to be sent to distant markets.

(ii) Pink stage tomatoes are picked for the local market. At this stage, the colour turns to pink or red at the end of the blossom.

(iii) Ripe stage fruits are red colour on the surface and soft.

(iv) Fully ripe tomato fruits are soft in texture and have reached their maximum colour development. Starch is converted into sugar. These fruits are either consumed or used for canning and/or processing purpose.

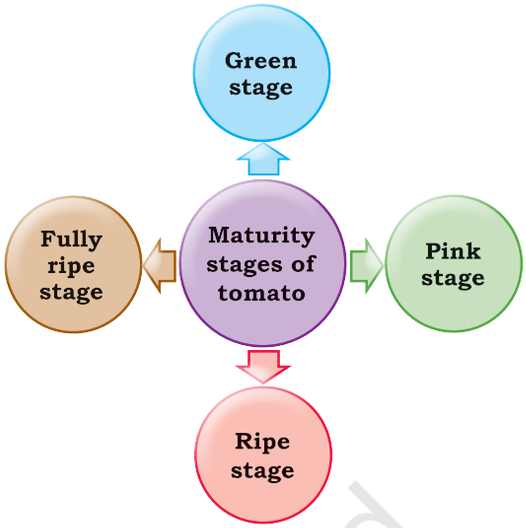


Fig. 4.3: Maturity stages of tomato

Depending on its use and the distance to the market, the tomato fruits are harvested manually by plucking the fruits at different maturity stages.

In indeterminate cultivars, tomatoes can normally be harvested at 80-100 days after planting and 70 days after planting in determinate cultivars. Harvesting of the fruit should be done at the right stage depending on the consumption purpose of the fruit.

(a) Dark green colour— when the dark green colour fades, a reddish pink shade can be seen on the fruit. Harvesting at this stage is suitable for fruits to be shipped to long distance market. These fruits are then sprayed with etheral or ethephon 48 hours before shipping or transportation. Slicing a tomato with a sharp knife is the easiest way to determine the maturity of the fruit. If the seeds cut easily, the fruit is too immature for harvest and will not ripen properly.

(b) Pink or the Breaker stage— the fruits are harvested at breakage stage to ensure the best quality. In this

stage, a light pink colour can be seen on 1/4th of the fruit. These fruits injure less during shipping and often bring in a higher economic return than less mature tomatoes.

(c) Ripe or the Turning stage — at this stage, 3/4th of the fruit is pink in colour. At the reddish pink stage the fruits are still firm. Harvesting is done at this stage to sell the fruits in the local markets.

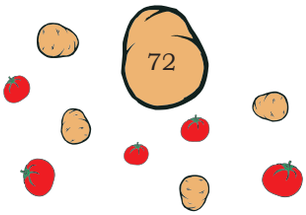
(d) Fully ripe or the Red ripe — the red ripe stage means the tomato fruits are fully ripe and soft. These fruits are used for canning and processing. Such fruits must be harvested either in the early morning or late evening. A twisting motion of the hand separates the fruit from the plant. The harvested fruit should be placed in suitable containers in the shade. All the fruits do not mature at the same time as they are harvested at 4–5 days interval. During the crop's life span, tomatoes can be harvested 7–11 times.

Chili and capsicum

Chili is harvested manually by hand picking, either as a green fruit or red ripe fruit. The green fruit picking continues for about two months at an interval of 10–12 days. There are five to six pickings for green chilies and three to four for red ripe fruits. The red ripe chili fruits should be dried for 5–7 days in bright sunlight before being sent to the market or stored. When there is a good demand for green chilies, one or two pickings of the green fruit can be done even if the crop grown is for red chilies. For vegetable purposes, the chili crop should be harvested at fully grown green stage and for drying purposes it must be harvested at the red ripe stage. For pickle making, the chilies can be picked at either the green or red ripe stage. The number of harvesting depends on cultivar, season and cultural practices. It can continue for three months with proper cultural practices.

Brinjal

Brinjal fruits are harvested when they have developed a marketable size, have a good colour, are immature and



have an attractive bright glossy appearance with soft seeds. The fruits are harvested with a stack at the joint where they are attached to the branch. The frequency of harvest depends upon the size of the fruit. Small size fruits are harvested more frequently than the bigger fruits. Fruits should be harvested in the morning to avoid sun scalding.

Potato

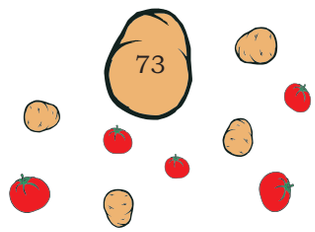
Big size tubers are harvested at full physiological maturity stage. The crop falls off when it is fully matured. This is the sign of maturity of the tuber inside the soil.

Table 4.1: Maturity indices of solanaceous vegetables

S.No.	Crop	Crop Maturity Indices
1.	Tomato	**Mature green**: fruit firm and mature, colour changes from green to light green **Pink**: pink colour on the blossom end. At room temperature, fruits will ripen in about three days. **Ripe**: when the fruit is completely red but still firm, it should be used immediately
2.	Potato	Collapse of the crop, size of the tuber, development of periderm, starch content and specific gravity
3.	Brinjal	Glossy skin, desirable size, tender and soft seed
4.	Chili	Fully mature, green, before they change from green to red
5.	Bell pepper	Well developed, firm, shining and bright coloured (red, yellow, orange, green, etc.)

Harvesting

The assembling of plants or its parts at a certain stage for economic purposes is called harvesting. After attaining proper maturity, the produce is harvested for marketing. It involves detachment or separation of the produce from the main plant at the right stage of maturity, depending on the purpose for which it is grown. Vegetables are delicate, hence, avoid mechanical injuries. Bruises, splits, cuts, breakage and wounds during harvest could become the path for pathogens to enter and accumulation of dust, which affects the appearance and leads to early decay. The persons involved in harvesting must be efficiently trained and skillful in handling the fresh produce.



Harvesting management

Harvesting should be done

- during the cool hours of the day as low temperature reduces physiological activities in plants.
- at the proper stage of maturity, otherwise it affects acceptability and shelf life.
- by using proper methods to reduce losses and damage to the produce as well as the plant.
- by an experienced, skilled person who can harvest selectively (only the mature produce).
- by maintaining proper hygiene standards (clean tools, baskets or containers).

Harvesting arrangement

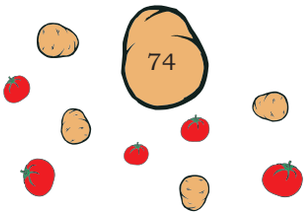
- Inspect the field to identify the correct stage of the crop.
- Remove obstructions in the field, if any, to facilitate harvesting and avoid damages to the produce.
- Erect a temporary shade to stack the harvested produce and to prevent it from scorching in the sun.
- Wash and clean the harvesting tools, collecting baskets, etc.
- Use proper harvesting methods like fruit plucking (brinjal, tomato,chili) or digging (potato).
- Harvesting containers should be used to collect and transfer the produce into the shade directly.

Methods of harvesting

Harvesting can be done either manually or mechanically. Careful harvesting and transporting practices are essential to ensure that wound and bruise free good quality produce reaches the market.

Manual harvesting

It is one of the most accepted and suitable methods of vegetable harvesting. Selective harvesting by well-trained and experienced people ensures that harvesting is done at the right stage of maturity. Tomatoes, brinjals and chilies must be picked with a gentle twisting motion of the hand to separate the



fruit from the plant. Manual harvesting includes hand picking, clipping, cutting with knives and digging.

Mechanical harvesting

It results in a significant reduction in management and labour costs and can result in savings as high as 30–45%. The mechanical method involves the use of machinery and specialised equipment made especially for harvesting purpose. It is common in large scale harvesting. It is a fast method and requires less labour. Nowadays, in many countries automatic robotic systems are used for harvesting high value crops like tomatoes and capsicum in poly houses. This method is not economical in small scale production.

Harvesting of solanaceous crops

Solanaceous vegetables can be efficiently harvested by plucking with hand (except potato) and no specialised tool is required. With maturity, a natural abscission layer is formed, which enables easy plucking. The presence of abscission zones between the stem and the stalk of the fruit, such as tomato, brinjal and chili has been observed to become prominent at maturity. That is why the matured tomato fruits can be easily detached from the plant with just a slight pressure.

A crop like potato is dug out with the help of a potato digger or wooden plough. In large scale production, the mechanised method can be followed. Tubers that are dug out are collected and brought to the shade house.

Harvesting containers

The harvesting containers should be easy to handle for workers to harvest the vegetables. Containers made of material, such as paper, polyethylene film are relatively cheap but they give little protection to the produce against handling and transport damage. The fruits with firm skins, like brinjal and chili are harvested and collected in harvesting bags, which are later emptied from the bottom into a field container instead of tipping the bag. Plastic crates are most suitable for harvesting tomatoes. For harvesting fresh fruits and vegetables,

bulk bins of 200–500 kg capacity are used. Such bins are more useful than the field boxes, in terms of fruit carried per unit volume and the protection of the product in transit to the packing house. Pallet boxes have a standard size of 1.2 × 1 metre with varying height. These are generally used to carry harvested produce from the field to the packing house or for handling produce in the packing house.

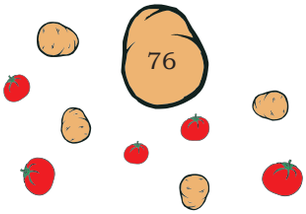
Sacks or gunny bags are still commonly used for crops, such as potatoes, onions, pumpkins, etc. Other types of field harvest containers, such as plastic baskets, buckets, picking baskets and plastic crates are used for tomatoes, brinjal and chilies. For high-risk produce, like sweet pepper, woven baskets and sacks are not recommended because of the risk of contamination. Vegetables should be harvested in plastic crates and further handled in cardboard boxes or cartons in transit to maintain better quality. These containers should be smooth so that they do not damage the produce or harm any person.

Fig.4.4: Harvesting container (Plastic crates)

Precaution during harvesting of solanaceous vegetables

In all solanaceous vegetables, care should be taken to prevent any injury because of faulty operations during harvesting and handling. The hands of the harvesters are the most important points of contact as they touch the product. The injuries occurred during harvesting can be reduced if

- the field containers do not possess any protruding nails or staples or have rough edges.
- the worker wears cotton gloves, trims the fingernails, does not wear jewellery, such as rings and bracelets during harvest.



- care is taken while transferring products from one container to another.
- all impact areas are padded, wherever possible.
- clean equipment and containers are used and sand and all debris are removed from the containers.
- overfilling of containers is avoided.

Practical Exercise

Identify the different maturity stages of tomato fruits.

Material required

Different samples of tomato fruit, plastic baskets, blade or knife and writing material.

Procedure

1. Tomato fruits in different maturity stages procured from a farmer's field or the local market.
2. Compare the fruit samples with the colour chart and fruit maturity stages given in images.
3. Visualise the fruit maturity stage.
4. Note down the following observations.

Sample number (S)/ sample code	Maturity stages/indices of fruit (Mention with colour grading from chart)	Expected days of maturity

Check Your Progress

A. Fill in the blanks

1. The attainment of the final stage of biological development of a plant or plant part is known as_____.
2. The examples of climacteric vegetables are _____.
3. Vegetables that ripen on the plant itself and must be harvested at the appropriate maturity stage are known as _____ vegetables.
4. Vegetables should be harvested either in the _____ or _____ hours.

B. Multiple choice questions

1. The stage of maturity at which the produce is in the most desirable form and is harvested as per the consumer's preference is called _____.
   (a) physiological maturity
   (b) horticultural maturity
   (c) ripening
   (d) none of the above

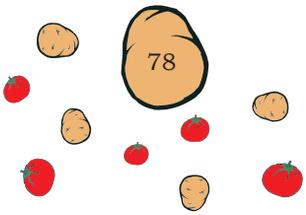
2. Horticultural maturity in most of the vegetable crops occurs _____.
   (a) prior to the physiological maturity
   (b) after the physiological maturity
   (c) with physiological maturity
   (d) both a and b
3. Tomato fruits for distant markets may be harvested at _____.
   (a) green stage
   (b) red stage
   (c) ripe stage
   (d) over ripe stage
4. Ripening is associated with a rapid increase in _____.
   (a) transpiration
   (b) respiration
   (c) evaporation
   (d) pollination
5. The specific gravity of a fruit or vegetable is _____.
   (a) its weight in air divided by the weight in water.
   (b) its weight in water divided by the weight in air.
   (c) its weight in air multiplied by the weight in water.
   (d) its weight in air plus weight in water.

C. Subjective questions

1. Write short notes on
   (a) Maturity indices
   (b) Physiological maturity
   (c) Horticultural maturity
   (d) Climacteric and non-climacteric vegetables
2. Explain the different methods of determination of maturity in solanaceous vegetables.
3. Describe the harvesting process of solanaceous vegetable crops.

D. Match the columns

A	B
1. Maturity indices	(a) Assembling of plants or parts at a certain stage
2. Colour of the produce	(b) Indicate the stage of maturity
3. Abscission layer	(c) Important visual maturity index
4. Acid content	(d) Eases plucking of fruits
5. Harvesting	(e) Falls with maturity



Session 2: Post-harvest Handling of Solanaceous Crops

Post-harvest Handling

Post-harvest handling involves careful movement of harvested commodities from the time of harvest to just before meal preparation. Its objective is to reduce losses at the least possible cost. It includes precautions, care and treatment of harvested produce to reduce damage loss and to enhance its appearance, quality and storability. This includes pre-cooling, cleaning, treating, sorting, grading, packing, transport, etc.

Causes of post-harvest losses

- Improper method of harvesting and carelessness
- Mechanical injuries to the produce
- Presence of infected and decayed produce in the lot
- Improper curing (roots, tubers and bulbs)
- Improper packing
- Improper storage conditions
- Sprouting inpotatoes
- Bruising in transit

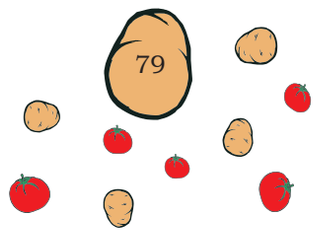
Objectives of post-harvest technology

- To keep the produce in more acceptable conditions.
- To maintain the appearance and flavour of the harvested produce.
- To protect food safety and nutritive value.
- To reduce losses after harvesting up to consumption.
- To make them available in off season.

Post-harvest process

- Collection of harvested produce
- Pre-cooling
- Sorting
- Cleaning and disinfection
- Drying
- Grading

Notes



- Other treatments
- Packing
- Storage
- Transport

Since vegetables are perishable, careful and proper handling of the produce during all the above processes is important.

Collection of harvested produce

Horticultural produce is delicate as the water content is more in them. A slight bruising or pressure to it post-harvest may show up as blemishes, patches or injuries. Care should be taken during the collection of the harvested produce.

Pre-sorting

It is the process in which injured, warted, diseased, bird pecked, decayed, misshapen produce is separated. This minimises further handling expenses as the lot becomes free of undesirable produce.

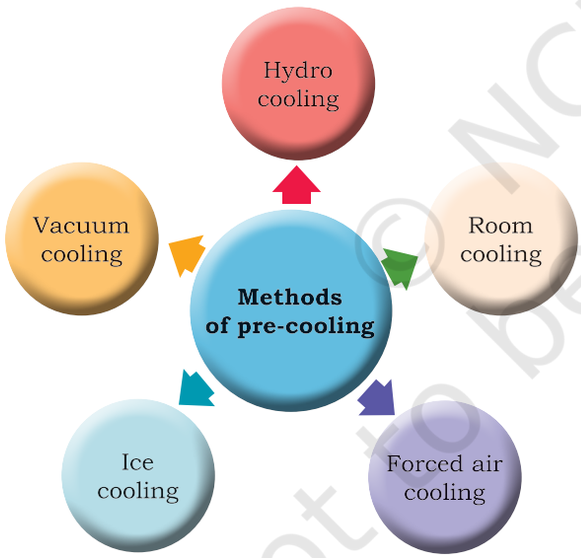


Fig. 4.5:Methods of pre-cooling

Pre-cooling

It is a treatment given to the harvested produce to remove the field heat. It reduces respiration rate, enzymatic activity, ethylene production rate, water loss and microbial spoilage.

Methods of pre-cooling

Hydro cooling is when the harvested produce is either showered or submerged in running cold water. It is mostly practised on leafy vegetables. During hydro cooling, water temperature should be maintained at 12–15°C.

Room cooling is when in an insulated and refrigerated room, cool air is circulated by a convection.

Forced air cooling is when the produce is kept in a refrigerated room and cold air is circulated with the help of powerful fans.

Ice cooling is when harvested produce is pre-cooled with crushed ice. Waterproof packages are used to wrap the produce.

Vacuum cooling is when heat from the harvested produce is removed at low atmospheric pressure in a chamber.

Trimming, washing and cleaning

The harvest must be washed to remove the soil and dust from the produce. Decayed or damaged portions should be trimmed off. A solution of chlorine @ 100-150ppm can be used for washing the harvested produce. Washing removes inoculums from the surface of the produce, gives a fresh appearance and cleans any foreign smell or taste from the surface.

Drying

This step is important after washing or pre-cooling the produce to bring the moisture to a desirable level in the produce. Drying should be done in partial shade.

Waxing is done on the surface of the harvested produce to

- prevent water loss during handling and marketing,
- protect against bruising and scars,
- seal openings against any unwanted entry, and
- extend shelf life and maintain quality.

Sorting

It is the process of separating the damaged, diseased and insect pest affected vegetables that are not suitable for either the market or storage. It is done by hand after the vegetable produce is harvested.

Grading

It is the categorisation of the produce according to size, shape and colour into different uniform lots. It can be done manually or by grading lines. Grading according to size of round produce can be done by sizing rings. Better grade produce fetches a better price in the market.

Tomato fruits are graded into four groups based on its size that is, Super A, Super, Fancy and Commercial. Similarly, large, medium and small tubers are graded as per their size. Low grade produce can be utilised for making value added products like pickle, ketchup, sauce, etc.

Packaging

It is the process of preparing commodities for transportation, distribution, storage, retailing and presenting to the consumer in the most attractive form. Packaging ensures delivery of the produce to the end user in good condition at the minimum cost.

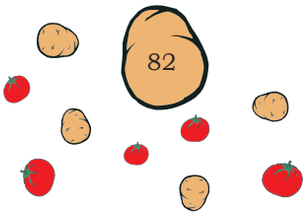
Packaging must be appropriate to protect the produce during handling and transport. The selection of right packing material is important. It should be selected according to the produce, means of transport, distance to the market or period of storage. Bamboo baskets and jute sacks are commonly used for transporting to local markets.

Packages can be classified as follows:

- *Flexible sacks and bags* that are made of plastic, jute, canvas, wire and net are used for potatoes, chilies and brinjals.
- *Wooden crates* are generally used for tomatoes and pepper.
- *CFB boxes* (cardboard) are used for tomatoes.
- *Plastic crates* are used for tomatoes, chilies, brinjals, potatoes, etc.
- *Different types of baskets* made of bamboo, plastic and even leaves woven together can be used.
- *Pallet boxes and shipping containers* are used for exporting the produce.

Transportation

Transporting the produce to the market is the next step to packaging. At present, vegetables are transported in bulk in rickshaws, carts, jeeps, rail and trucks. This results in severe loss and damage during transportation. However, now producers are paying attention to this and even refrigerated vans are



being used for transporting fresh vegetable produce. Transportation during cool hours, use of refrigerated vans or cool-chain vehicles for long distance, a well-ventilated vehicle for nearby markets, proper stacking of baskets or racks are certain factors that can minimise transit damage. The government is providing support to establish a cool chain facility for the horticultural produce.

Causes of Impairing Quality of Produce in Transit

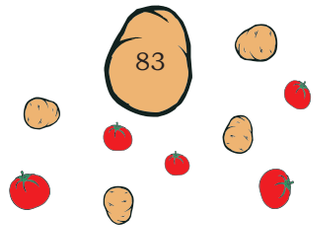
- Bruising, vibration caused by loose packing of vegetables.
- Careless loading and unloading of produce.
- High transit temperatures (if not cooled immediately).
- Poor or no packaging.

Storage

This is a step that comes after harvesting. It is necessary to store the produce till it reaches the market. Hence, it is an important activity that helps to prevent the produce from spoiling and enhances its shelf life. Temperature and relative humidity of the storage house are the main factors that affect respiration and transpiration of the stored produce. If temperature and relative humidity are not maintained, it can cause spoilage of the produce. Innovative technologies that can make it possible to achieve optimal environment in the insulated storage areas are now available.

Objectives of storage

1. To meet the demand of fresh vegetables throughout the year.
2. To avoid glut season and maintain the price during the peak season.
3. To provide planting material when needed.
4. To slow the biological activity of the produce by maintaining a low temperature.
5. To protect moisture content of the produce.
6. To protect the produce from micro-organisms.



Storage methods

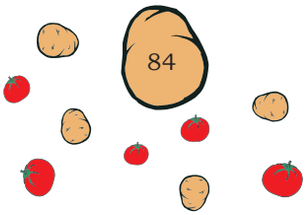
There are two kinds of storage methods.

In uncontrolled condition

- **Sand or coir** method is used to store potatoes for a long time. In this method, the produce is covered with sand and coconut fibre (coir).
- **Pits** are used to store potatoes. In this method, pits or trenches are dug at the boundaries of the field where the crop has been cultivated. Generally, pits are sited at the uppermost point of the field, particularly in areas of high rainfall. Straw or other organic material is used to line the pits or trenches, packed with the crop produce being stored, and then topped with a layer of organic material followed by a layer of soil. Straws are used to make holes on top for ventilation. Lack of ventilation could cause the crop to rot.
- **Evaporative cooling** should be ensured. The degree of cooling depends on the RH of the air and the efficiency of the evaporating surface. If the surrounding air contains low RH and is humidified to around 100% RH, then a big reduction in temperature will be achieved.
- **For night ventilation**, a fan is installed in the store room, which switches on when the external temperature at night becomes lower than the internal temperature. It switches off when the temperatures equalise. The fan is monitored by a thermostat, which continuously equalises the outside air temperature with the internal storage temperature.

In controlled condition

Modified atmosphere storage is commonly used for fruits and tomatoes. These types of storages are airtight chambers with wall, roof and floor. In this method, the proportion of atmospheric gases inside the storage is altered by reducing oxygen and increasing CO_2 level. Depending upon the variety and kind of produce, the proportion of O_2, CO_2 and nitrogen is maintained.



- **In forced air ventilation**, air flowing capillaries are provided under the perforated floor of the store so that the air can be forced through the stored produce.
- **Refrigeration** can be defined as a technique of extracting heat from a substance under controlled conditions. It includes decreasing and maintaining the temperature below the ambient temperature. Such storage is provided with exhaust facilities to release the heat generated by the produce. It is essential to control the temperature and relative humidity conditions within the refrigerated storage surroundings, according to the crop or variety.
- **Cold chain or cool chain** is a temperature-controlled facility of transportation from the field to the market or storage. In this, all practices of production, storage and supply are performed under refrigerated situations. Cold chain ensures preservation and extended shelf life of the produce.

Table 4.2: Recommended storage temperature and relative humidity for solanaceous vegetables

Sr.No.	Crop	Temperature (°C)	Relative humidity (in %)	Storage life
1.	Tomato (Ripe)	7.0–10	85–90	4–7 days
2.	Tomato (Green)	12–20	85–90	1–3 weeks
3.	Brinjal	7–10	90	1 week
4.	Pepper	7.0–10	90–95	2–3 weeks
5.	Potato	5–10	93	2–5 months

Source: FAO 1989. Prevention of post-harvest food losses of fruits, vegetables and root crops training manual. Training;17(2). Rome, Italy.

Fig.4.6: Packing in the field to transport to storage

Fig.4.7: Corrugated cardboard boxes

Post-harvest Handling of Tomato

Tomato fruits should be cooled soon after harvest and stored in the appropriate temperature (7-20°C). The produce may be stored temporarily if there is a wait to transport it to the market. To maintain quality before sale and consumption, it must be stored in a cool storeroom. The life of vegetables is greatly extended by maintaining low temperatures in the storage area. Under evaporative cool storage, tomatoes are stored at low temperature. In India, generally tomatoes are not commercially stored in cold storage. The storage life of tomatoes can be enhanced by pre-cooling the produce immediately after harvest and prior to storage and transportation. Tomato fruits in the mature green stage can be stored successfully at 12°-13°C in polythene bags of 100 gauze thickness for 4–5 weeks. The storage life of tomatoes can be increased by keeping them in evaporative cool storage (zero energy cool chambers). It is found that the shelf life of tomatoes in the breaker stage, stored in zero energy cool chambers during the summer,can be extended by 4–5 days. The cool chamber can be used effectively for longer duration storage of fruits and to reduce weight loss significantly.

Short duration storage of fruits and vegetables can be effectively done by using a zero energy cool chamber. It reduces the storage temperature and also increases the RH of the storage that is responsible for maintaining the freshness of the produce.

Grading

Tomato is graded for specialised city markets based on the size of the fruits. This can be categorised in two groups. The first superior group comprises fully developed fruits,uniform in size and colour. The second group comprises fruits in variable size and colour. Grading is essential for higher returns but is not common in the local markets. The Bureau of Indian Standards suggested four grades for tomatoes, Super A, Super, Fancy and Commercial. The fruits are packed in plastic

crates, corrugated fibre boxes, wooden field boxes or cardboard boxes and transported to nearby markets.

Post-harvest handling of chili

Immediately after harvesting green chilies and capsicum, pre-cooling is essential. Chilies are stored and transported at 7.5°C–8°C temperature with 90–95 RH. If they are properly cooled and stored, their shelf-life can be extended by 14–21 days. In case of dry chilies, pods must be dried properly after cleaning them properly of plant parts and other foreign material. Later, they can be packed in clean or dirt free, dry gunny bags and stored in cold dry places to protect them from moisture. Care should be taken to stack the bags 50–60 cm away from the wall. The stored product should preferably be exposed to sun periodically.

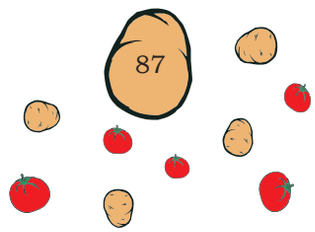
Dry chili can be stored better in a kraft packet 27°C and 65% relative humidity. For chili powder, a polythene bag is more effective than a glass container. The colour and pungency of chilies and colour, in the case of paprika, are maximally preserved during the storage. Preference is given to mechanically dried (dehydrated) capsicums with around 10% moisture. Overdried capsicum suffer from loss of colour and those with higher moisture level are susceptible to infection and bleaching of colours during storage.

Grading

In India, chilies are chiefly graded by farmers on the basis of colour and size, before they are sent to the market. Injured, discoloured and underdeveloped pods are removed depending on the market demand. The other factors important in grading chilies are:

(a) Seed and fruit (pod) ratio,
(b) Seed size and hardness,
(c) Thickness of the pod skin, and
(d) Pungency.

In the market, there are two types of grades: special and standard. The fruits are packed in plastic crates, corrugated fibre boxes, wooden field boxes and gunny bags and transported to nearby markets.



Post-harvest handling of brinjal

The freshly harvested fruits, free from injury, disease and insect blemishes are cleaned properly by washing them under a sprinkler, wrapped and arranged in suitable plastic trays or cartons.

Grading

The fruits are graded according to their size and colour. The Bureau of Indian Standards has suggested three grades for brinjal— super, fancy and commercial.

Practical Exercise

Demonstrate the harvesting and packaging of tomatoes

Material required

Tomato fruits, packaging material and writing material.

Procedure

1. Select a tomato crop that is at the physiological maturity stage.
2. Generally, depending on the variety, tomato fruits are ready for harvesting 60–90 days after transplanting.
3. Pick ripe fruits carefully and place them in buckets.
4. Collect the harvested fruits in the shade.
5. Clean and grade the harvested fruits.
6. Pack the harvested fruits in containers (plastic crate) for transport.

Check Your Progress

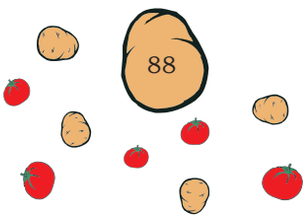
A. Fill in the blanks

1. The process that removes the field heat of harvested vegetables is known as _____.
2. Chlorine solution @ _____ ppm can be used to wash harvested produce.
3. A temperature-controlled transportation facility from the field to the market is called_____.
4. The process that makes delivery of the produce to the end user in good condition at a minimum cost is known as_____.

B. Multiple choice questions

1. The process of categorisation of the produce according to size, shape and colour into different uniform lots is called _____.

   (a) packing
   (b) sorting
   (c) grading
   (d) None of the above



2. Storage temperature for ripe tomatoes is_____°C.
   (a) 3–5
   (b) 7–10
   (c) 12–15
   (d) 15–20
3. Curing is an effective post-harvest operation in _____ fruit or crop.
   (a) brinjal
   (b) tomato
   (c) tuber
   (d) chili
4. The mixture of atmospheric gases inside the storage is altered in _____.
   (a) evaporative storage
   (b) pit storage
   (c) modified atmospheric storage
   (d) refrigerated storage
5. Brinjal grades suggested by the Bureau of Indian Standards is (are) _____.
   (a) super
   (b) fancy
   (c) commercial
   (d) All of the above

C. Subjective questions

1. List the different harvesting stages of tomato.
2. Write about grading of tomatoes and chilies.
3. Describe in detail the different causes of post-harvest losses in vegetables.
4. Write a note on modified atmospheric storage.
5. How are pit storages prepared?

D. Match the columns

A	B
1. Zero energy cooling	(a) Loose packing
2. Refrigeration	(b) Protection of moisture content
3. Trimming	(c) Cutting decayed part
4. Waxing	(d) Extracting heat under controlled condition
5. Bruising	(e) Effectively used for short duration storage

Unit 5

Basic Farm Management

Introduction

Of the two words in farm management, farm literally means a piece of land where crops and other enterprises are taken up under a common management and has specific boundaries, and management means coordinating and effectively utilising available resources such as material, machinery, manpower, money, methods and markets (the 6Ms principle). In other words, farm management is the art of managing a farm successfully, as considered on a scale of profitability. Farm management has its own importance in commercial as well as in subsistence type of agriculture all around the world. This unit will help you understand the basics of farm management and the tasks of a farm manager

Tasks of a Farm Manager

An efficient farm manager must be concerned with the costs and returns of the agricultural production system. The farm manager must be able to recognise the efficient use of limited generative resources in farm production to meet aims and maximise profit. The farm manager must also be able to respond to financial

setbacks that happen from both within and outside the farm.

Vegetable Farm

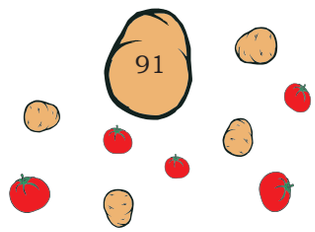
Growing commercial vegetables or production of quality vegetable crop seeds along with raising nurseries for commercial purposes are what constitute a vegetable farm. Commercial vegetable production is an important constituent of a farm. Producing fresh vegetables means marketing them immediately after harvest due to their perishable nature. However,this gives easy and fast farm income.

Specialised techniques, and all seed norms and regulations as per the Seed Act, 1960, need to be followed for quality seed production of vegetable crops. The production of certified seeds of notified varieties can improve the farm income as these can be sold to farmers, government agencies, etc. A hi-tech nursery to raise vegetables under protected structures can also bring good remuneration to the farm. Thus, all these aspects should be incorporated in any new farm establishment.

Session 1: Farm Management and Selection Criteria of Vegetable Crops

For a profitable farm, it is important to consider the following farm resources.

- **Land management** is of utmost importance in the production process. Agronomists and soil scientists check the land for intensity of land use, fertility of soil, levelling and bunding, drainage and irrigation, weed management, etc.
- **Labour management** refers to the total amount of industrious work per man per unit time. The higher the labour efficiency, the greater are the returns from farming. Farm labour can be classified into four categories:
  (i) Farm manager's labour,
  (ii) Farm family's labour,
  (iii) Permanently hired labour, and
  (iv) Casual hired labour.



The first three categories constitute the permanent labour force available on the farm. This is a fixed resource due to general lack of mobility. The fourth category is a variable input and can be hired when needed.

Financial management

Judicious management of finances of a farm business is important to increase the income of the farm. This part of the farm management pertains to the acquisition and use of capital.

Machinery management

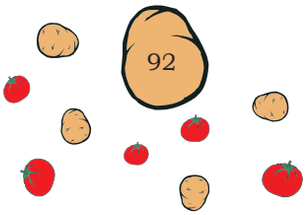
Mechanisation of select farm operations is key to the successful implementation of a farming system based on intensive use of yield increasing technology and multiple cropping. Mechanisation remarkably increases output and labour productivity in a farm.

Building management

With the advancement of production technology, the importance of buildings has increased because the number of implements, machines, processing, storage, etc., has increased. Like with the other resources, marginal investments made on farm buildings will bring the highest returns to the farm.

Different Farm Buildings or Structures

- **Farm office** belongs to the farm manager or farmer. It should be located at the centre of the farm for proper supervision. The office must be connected to the main road and located on high ground for proper drainage. The source of water supply and electricity should be provided accordingly.
- **Farm implements and vehicle shed** should be near the office building. Enough space should be provided for both the implements and the tractors and trolleys.
- **Storehouse** is used to keep fertilisers and related sources at an appropriate and safe place.
- **Pack house** is a space for packing any produce.



- **Threshing floor** is a safe and protected area where threshing operations can be done after harvesting.
- **Processing unit** is also an important structure for cleaning and grading of seeds. Many vegetable seeds may require to be graded in uniform size and shape.
- **Structure for storage of farm produce** is essential as, after grading and packing of the produce, the produce has to be stored till it is sold.
- **Nursery raising structures** should have polytunnels or polyhouses or nethouses or lath houses or cold frames, etc. These structures can be constructed as per the requirement and investment capability.

Crop Planning

Selection of vegetable crops

Vegetable crops are selected on the basis of soil and climate of the area. Accordingly, vegetables are divided into three groups:

- **Summer or spring summer season vegetable crops** are brinjal, muskmelon, watermelon, long melon, snap melon, round melon, bottle gourd, bitter gourd, snake gourd, ash gourd, ridge gourd, sponge gourd, pumpkin, summer squash, winter squash, cucumber, okra, tomato, chili, cowpea, cluster bean, amaranths, Indian spinach, pointed gourd, etc.
- **Rainy season vegetable crops** are okra, brinjal, chili, bottle gourd, bitter gourd, snake gourd, ash gourd, ridge gourd, sponge gourd, pointed gourd, ivy gourd, cow pea, cluster bean, etc.
- **Winter or autumn winter season vegetable crops** are cabbage, cauliflower, broccoli, radish, carrot, turnip, beet, spinach, onion, garlic, peas, fenugreek, lettuce, potato, etc.

Cropping System

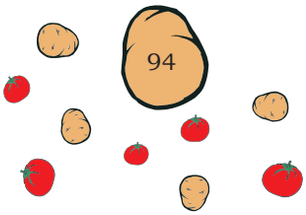
This refers to cropping pattern interactions on a farm with farm resources, other farm activities and production techniques. The yearly sequence, arrangement of a crop in streaks and uncultivated land in a given area is called cropping pattern.

Land resource in India is very limited. It is 0.12 ha per capita, which will further diminish by the turn of this century due to the population increase and fragmentation of land holding, resulting in lower production.

Moreover,a mere 3% of our total arable land is, at present, under vegetable cultivation. Realising the huge gap between demand and supply of vegetables, there is a suggestion to increase more area under vegetable cultivation, but it is difficult to get such horizontal expansion in vegetable cultivation in this situation. The total production per unit area can be increased by increasing the yield per unit area by using high yielding varieties, adequate and scientific crop management practices and increasing cropping intensities.

The following methods are recommended to increase cropping intensity.

- **Crop rotation** is a system of growing different crops in a regular sequence on the same land repeatedly for a period of two, three or more years. Here, the cropping sequence cycle takes more than one year to complete.
- **Succession cropping** is when, in a year, two or more crops are grown in succession on the same land. This system is generally followed in most market-oriented farms, where the aim is to keep the high-priced land occupied with cash crop for most part of the year.
- **Relay cropping** system is when the growing span of two crops overlap for a short period of time. In this system, the succeeding crop is sown on the same piece of land before the harvesting of the preceding crop in the same year.
- **In intercropping,** two or more crops are grown together or simultaneously in alternate rows or on the same land in the same season. The crops may or may not be sown or planted and harvested at the same time. It is mainly aimed at increasing the yield of the companion crop without reducing the yield of the main crop.

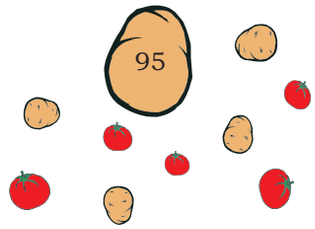


When these cropping sequences are practiced in a farm in an orderly manner for two, three or more years, the cropping system is called crop rotation.

Succession cropping

1. Vegetable cowpea (June to October); mid-season cauliflower (October to January); onion (January to May).
2. Pumpkin (October to February); okra (February to May); brinjal (May to October).
3. Potato (October to January); onion (January to May); okra (May to October).
4. Early radish (August to October); French bean (November to February); bitter gourd (February to June); amaranthus (June to August).
5. Cabbage (August to November); tomato (November to February); ridge gourd (February to June); cowpea or rice bean for green manure (June to July).
6. Early cauliflower (July to October); brinjal (October to March); amaranthus (March to June).
7. Early tomato (August to December); onion (December to May); green manure crop (June to July).
8. Brinjal (July to November); pea (November to February); cucumber (March to July).
9. Sweet pepper (November to February); taro (February to July); bitter gourd (July to November).
10. Chili (October to April); okra (April to August); spinach (August to October).
11. Late tomato (late December to April); okra (April to August); hyacinth bean (August to December).
12. Radish (October to December); watermelon (December to April); brinjal (April to October).
13. Elephant foot yam (March to October); pumpkin (October to February).
14. Bottle gourd (October to February); okra (February to July); Radish (July to October).

Note: To make such multiple cropping successful, cucurbit seeds should be raised in polyethylene packets. Before starting them during winter, the seedlings should be raised under a polyethylene house or shed to avoid cold injury. Such deviation from the normal growing



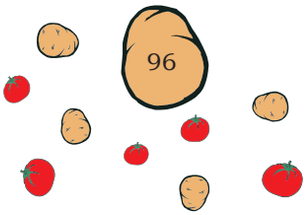
season is profitable from the point of view of marketing the produce. In the plains of West Bengal, good quality fruiting in tomato can be extended up to April if planted in late December (refer to point no.11).

Relay cropping

1. **Potato and pumpkin:** potato is harvested in March and pumpkin seeds are sown in the last week of January. After harvesting potato,pumpkin is continued up to June.
2. **Brinjal and ridge gourd or bitter gourd or watermelon:** brinjal is grown between September and February. Seedlings of cucurbit grown in polyethylene packets are to be planted in December and continued up to April.
3. **Bitter gourd and okra:** bitter gourd is grown during October to February. Pre-germinated seeds of okra are to be sown in January and continued up to May.
4. **Bottle gourd or summer squash and bush type vegetable cowpea:** cucurbits are grown during January to May following the ridge and furrow method. Cowpea seeds are sown in the beds between two furrows in April and continued up to July.
5. **Cabbage and watermelon/cucumber:** cabbage is grown from late October to the first week of February. Cucurbit is started with the seedlings in polyethylene packets from December. Then they are planted and continued up to April.

Intercropping

1. **Cabbage + radish:** cabbage is the main crop. The companion crop radish is of short duration and harvested early.
2. **Tomato + radish + lettuce:** tomato is the main crop and is to be grown at a higher spacing of 75–90 cm of the companion crops. Radish is harvested 50 days and lettuce 80–85 days after sowing. So, enough space is left after harvesting the companion crops to continue tomato successfully up to 150 days after planting. In this intercropping, tomato must be staked and trained.

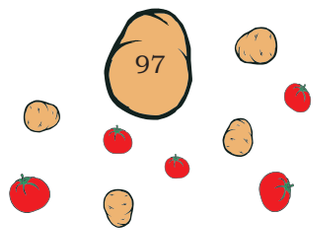


3. **Cucumber + cabbage or cauliflower:** cucumber is the main crop and is sown in October with a view to capitalise on the advantage of early harvest in spring. Cabbage or cauliflowers are grown in the interspaces successfully for the initial 80-day period.
4. **Carrot + peas:** carrot, the main crop grows slowly for the initial 45 days. Early pea varieties like Arkel from which the first picking of pods can be done 55–60 days after sowing, can successfully be grown in between for a period of 85 days, at the time of the last harvesting of peas. The plants should be uprooted and earthling up of carrot done simultaneously. Carrot is continued for 130–135 days after sowing.
5. **Tomato+spinach:** spinach can be grown successfully in between tomato for a duration of 75 to 80 days. Harvesting of spinach by uprooting the entire plant starts 35 days after sowing.
6. **Pointed gourd+spinach or radish or early cauliflower:** the vine or root cutting of the main crop, pointed gourd, is planted in October, on the side of a raised bed of 2.5 to 3 m width. The initial growth of the regenerated vine is slow due to the comparatively low temperature at this time. A short duration crop (75 to 80 days) can be grown profitably as a companion crop in the beds. Pointed gourd is continued up to August-September. In case of two successive crops, ratooning is done in October enabling the companion crop to grow again.

Principles for Arranging the Cropping Sequence

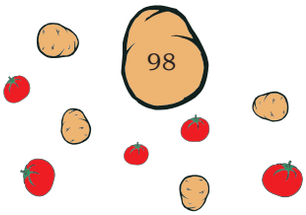
The economic effect of crop rotation, succession cropping and relay cropping depends on the set of crops. However, there should be a definite plan in arranging the cropping sequence based on the following principles.

1. Repetition of the crops that have common diseases and pests should be avoided. For example, solanaceous crops should be avoided in the rotation when there is a problem of fusarium wilt and bacterial wilt in tomato and brinjal. Many serious diseases and pests can be controlled by scientific



crop rotation. For example, club root of cabbage and other crucifers caused by the fungus *Plasmodiophora brassicae* can be effectively controlled by keeping the land free from cruciferous crop for a period of at least three years.

2. Generally, the relation of individual crops to their predecessors must be taken into consideration. Vegetable crops of different families grow well after the growth of a majority of the crops. A number of vegetable crops, like onion, spinach, tomato, etc., are good forerunners for the other crops if compatibility conditions are fulfilled.
3. Raise deep-rooted crops after the shallow-rooted crops. Deep-rooted vegetable crops, like pumpkin, tomato, peas, beans, carrots, etc., are able to use nutrients extracted from the deep layers of the soil. So these crops should be rotated with crops having shallow roots on the same piece of land. Shallow-rooted crops are onion, leafy greens, lettuce, cucumber, etc.
4. Heavy feeding crops, like cabbage, cauliflower, potato, brinjal, etc., that have high nutrient requirement should be followed by lowfeeding crops like okra, cucumber, lettuce, pumpkin, etc., that have a comparatively low nutrient requirement.
5. Crops that efficiently utilise the organic manure residues should be grown after the crop that does not utilise them fully. For that matter, immediately after the addition of organic matter to the soil, cucumber, pumpkin, summer squash, cabbage, leek, etc., should be grown. This should be followed by root crops that can utilise the organic residues fully.
6. Leguminous vegetable crops should be included in the cropping sequence. This not only upgrades the protein status of the farm produce but also enhances soil fertility.
7. Green manure crops should be accommodated in the rotation to increase the organic matter status in the soil.



8. Crop rotation without applying fertilisers maintains organic matter in the soil but does not maintain high productivity levels. A combination of crop rotation and judicious fertiliser application produces the highest yields and maintains the highest soil organic matter levels.

Important considerations for intercropping

1. Crop compatibility in the mixed stand.
2. Growth behaviour of the crops and efficient use of light by the crops in mixed stand.
3. Time of sowing or planting of the crops.
4. Space required by each crop at various stages of growth.
5. Assured supply of water and nutrients.
6. Assured management practices.

Advantages of intercropping

1. High return from per unit land area. The main objective of inter cropping is to increase the yield of the component crop without reducing the yield of the main crop.
2. The total yield from the same area under intercropping is much higher than the sole crop yield.
3. Better use of growth resources.
4. Better control of pests, diseases and weeds.
5. Effective guard against market risks as different crops are harvested from the same land.
6. Economy of space.

Financial Management

Economics of vegetable production

Financial management is concerned with productivity, that is, use of and income from production resources. Specifically stated, the production economics includes, combination of farm enterprises, method of production, size of the farms, returns to scale, leasing, production possibilities, farming efficiency, use of credit and capital, risk and uncertainty, which affects decision making.

Cost of production

The cost refers to the total amount of funds used in production. The nature of production and the prices thus determine the cost structure. Cost of production involves both cash cost items and non-cash items. Cash costs are when resources, such as fertilisers, fuel oil, casual labour, etc., are purchased and used immediately in the production process. Non-cash costs consist of depreciation of farm implements, equipment, buildings, etc., and payments made to the farmer themselves or family labour, management and owned capital.

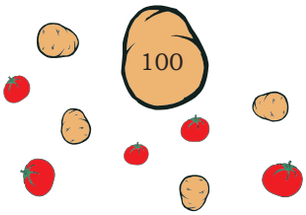
Categories of cost

Several kinds of costs are involved in even the simplest production process but the two major categories of costs are fixed costs and variable costs.

1. **Fixed costs** are those that do not change with the amount of output and are incurred even when there is no production. Fixed cash costs include land taxes, interests, insurance premiums, annually hired labour, permanent labour, electricity charges, etc. Non-cash fixed costs include depreciation on buildings, machinery, interest on capital investments, cost of family labour and cost of management.
2. **Variable costs** are the cost of using variable inputs. They vary with the level of production. The higher the production the more will be the variable costs. It includes items, such as seeds, fertilisers, casual labour, insecticides, fuel consumption, etc.
3. **Total costs** is the sum total of fixed costs plus variable costs. Total costs are required for computing net revenue. Net revenue is equal to total revenue less total costs. During the planning period, all inputs are variable.

Farm Record Keeping

It is the art and science of recording various farm details and business dealings in a regular and systematic manner so that their nature, extent and financial effects can be readily ascertained at any time of the year.



Advantages of farm records and accounts

1. **Means to higher income:** to obtain higher income farmers must have exact knowledge about the present, potential gross income and operating cost.
2. **Basis for diagnosis and planning:** diagnosis of management problems is the pre-requisite of sound planning. Data and accounts provide the necessary information needed for such a diagnosis. It is also a way to improve the risk bearing ability of a farmer.
3. **Basis for credit acquisition and management:** properly kept records and accounts can demonstrate and authenticate the production and income potential and credit worthiness of the farmer.
4. **Guide to better home management:** records and accounts provide information on the farm household economy. This is particularly important in Indian conditions where the farm and home management are so closely integrated. It is the basis of research conducted in agricultural and production economics.
5. **Basis for government policies:** various state and central government policies, such as land policies, price policies and crop insurance, etc., need a farmer's feedback for their more practical viability. That is when these records and accounts are helpful in obtaining the correct data for examining and developing sound policies.

Principles of Book Keeping or Accounting

There are two systems of farm accountancy— double entry system, and single entry system.

Double entry system is a method of recording each transaction in the account books in its two-fold aspects. It means two entries are made for each transaction in the same set of books, one as a debit entry and the other as a credit entry.

The theory of double entry is that every business transaction involves two parties— one for receiving the goods or services and the other for giving them. Therefore, every transaction is entered at two places, for credit and for debit.

Advantages of double entry system

1. The system provides for complete personal and impersonal records, which include assets, liabilities, gains or losses. Thus, the nature and value of the possessions can be ascertained.
2. It furnishes ways and means for checking arithmetical accuracy because two entries are made for each transaction.
3. The system provides detailed information regarding the business. Classified records of all transactions will show combined overall results of a given policy.
4. The system provides for automatic checks to prevent mistakes.
5. It affords an easy and ready reference to details of accounts.

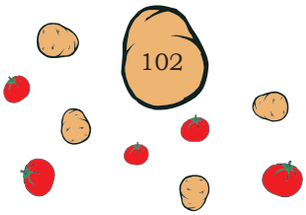
Single entry system is a system, which ignores the double effect of transactions. Only personal accounts of debtors and creditors are kept, and impersonal accounts are ignored altogether. It is, therefore, relatively imperfect. Its results are less reliable, and its accuracy cannot be tested by means of a trial balance, which is possible under the double entry system alone.

Types of farm records

The farm record system has three parts: physical farm records, financial farm records and supplementary farm records.

Physical farm records are related to the physical aspects of the operation of a farm business. The records include:

(i) Map of the farm, soil and contour, etc.
(ii) Preparation of charts on physical efficiency
(iii) Records on utilisation of land
(iv) Records on crop production and disposal
(v) Daily work record diary, labour records
(vi) Machinery use records
(vii) Stock/register, etc.
(viii) Casual and hired labour records



Financial farm records are mainly related to the financial aspects of the operation of a farm business. The records include:

(i) Farm inventory
(ii) Farm cash accounts or farm financial accounts
(iii) Classified farm cash accounts and annual farm business analysis
(iv) Balance sheet for net worth statement

Supplementary farm records include

(i) Capital assets sale register
(ii) Cash sales register
(iii) Credit sale or purchase register
(iv) Wage register
(v) Funds borrowed or repayment register
(vi) Farm expenses register.
(vii) Non-farm income record

Practical Exercise

Activity 1

Demonstrate different cropping patterns of vegetable crops

Material required

Writing material, practical file

Procedure

1. Visit a field where vegetable cropping pattern is followed, such as the Krishi Vigyan Kendra, Agricultural Institute or a farmer's field.
2. Differentiate between crop rotation, relay cropping, inter cropping and succession cropping with suitable examples.
3. Note the following observations in the Table given below.

S.No.	Location	Cropping pattern (including crops in cropping pattern)	Growing season	Remark	Picture

4. For each cropping pattern write two examples based on tuber crops.
5. Discuss advantages of vegetable cropping pattern.

Activity 2

Work out benefit cost ratio for any one tuber crop

Material required

Writing material

Procedure

1. Decide on a potato crop to work out benefit: cost ratio.
2. Collect the primary data of expenditure to raise a particular crop.

3. Place the data in Table 1 to find out the variable cost and fixed cost.
4. Calculate benefit: cost ratio with the help of the given formula and Table 2.
5. Compare the benefit: cost ratio of a particular crop with the group.

Table 1: Variable cost and total cost of cultivation of ..... (crop name)

S. No.	Variable cost			Total (Rs/ha)	Fixed cost (Rs/ha)	Total cost (Expenditure) (Rs/ha)
	Quantity	Rate (Rs)	Amount (Rs)			

Table 2: Economics of tuber crop.....production

S. No.	Expenditure (Rs/ha)	Gross monetary return (Rs/ha)	Net monetary return (Rs/ha)	Benefit: Cost ratio

Check Your Progress

A. Fill in the blanks

1. Costs involved in production process are _____and _____.
2. A system of entry that ignores the double effect of transactions is called _____.
3. A method of recording each transaction in the account books in its two-fold aspects is known as _____.
4. A type of unit that is an important structure at a farm for cleaning and grading of vegetable seeds is called _____.
5. After grading, packing of the produce, the _____ structures are essential until selling.

B. Multiple choice questions

1. Which of these is a winter or autumn winter seasonal vegetable?
   (a) Melons (b) Carrot
   (c) Squash (d) Gourds
2. Which of these vegetables grows in the summer season?
   (a) Gourds (b) Fenugreek
   (c) Carrot (d) Cabbage

3. Growing different crops in a sequenced season on the same land is called _____.
   (a) multi cropping (b) crop rotation
   (c) mixed farming (d) sequence cropping
4. The succeeding crop sown/planted before the preceding crop is ready for harvest is called _____.
   (a) relay cropping (b) crop rotation
   (c) intercropping (d) succession cropping
5. An example of supplementary farm record is _____.
   (a) farm inventory (b) cash sale register
   (c) farm cash accounts (d) All of these

C. Subjective questions

1. Define farm management. Describe the different farm resources.
2. What is a vegetable farm? Describe the farm buildings.
3. Write short notes on
   (a) Succession cropping
   (b) Relay cropping
   (c) Intercropping
   (d) Crop rotation
4. Discuss the double entry system and its importance.

D. Match the columns

A	B
1. Wage register	a. Soil map
2. Fix coast	b. Farm inventory
3. Variable cost	c. Supplementary farm records
4. Financial farm records	d. Land taxes
5. Physical farm records	e. Pesticides

SESSION 2: BASIC MARKET INFORMATION

Concept of Market Information

Market information system is also known as market intelligence system (MIS). This system is generally used to collect, analyse and disseminate information regarding demand and supply of any agricultural commodity keeping fluctuating prices in mind, and other needful information. Basic market information plays a vital role in agri-horti industries and floral supply chain. To get a better price in the market it is essential for farmers and traders to have market information regarding the demand and supply of

any commodity so that they get a good price for their produce. There are some sources that provide this basic market information.

Importance of Market Information

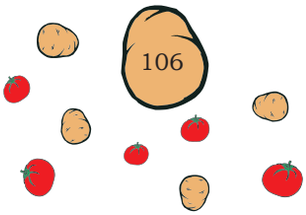
All the sectors whether run individually or by a group, depend on market information to work out their marketing needs.

1. **Farmers** uses market information for improving their decision-making powers to decide when, where and through whom produce should be sold and bought.
2. **Middleman** uses market information to plan the purchase, storage and sale of commodities. This information helps the middleman decide whether to sell the commodities in the market immediately or to stock it for some time before making a sale.
3. **Government** uses market information to formulate agricultural policies related to import-export regulations and administered prices. It also helps the government to make decisions related to support price.
4. **General economy** the regulation of price of agricultural products for the development of a competitive market helps in the growth of the economy.

Collection and Dissemination of Market Information

The collection and dissemination source of market information are as given below.

- State Agriculture Marketing Department
- State Agriculture Marketing Board
- Fund Department
- Directorate of Economics and Statistics
- Personal contact
- Post and telephones
- Newspaper
- Magazines
- Government agencies or experts
- Price bulletins



Agencies Involved in Agricultural Marketing

1. **National Agriculture Cooperative Marketing Federation of India Limited (NAFED)** was established on October 2, 1958 to organise, promote and develop marketing, processing and storage of agricultural and horticultural produce, and to facilitate import and export and wholesale or retail trade. It also facilitates, coordinates and promotes the marketing and trading activities of cooperative institutions.
2. **National Bank for Agriculture and Rural Development (NABARD)** was established on July 12, 1982 to promote sustainable and equitable agriculture and rural development through financial and non-financial interventions, innovations technologies and institutional development.
3. **Agriculture and Processed Food Products Export Development Authority (APEDA)** was established under the Agricultural and Processed Food Products Export Development Authority Act in December 1985. The Act came into effect from February 13, 1986. The main work of APEDA is to fix standards and specification for the scheduled product for export import.

Demand and Supply of Vegetables

In economics, demand and supply helps to determine the price of goods sold in the market. To a large extent, it relies on the competition among buyers as well as sellers. If there are more buyers they bid against each other and raise the price because the demand of goods is more and supply is less, On the other hand, if there are more sellers or more supply then the sellers bid against each other and lower the price. The equilibrium is when all the bidding has been done and nobody has an incentive to offer higher prices or accept lower prices.

The concept of demand

The quantity demanded of a good or vegetable in a given time is the total amount of goods or vegetables that the buyers would choose to purchase under the given conditions. The conditions are:

- Price of the vegetable
- Price of complement
- Income and wealth
- Preferences
- Quantity
- Expectations of future prices

The law of demand: when the price of a good rises, and everything else remains the same, the quantity of the good demanded will fall.

The concept of supply

The quantity supplied is the total amount of goods or vegetables that sellers would choose to produce and sell under the given conditions at a given time. The given conditions include:

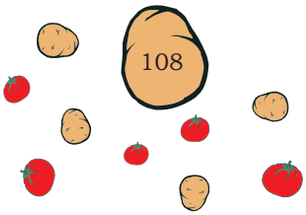
- Price of the vegetable
- Price of factors of production (labour, capital)
- Price of alternative products the farm could produce
- Technology
- Productivity
- Expectations of future prices

The law of supply: when the price of a particular good rises, then the quantity of that good supplied will also rise subject to all other things remaining the same.

Price fluctuation

The normal supply of vegetables is directly related to people's livelihood and social stability. Smooth price of vegetables is important for social development. The management strategies to control fluctuations in the price of vegetables are as follows:

- Establishing and improving the channels of information transmission.
- Making production and marketing information symmetrical.
- Balancing supply and demand.
- Actively promoting the industry standardisation of vegetables.
- Reducing the intermediate links.
- Curtailing the circulation cost of vegetables.



- Regulating the 'green channel' of vegetables.
- Preventing uptick in the prices of vegetables in the 'last mile'.
- Cracking down on the vegetable speculation behaviour to ensure healthy development of the vegetable market.
- Actively giving play to the role of the government.
- Building vegetable protection system.

The quality and quantity may be affected by climatic factors, such as drought, frost, rain, heat, etc., at the production levels, which, in turn, influence the availability. Other than this, insect pest and diseases also affect the production. The price of fresh produce is also influenced by the time of the purchase, as products outside or at the beginning or end of the season might be more expensive than in the middle of it.

Interdependencies among product categories influence the final price. Factors, such as variety, size, packaging, maturity of the product, organoleptic quality, promotional activities, the demand for specific growing practices, such as organic production, etc., also influence the price of fresh vegetables at the demand level. All these elements influence the price. Furthermore, logistical constraints or the place of purchase (supermarket, hard-discount and grocery store) also influence the final price. Finally, one should consider the overall economic situation and purchasing power, the demand for competing products, changes in consumer demands and so on.

Marketing System of Vegetable Crops

Marketing of vegetables comes with a lot of constraints due to their high perishable nature, seasonal market arrivals and bulky nature. Assembling and subsequent marketing of the produce is still a struggle due to lack of proper storage facilities and quick transport systems. Very often, producers are forced to dispose of their produce at a nominal price when there are seasonal gluts due to these bottlenecks. Another major defect in vegetable marketing is the involvement of several intermediaries, who dominate the trade and reap a

huge profit. Consequently, the producer's margin in the consumer's price becomes low. In vegetable marketing, the following four channels are predominant.

1. Producer→ Commission agent→ Wholesale trader→ Retailer→ Consumer
2. Producer → Wholesale trader → Retailer→Consumer
3. Producer → Commission agent → Wholesaler → Consumer
4. Producer → Retailer → Consumer
5. Producer → Consumer

A majority of the produce is marketed through channel 1 and 2. Channel 4 operates only when the producing area is situated near big markets or *haats* or cities. Vegetables are generally marketed in big hotels or other establishments through Channel 3.

Marketing through cooperatives is inadequate in our country. It is urgently felt that more horticultural producers' cooperative marketing societies should be established at the village and district levels to control the activity of the intermediaries and to regulate vegetable marketing. At present, NAFED, several state tribal cooperative corporations headed by TRIFED and primary cooperative marketing societies have taken up procurement and marketing of potato, onion and ginger. Besides NAFED, about 12 states and central level societies and more than 275 primary marketing societies are directly engaged in the marketing of vegetables. Horticultural Producers Marketing and Processing Society (HOPCOMS), Bangalore, Nilgiris Cooperative Marketing Society, Udhagamandalam, Nilgiris Vegetable Growers Cooperative Marketing Society, Udhagamandalam, Nasik District Potato and Onion Growers Cooperative Association are some of the other cooperative agencies rendering their services in the marketing of vegetables. The National Horticulture Board has started providing information regarding the prevailing prices of vegetables at various wholesale markets on a daily basis.

The existing systems need to be streamlined and monitored. The facility of the cooperative societies should be extended to the grass root level. Moreover, closer coordination among the Agriculture Marketing Board,

National Horticulture Board and State Department of Agriculture or Horticulture should formulate an action plan for marketing of vegetables.

Defects in the vegetable marketing system

- Poor transport facilities and almost complete lack of refrigerated transport network makes it difficult to send perishable products like vegetables to distant markets in a good condition. It is found that most of the post-harvest losses in the produce occur during transportation and distribution.
- Lack of storage facilities often results in surfeit. In this situation, the growers are forced to sell their produce even at throw away prices.
- Preponderance of intermediaries in the marketing channel lowers the producer's profit.
- There is no provision to fix floor prices, even for some important vegetables, therefore, producers are often cheated by the clever middlemen.
- Lack of grading and quality control system.
- Concept of consumer packaging is practically unknown in the domestic markets.
- Absolute lack of coordination between production targets of the state agriculture department and action plan of the marketing directorate.
- Primitive methods of selling, like secret sale, private negotiation, under cover, etc., are very much in vogue.
- Government and other cooperative marketing agencies' participation in vegetable marketing.
- Lack of pre-cooling, refrigerated transportation, chill cold storage and frozen cold storage.

Transportation in Marketing

It has been estimated that one-third of the vegetables get spoilt between the farm and the transit and another one-third before it reaches the consumer. In our country, transportation network for perishable commodities like vegetables is very weakly developed. The concept of refrigerated transport for vegetables is yet to be developed.

This spoilage happens in transit due to inadequate as well as loose packaging. In this situation, an efficient and a cost-effective transit network should be provided in the potential vegetable growing areas. Rail transport is 8-10 times more efficient than road transport with respect to the use of energy for the movement of the same tonnage. Unfortunately, long distance transport of vegetables is mostly done by road because rail transport has not yet proved to be dependable for vegetables in our country. Therefore, it becomes necessary to modify the long distance transport carriages by introducing refrigeration, more ventilation and by improving quick loading and unloading systems.

Fresh vegetables are normally exported by air from Mumbai. Onion, potato, garlic, sweet potato and elephant foot yam are exported by ship. Some onions are also exported from Porbandar in Gujarat, Chennai and Nagapattinam ports in Tamil Nadu by ship. Thiruvananthapuram and Delhi are the other airports from where vegetables are exported. Kuwait Airways, Saudi Air Lines and Air India are the major airlines, which transport vegetables. Fresh vegetable exports other than onions are allowed freely under the 'Open General License' (OGL). Onion is exported through NAFED. Private traders can also export onion by becoming associates of NAFED.

Practical Exercise

Activity 1

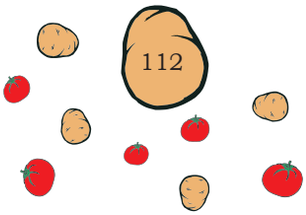
Marketing system of vegetable crops

Material required

Writing material, practical notebook

Procedure

1. Visit a nearby vegetable market or *mandi*.
2. Note down the various types of vegetables available in the market.
3. Observe the functions of different marketing channels.
4. Note down the various activities of marketing channels.
5. Note down the price variation between the producer, wholesale trader, retailer and consumer.



6. Calculate the difference in cost of vegetables between the different channels.
7. Observe difficulties, if any, faced by the producer and discuss the marketing information acquired by the producer.

Check Your Progress

A. Fill in the blanks

1. A majority of the produce is marketed through Channel _____ and _____.
2. A model that determines the price and quantity of any product is called _____ model.
3. APEDA stands for _____.
4. Marketing information system is also known as _____.
5. NAFED was established on _____.

B. Multiple choice questions

1. How many channels are predominant in vegetable marketing?
   (a) 1
   (b) 2
   (c) 3
   (d) 4
2. APEDA was established in _____.
   (a) 1986
   (b) 1996
   (c) 2002
   (d) 2005
3. The collection source of marketing information is _____.
   (a) newspaper
   (b) magazines
   (c) government agencies or experts
   (d) All of the above
4. Bulb and tuber crops are generally transported _____.
   (a) by air
   (b) by ship
   (c) by rail
   (d) None of the above

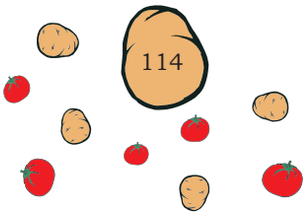
C. Subjective questions

1. What is the marketing system of vegetable crops?
2. What are the reasons for price fluctuation in the market?
3. Define demand with a suitable example.
4. Define supply with a suitable example.

NOTES

D. Match the columns

A	B
1. Source of market information	(a) Market information
2. Marketing Federation of India	(b) APEDA
3. Product Development Export Authority	(c) NAFED
4. Agriculture and Rural Development Bank	(d) Directorate of Economics and Marketing
5. Price determination	(e) NABARD



Answer Key

Unit 1: Irrigation Management in Vegetable Crops

Session 1: Irrigation and Water Quality

A. Fill in the blanks

1. element
2. frequent, more water
3. poor
4. 6.5-8.5

B. Multiple choice questions

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

D. Match the columns

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

Session 2: Water Requirement and Irrigation Methods

A. Fill in the blanks

1. irrigation scheduling
2. critical stage
3. border irrigation
4. overhead irrigation
5. bulb formation stage
6. emitters or drippers
7. drip irrigation

B. Multiple choice questions

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

D. Match the columns

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

Unit 2: Weed Management in Vegetable Crops

Session 1: Weeds in Vegetable Crops

A. Fill in the blanks

1. weeds
2. two seed leaves
3. annual
4. Perennial
5. grassy

B. Multiple choice questions

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

D. Match the columns

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

Session 2: Weed Management

A. Fill in the blanks

1. intercropping
2. 44–50
3. crop rotation
4. hand weeding
5. post-emergence

B. Multiple choice questions

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

D. Match the column

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

Unit 3: Integrated Pest and Disease Management in Vegetable Crops

Session 1: Major Insect-pests of Solanaceous Crops

A. Fill in the blanks

1. African marigold
2. tomato aphids
3. leaf miner
4. curl upwards
5. mites
6. shoot and fruit borer

B. Multiple choice questions

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

D. Match the columns

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

Session 2: Major Diseases of Solanaceous Crops

A. Fill in the blanks

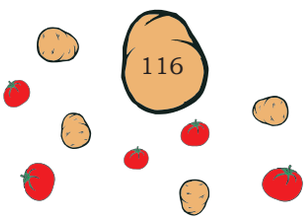
1. Damping off
2. Little leaf of brinjal
3. die-back
4. nematodes
5. virus

B. Multiple choice questions

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

D. Match the columns

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



Session 3: Integrated Pest and Disease Management of Solanaceous Crops

A. Fill in the blanks

1. diamond black moth
2. brinjal
3. trap crop
4. nitrogen
5. male
6. fruit flies
7. predator

B. Multiple choice questions

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

D. Match the columns

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

Unit 4: Harvest and Post-harvest Management

Session 1: Maturity Standards and Harvest of Solanaceous Crops

A. Fill in the blanks

1. physiological maturity
2. tomato and muskmelon
3. non-climacteric
4. morning, evening

B. Multiple choice questions

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

D. Match the columns

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

Session 2: Post-harvest Handling of Solanaceous Vegetable Crops

A. Fill in the blanks

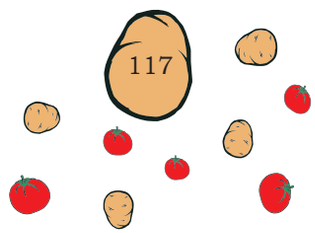
1. pre-cooling
2. 100–150
3. cold chain
4. packaging

B. Multiple choice questions

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

D. Match the columns

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



Unit 5: Basic Farm Management

Session 1: Farm Management and Selection Criteria of Vegetable Crops

A. Fill in the blanks

1. fixed costs and variable costs
2. single entry system
3. double entry system
4. processing unit
5. storage

B. Multiple choice questions

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

D. Match the columns

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

Session 2: Basic Market Information

A. Fill in the blanks

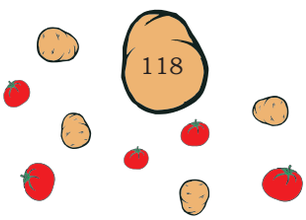
1. 1, 2
2. demand and supply
3. Agricultural and Processed Food Products Export Development Authority
4. market intelligence system
5. October 2, 1958

B. Multiple choice questions

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

D. Match the columns

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



GLOSSARY

Admixture: *mixing an ingredient with something else.*

Adulteration: *addition of a substance, which may result in the loss of actual quality.*

Alternate host: *an organism that serves as a temporary host in the absence of host.*

Barrier crop: *a tall growing crop that inhibits insects from flying over.*

Biochemical: *a chemical process, that occurs in living organisms.*

Bioherbicide: *an organism that is toxic to unwanted vegetation and is used to destroy weeds.*

Bulbs: *a round underground storage organ. It is present in some plants. It consists of a short stem surrounded by fleshy scale leaves or leaf bases.*

Buldgy: *a protruding part with an outward curve or swelling.*

Cochineal insects: *a scarlet dye used for colouring food, made from the crushed dried bodies of a female scale insect.*

Coir: *fibre from the outer husk of a coconut.*

Concentric rings: *rings with a common centre.*

Conservation: *preservation, prevention.*

Corms: *it is the same thing as a bulb.*

Cost of cultivation (Rs/ha): *the expenditure incurred from field preparation to harvest is calculated at rupees per hectare.*

Depletion: *exhaustion*

Determinate type: *plants, such as tomato, that terminate in flower buds, self topping type.*

Diffusion: *the movement of molecules from high to low concentration.*

Disperse: *spreading something over a large area.*

Disseminate: *spread, circulate, distribute.*

Dormant: *resting period. Not active.*

Dumping: *deposit or dispose of waste carelessly.*

Entomopathogenic: *pathogenic to insects.*

Eradicate: *destroy completely, put an end to, eliminate.*

Evapo-transpiration: *the process by which water is transferred to the atmosphere. It could be by evaporation from the soil and other surfaces and by transpiration from plants.*

Fertigation: *it is the process of direct application of water soluble solid fertilisers or liquid fertilisers with irrigation water.*

Fungicides: *it is a substance or chemical used to kill or control fungi.*

Gross returns (Rs/ha): *the yield is computed per hectare and the total income worked out at rupees per tonne according to the prevailing market price.*

Heavy metal: *a metal of relatively high density or high relative atomic weight.*

Herbaceous: *tender, grassy.*

Homogenous: *denoting a process involving substances in the same phase.*

Indeterminate type: *tall (vine like) growing varieties.*

Infestation: *an unusually large number of insects present in a particular place or host.*

Insect: *a small animal of the insect class with three pairs of legs, two pair of wings, and body divided into three segments head, thorax and abdomen.*

Insecticides: *a substance or chemical used to kill or control insects.*

Insulate: *protect from heat, cold or noise.*

Irrigation interval: *a break in the number of days between two consecutive irrigations during the critical period of consumptive use of the crop. The interval depends on the crop, soil and climate.*

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

Maturity indices: *measurement that can be used to determine whether a particular commodity is mature.*

Mulching: *applying coarse plant residue or chips, or other suitable material, to cover the soil surface. It reduces evaporation from soil surface and weed growth.*

Myco-herbicide: *fungus or fungi used to destroy weeds.*

Nematicides: *chemicals that control nematodes.*

Net returns (Rs/ha): *obtained by subtracting the cost of cultivation from gross returns for each treatment and expressed as rupees per hectare.*

Osmosis: *a fluid, usually water, passing through a semi-permeable membrane into a solution where the solvent concentration is higher.*

Parasite: *an organism which lives in or on another living organism (its host) and benefits by drawing nutrients at the other's expense.*

Parasitoid: *an insect whose larva lives as a parasite and eventually kills the host.*

Pathogens: *any organism that causes disease in another organism.*

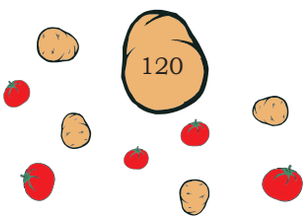
Permeable: *a material or membrane that allow liquid or gas to pass through it.*

Pest: *a destructive being that attacks crop, livestock, food, etc.*

Pesticide: *a substance used to control pests.*

Pheromone trap: *a trap that uses pheromones to lure insects.*

Pheromone: *a chemical that is secreted or excreted to trigger a social response in members of the same species.*



Photosynthesis: *a process in which green plants convert solar energy into chemical energy and later release it as fuel.*

Physiology: *a branch of biology that deals with the functions and activities of living organisms and their parts, including all physical and chemical processes.*

Phytotoxic: *lethal to plants*

Porous: *material having minute interstices (spaces) through which liquid or air can pass.*

Predator: *an organism that preys on other organisms.*

Residue: *something that remains after use; remainder.*

Respiration: *inhalation and exhalation of air by a living organism.*

Rhizomes: *a continuously growing horizontal underground stem, which puts out lateral shoots and adventitious roots at intervals.*

Scars: *marks of injuries.*

Shelf life: *the length of time for which an item remains usable or fit for consumption.*

Sodium Absorbance Ratio (SAR): *it is an irrigation water quality parameter to determine the concentration of ions of sodium and calcium plus magnesium content in the water.*

Soil borne: *inhabitant of soil; lives and grows in soil.*

Solarisation: *using solar power for controlling pests.*

Succulent: *a plant having thick fleshy leaves or stems adapted to storing water; juicy.*

Sunken spot: *a spot that is deeper in the centre and shallow on the outer sides.*

Systemic insecticides: *insecticides translocated to various parts of the plant irrespective of the part applied to.*

Thuricide (*Bacillus thuringiensis*): *a liquid formulation of bacteria that controls caterpillars, loopers, etc.*

Trap crop: *a crop that you add to your garden to attract pests away from the main crop.*

Trimming: *to put into a neat or orderly condition by clipping.*

Tubers: *a much thickened underground part of a stem.*

Vacuum: *a region with gaseous pressure much less than the atmospheric pressure.*

Vectors: *carrier of pathogens.*

Viable: *able to germinate or grow.*

Notes

List of Credits

Unit1: Irrigation Management in Vegetable Crops

Fig. 1.1 : Sources of irrigation water
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.1.2 : pH colour strip scale
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.1.3 : Digital pH meter
Courtesy: Prof. R K Pathak, DAAH, PSSCIVE, Bhopal

Fig.1.4 : Digital Electrical Conductivity (EC) meter
Courtesy : https://bit.ly/2WLpwdG

Fig.1.5 : Irrigation systems and methods
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.1.6 : Flood irrigation method
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.1.7: Border irrigation method
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.1.8 : Line diagram of check basin irrigation method
Courtesy : DAAH, PSSCIVE, Bhopal

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Courtesy : DAAH, PSSCIVE, Bhopal

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Courtesy : https://bit.ly/2E9okKV

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Courtesy : https://bit.ly/2pcDdEj

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Fig.1.12 : Components of drip irrigation system
Courtesy : DAAH, PSSCIVE, Bhopal

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Courtesy : https://bit.ly/2MPyenZ

Unit 2: Weed Management in Vegetable Crops

Fig. 2.1 : Broadleaf weeds, Camphor grass (*Chromolaena odorata*)
Courtesy : https://bit.ly/2NioiH2

Fig. 2.2 : Grassy weeds Johnsongrass (*Sorghum halepense*)
Courtesy: https://bit.ly/2Nlj0dO

Fig.2.3 : Amaranth (*Amaranthus viridus*)
Courtesy : https://bit.ly/2pfFG0G

Fig. 2.4 : *Common Crabgrass (Digitaria sanguinalis)*
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Courtesy : https://bit.ly/2NkcGmI

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Courtesy : https://bit.ly/2pcW55Z

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Asthma Plant (Euphorbia hirta)
Courtesy : https://bit.ly/2xjavG7

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Courtesy : https://bit.ly/2QCnURS

Fig.2.10 : Creeping thistle (Cirsium arvense)
Courtesy : https://bit.ly/2Nk4hA2

Fig.2.11 : Doob grass or Bermuda (Cynodon dactylon)
Courtesy : https://bit.ly/2QzAPnn

Fig.2.12 : Purple nut sedge or Motha (Cyperus rotundus)
Courtesy : https://bit.ly/2MEg9aQ

Fig. 2.13 : Bishkhapra (Boerhavia difusa)
Courtesy : DAAH, PSSCIVE, Bhopal

Fig. 2.14 : Methods of weed control
Courtesy : DAAH, PSSCIVE, Bhopal

Fig. 2.15 : Types of Herbicides
Courtesy : DAAH, PSSCIVE, Bhopal

Fig. 2.16 : Knapsack sprayer
Courtesy : https://bit.ly/2E9p2YB

Unit 3: Integrated Pest and Disease Management in Vegetable Crops

Fig 3.1 : Whiteflies in tomato
Courtesy : https://bit.ly/2W0MYap

Fig 3.2 : Aphids in tomato
Courtesy : https://bit.ly/2ZmHC7v

Fig 3.3 : Leaf hopper in brinjal
Courtesy : https://bit.ly/2MKKWIc

Fig 3.4 : Aphids in brinjal
Courtesy : https://bit.ly/2Q1rIfq

Fig.3.5 : Early blight of tomato
Courtesy : https://bit.ly/2MFLXfk

Fig.3.6 : Late blight of tomato
Courtesy : https://bit.ly/2PZVkKf

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Courtesy : https://bit.ly/2Nm7i2R

Fig.3.8 : Root knot in tomato
Courtesy : https://bit.ly/2MHFUqR

Fig.3.9 : Phomopsis blight in brinjal

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Courtesy : https://bit.ly/2NgLbul

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Courtesy : https://bit.ly/2NjbxvR

Fig.3.11 : Cercospora leaf spot in Brinjal
Courtesy : https://bit.ly/2NRKkzK

Fig.3.12 : Fusarium wilt in tomato
Courtesy : https://bit.ly/2OuSqvv

Fig.3.13 : Integrated pest management (IPM)
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.3.14 : Biological pest control

Two spotted lady beetle (*Adalia bipunctata*) feeding amongst aphid colony

Courtesy : https://bit.ly/2VlHZg9

Fig.3.15 : Biological pest control (The parasitoid wasp *Adalia bipunctata* laying eggs on a caterpillar)
Courtesy : https://bit.ly/2xkikLG

Unit 4: Harvest and Post-harvest Management

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Courtesy : DAAH, PSSCIVE, Bhopal

Fig. 4.2 : A view of maturity stages in tomato
Courtesy : DAAH, PSSCIVE, Bhopal

Fig. 4.3 : Maturity stages of tomato
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.4.4 : Harvesting container (Plastic crates)
Courtesy : DAAH, PSSCIVE, Bhopal

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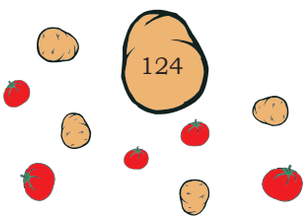
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.4.6 : Packing in the field and transport to packing house
Courtesy : DAAH, PSSCIVE, Bhopal

Fig.4.7 : Corrugated cardboard boxes
Courtesy : https://bit.ly/2XH5Yvs



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