

AGRICULTURE SCIENCE AND TECHNOLOGY

Standard XI



The Constitution of India

Chapter IV A

Fundamental Duties

ARTICLE 51A

Fundamental Duties- It shall be the duty of every citizen of India—

- (a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
- (b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
- (c) to uphold and protect the sovereignty, unity and integrity of India;
- (d) to defend the country and render national service when called upon to do so;
- (e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities, to renounce practices derogatory to the dignity of women;
- (f) to value and preserve the rich heritage of our composite culture;
- (g) to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures;
- (h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
- (i) to safeguard public property and to abjure violence;
- (j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;
- (k) who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

The Coordination Committee formed by GR No. Abhyas - 2116/(Pra.Kra.43/16) SD - 4 Dated 25.4.2016 has given approval to prescribe this textbook in its meeting held on 20.6.2019 and it has been decided to implement it from academic year 2019-20.

AGRICULTURE SCIENCE AND TECHNOLOGY

Standard XI



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Subject Committee:

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Dr. Naikare Shriram Maruti

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Production :

Shri Sachchitanand Aphale

Chief Production Officer

Shri Prashant Harne

Production Officer

Coordinator :

Shri. Rajiv Arun Patole

**Special Officer
(Agriculture Science and Technology)**

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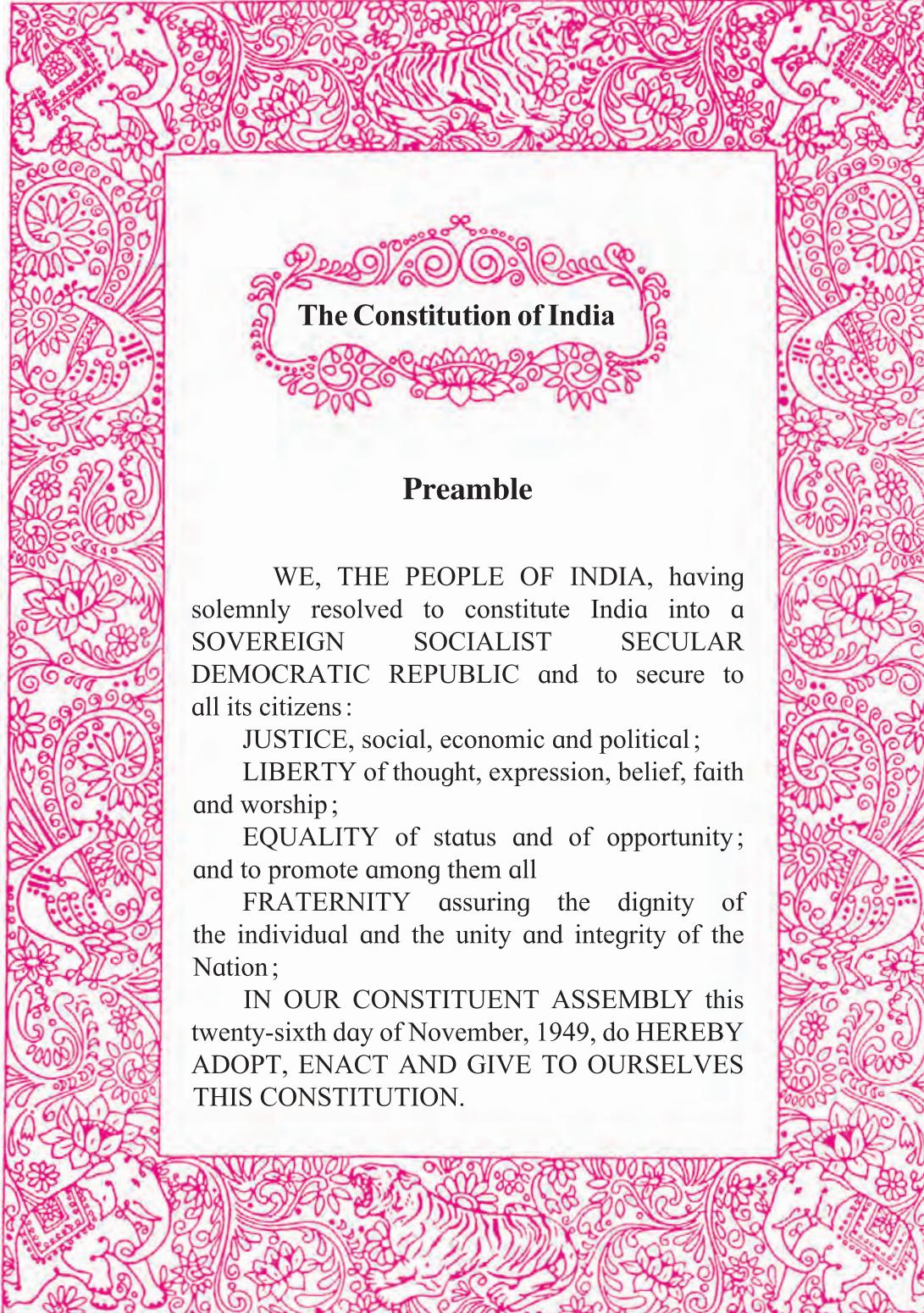
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The Constitution of India

Preamble

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC and to secure to all its citizens:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.

NATIONAL ANTHEM

Jana-gana-mana-adhināyaka jaya hē
Bhārata-bhāgya-vidhātā,

Panjāba-Sindhu-Gujarāta-Marāthā
Drāvida-Utkala-Banga

Vindhya-Himāchala-Yamunā-Gangā^ā
uchchala-jaladhi-taranga

Tava subha nāmē jāgē, tava subha āsisa māgē,
gāhē tava jaya-gāthā,

Jana-gana-mangala-dāyaka jaya hē
Bhārata-bhāgya-vidhātā,

Jaya hē, Jaya hē, Jaya hē,
Jaya jaya jaya, jaya hē.

PLEDGE

India is my country. All Indians
are my brothers and sisters.

I love my country, and I am proud
of its rich and varied heritage. I shall
always strive to be worthy of it.

I shall give my parents, teachers
and all elders respect, and treat
everyone with courtesy.

To my country and my people,
I pledge my devotion. In their
well-being and prosperity alone lies
my happiness.

Preface

Dear students,

Welcome to std. XI. We have great pleasure in offering to you textbook of agriculture science and technology based on the new syllabi. This textbook is designed to get you prepared for higher studies. The information and skill from this textbook will also help to develop entrepreneurship qualities.

The educational science understands a paradigm shift in our country. The student community is waiting for exploring new vistas to meet the demands and challenges. It was necessary to bring a change at +2 level of education. This stage deals with adolescents, who are hungry for knowledge and are sensitive as well. Efforts are made to make this text compatible and digestible for this age group.

The world as well as Indian population is ever increasing. Hence, it is imperative to boost up production. This problem can be turned into opportunity by developing skilled manpower to utilize the available resources for food security. Agriculture education can meet this challenge. New technologies have to be evolved and taken from lab to land for sustained yield. The present book on agriculture is to serve as a source of information covering maximum aspects, which can help understand the topics with eagerness to study further higher courses.

While studying this textbook the section ‘can you recall’ ‘recall a little’ and ‘can you tell’ are used for revision. Many activities given under the titles ‘observe and discuss’ and ‘try this’ ‘use your brain power’ think about it’ etc. will stimulate power of thinking. Ask your teachers, parents and classmates for help wherever you need it.

QR code is given by using you can get additional audio – visual information as supporting articles. The students from rural area, enrolling for this subject will certainly get advanced knowledge of agriculture, thereby they will educate their parents for the same advanced techniques of farming.

While studying the book make proper use of devices of information communication technology, which will make studies much easier. The efforts taken to prepare the textbook will not only enrich the learning experiences of the students, but also benefit other stakeholders such as teachers, parents as well as candidates appearing for the competitive examinations.

We look forward to a positive response from the teachers and students.

Our best wishes to all!



(Dr. Sunil Magar)

Director

Maharashtra State Bureau of Textbook
Production and Curriculum Research, Pune.

Pune

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Competency Statements

Unit I Elements of Agriculture	<ul style="list-style-type: none"> • Explain definition of rock, mineral and soil. • Classify rocks according to mode of formation and on the basis of chemical composition, classification of minerals • Observe and explain the physical, chemical and biological properties and functions of soil, explain soil health and distinguish soil fertility and productivity. • Explain and draw flow charts of weathering of rocks and formation of true soil. • Explain weather and climate with their elements such as temperature, rainfall, light, wind, humidity, dew, fog, frost and their effect on plant growth. Understand weather forecasting. • Use thermometer, thermograph, sunshine recorder, hygrometer, dew gauge, wind vane, anemometer, rain gauge. • Understand technologies, innovations and education regarding the modern agricultural approaches.
Unit II Seed and Sowing	<ul style="list-style-type: none"> • Define seed and explain its parts. • Differentiate between seed and grain. • Explain the characteristics of good quality seed. • Elaborate stages of seed multiplication. • Elaborate seed germination-definition, types, factors affecting germination, seed dormancy, methods of breaking dormancy. • Explain a procedure of germination tests, physical purity, seed heath, moisture and vigour and viability tests. • Explain information regarding sowing time, depth, spacing and seed treatment. • Use methods of sowing such as broadcasting, drilling, dibbling, planting, sowing in plough furrows and transplanting.
Unit III Needs of Plants	<ul style="list-style-type: none"> • Classify essential elements with examples. • Prepare chart on Functions and deficiency symptoms of nutrients • Explain about, manures, fertilizers and methods of application. • Elaborate different advantages of irrigation and adverse effect of irrigation with examples. • Explain the systems of irrigation like surface, subsurface, sprinkler, drip. • Collect Information regarding when to, how and how much to irrigate. • Explain meaning, importance, causes of improper drainage and remedies. • Explain watershed and watershed management. • Identify the macro, micro, mini, mili watershed. • Elaborate main components of watershed management. • Learn various steps in watershed management. • Explain the processes of rainwater, ground water and roof water harvesting.

Unit IV Cultivation Management	<ul style="list-style-type: none"> Explain and compare different types of cropping system viz.- monoculture, multiple cropping, mixed cropping, inter cropping, strip cropping, relay cropping, sequence cropping, multistoried cropping and catch cropping. Explain tillage, tilth and objectives of tillage. Explain Preparatory tillage, seedbed preparation, inter-cultivation, meaning, examples and list of tillage implements. Understand minimum tillage, zero tillage and mulching. Explain harvesting, threshing, winnowing, storage. Define weed with characteristics. Classify weed according to different aspects-life cycle, place of occurrence, plant family, dependence on hosts, soil types, morphology, origin, nature of stem and association. Explain beneficial and harmful effects of weed and understand weed dispersal. Explain preventive, curative and integrated weed management.
Unit V Crop Production Management	<ul style="list-style-type: none"> Explain pest, disease and their types and controlling methods, integrated pest management (IPM), integrated disease management (IDM). Explain pest of sugarcane, cotton, paddy, soybean, mango, pomegranate, citrus, coconut, onion, potato. Identify the diseases of sugarcane, cotton, paddy, soybean, mango, pomegranate, citrus, coconut, onion, potato. Explain the nature of damage by dears, elephants, rabbits, wild boar, monkeys, and nilgai. Suggest measures to protect crops and field from wild animals. Compare world situation, Indian conditions, reasons of losses due to waste. Classify the waste into solid waste, wet waste, dry waste, domestic hazard waste, e-waste, domestic waste, commercial waste, animal waste, plant waste. Explain processes of waste management like landfill, decomposition, biogas, vermicomposting, microbial decomposition. Elaborate by-products of wastes with their nutritive value and consequences.
Unit VI Fundamentals of Horticulture	<ul style="list-style-type: none"> Explain importance, scope and present status of horticulture in India. Make decisions for selection of site, layout of orchard, planting methods and explain objectives, methods, systems, advantages, procedure of development of new orchard. Explain the process of training and pruning, high-density planting, bahar treatment, girdling, bending, ringing, notching, hardening. Understand information about plantation crops, vegetable, medicinal, spice, aromatic and exotic crops, ornamental and flower crops.

- For Teachers -

Dear Teachers,

We are happy to introduce the revised textbook of Agriculture Science and Technology for Std XI. This book is a sincere attempt to follow the maxims of learning as well as develop a ‘constructivist’ approach to enhance the quality of learning. The demand for more activity based, experiential and innovative learning opportunities is the need of the hour. The present curriculum has been restructured so as to bridge the credibility gap that exists between what is taught and what students learn from direct experience in the outside world. Guidelines provided below will help to enrich the teaching-learning process and achieve the desired learning outcomes.

- To begin with, get familiar with the textbook yourself.
- The present book has been prepared for constructivist and activity-based teaching.
- Teachers must skillfully plan and organize the activities provided in each chapter to develop interest as well as to stimulate the thought process among the students.
- Always teach with proper planning.
- Use teaching aids as required for the proper understanding of the subject.
- Do not finish the chapter in short.
- Follow the order of the chapters strictly as listed in the contents because the units are introduced in a graded manner to facilitate knowledge building.
- Ask questions on information related to trends and patterns. Efforts have been made to provide the latest data available. Teachers must explain

to the students the importance of data collection and data analysis.

- Major concepts of Agriculture Science and Technology have a scientific base and they deal with abstractions. Encourage group work, learning through each other’s help, etc. Facilitate peer learning as much as possible by reorganizing the class structure frequently.
- Teaching-learning interactions, processes and participations of all students are very necessary and so is your active guidance.
- Do not use the boxes titled ‘Do you know?’ for evaluation. However, teachers must ensure that students read this extra information.
- Information provided in boxes with the various titles should be considered for evaluation.
- Exercises provided after each unit are prepared using different parameters such as observation, co-relation, critical thinking, analytical reasoning, etc. Evaluation pattern should be based on the given parameters. Equal weightage should be assigned to all the topics. Use different combinations of questions. Stereotype questions should be avoided.
- Use QR Code given. Keep checking the QR Codes for updated information. Certain important links, websites have been given for references. In addition, a list of reference books is given. Teachers as well as the students can use these references for extra reading and in-depth understanding of the subject.

Best wishes for a wonderful teaching experience!

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Can you recall?

The rocks are formed due to solidification of molten magma, derived from the volcano. Some rocks are formed at the surface whereas some deep below the earth surface. Some rocks are very massive while some are loose. They are composed of minerals combined with different salts.

1.1 Definition of Rock

A rock may be defined as a hard mass of mineral matter comprising of two or more minerals. Each rock possesses certain characteristics like colour, structure, specific gravity and mineralogical make up.

Observe the stones and rocks

Collect the pieces of marble, granite, shahbadi, chalk, etc. Study their colour, hardness, granulation, etc. Match the above with different types of rock.

1.2 Classification of rocks

(A) According to mode of formation

1. Igneous rocks - These rocks were the first to be formed with the molten mass cooled and consolidated in to solid rock. They are also called as primary rocks.

These are classified as follows :

- The rock formed by the slow cooling of molten magma beneath (deep) the surface is **intrusive or plutonic rock** e.g. Granite.
- The rock formed when the magma poured out on the surface of the earth and consolidated on cooling is **extrusive or volcanic rock** e.g. Basalt.

Plutonic and volcanic both rocks are known as igneous or primary rocks.

2. Sedimentary rocks - The sedimentary rocks are formed from sediments, derived from the breaking down of pre-existing rocks.

The sediments are transported by water, glaciers, etc. to new places, deposited in new arrangements and cemented to form a secondary rock.

3. Metamorphic rocks - The igneous and sedimentary rocks undergo considerable change known as metamorphosis and the rock formed by metamorphism is known as metamorphic rock. The metamorphosis is brought about by the action of water (hydrometamorphic rock), heat (thermometamorphic rock), pressure (dynamometamorphic rock) or by the combined action of all. eg : marble, slate, etc.

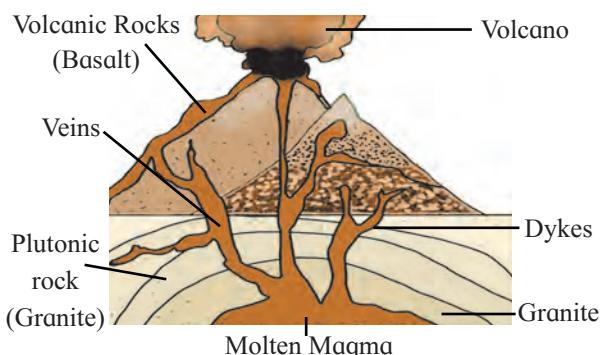


Fig. 1.1 : Formation of Rocks



Do you know ?

Igneous rocks can be transformed to others. They have different properties.

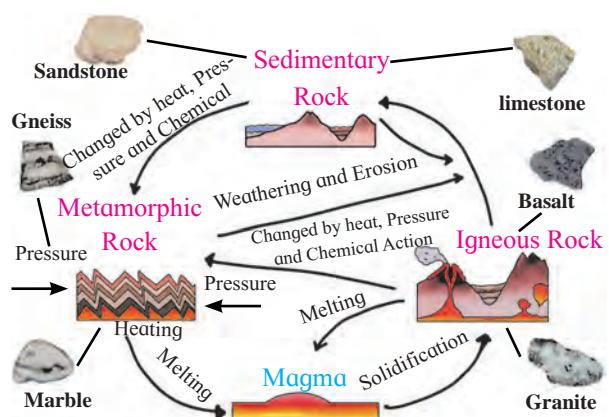


Fig. 1.2 : The Rock Cycle

Table 1.1 : Characteristics and dominant mineral in different types of rocks with examples.

Rocks	Dominant minerals	Characteristics	Availability
(1) Igneous rocks			
Granite	Feldspar, Mica	Acid rocks – SiO ₂ 65 % and above light coloured, having big crystals of feldspar	Khanapur, Southern part of Belgaon dist. Vadodara
Diorite	Plagioclase, Feldspar, Augite, Magnetite	Sub-basic rock containing 55 to 60 % SiO ₂	Dharwad, Junagadh
Basalt	Plagioclase, Feldspar, Augite, Magnetite	Basic rocks containing 55% or less SiO ₂ , less compact, dark coloured rocks. Micro crystalline texture. Smooth surface	Pune, Peninsular India
(2) Sedimentary rocks			
Limestone	Calcite (CaCO ₃)	Quick effervescence (evolution of CO ₂) when treated with dil. HCl	Porbandar, Kathiawad, Bagalkot, Shahabad
Dolomite	Dolomite CaMg (CO ₃) ₂	Quick effervescence (evolution of CO ₂) when treated with dil. HCl	As above
Sandstone	Quartz (SiO ₂)	Excellent building material	Gokak, Badami, Gadag
Shale	Clays	Compact clay rocks. They are porous and soft	Dharwad, Hubali, Gadag
(3) Metamorphic rocks			
Gneiss	Various quartz, Orthoclase, Hornblende, Biotite	Foliated light coloured hard rocks	Khanapur, Gokak, Vadodara
Quartzite	Quartz (SiO ₂)	Hard, compact, crystalline rock	Gadag, Bagalkot
Slate	Clays, mainly compacted clay	Medium, hard, fine grained rocks	Kaladigi, Vadodara
Marble	Calcite (CaCO ₃)	Shining, thoroughly crystalline, hard rocks	Jabalpur

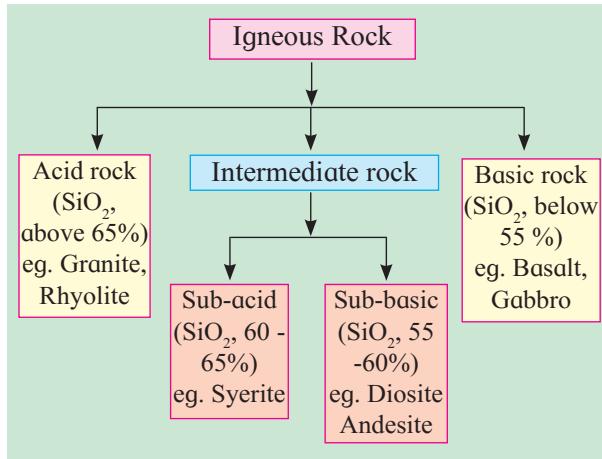
(B) Classification on the basis of chemical composition (Silica content)

The different rocks contain silica in different proportion. On the basis of silica content they are of different types.



Do you know ?

- ✓ Different rocks have different dominant mineral.
- ✓ They have specific character.
- ✓ They are available in different regions.



1.3 Definition of mineral

It is a naturally occurring inorganic substance having a definite chemical composition and distinct physical properties.

1.3.1 Classification of minerals

The minerals are classified on the basis of formation, component and specific gravity.

- **On the basis of formation :-**

Primary – Principal constituent of Quartz, Feldspar, Calcite, etc.

Secondary – Deposited as a result of subsequent changes in rocks like Gypsum, Dolomite, etc.

- **On the basis of characteristic component :-**

Essential minerals : e.g. Feldspar, Mica, etc.

Accessory minerals : Magnetite, Tourmaline, etc.

- **On the basis of specific gravity they are**
Heavy minerals : e.g. Haematite, Pyrite, etc
Light minerals: e.g. Quartz, Muscovite, etc.

1.4 Definition of soil

According to Jenny (1941) soil is a naturally occurring body that has evolved owing to the combined influence of climate and organisms acting on a parent material conditioned by relief over a period of time.

According to the glossary of soil science (Soil science society of America 1970) the term soil is defined as

- (i) The consolidated mineral material on the immediate surface of the earth that serve as a natural medium for the growth of plants.
- (ii) The unconsolidated mineral matter on the surface of earth that has been subjected to an influence by genetic and environmental factor of parent material, climate (including moisture and temperature), macro and micro organisms and topography, all acting over a period of time and producing a product, that is soil. It differs from the material from which it is derived in many physical, chemical, biological and morphological characteristics and properties.

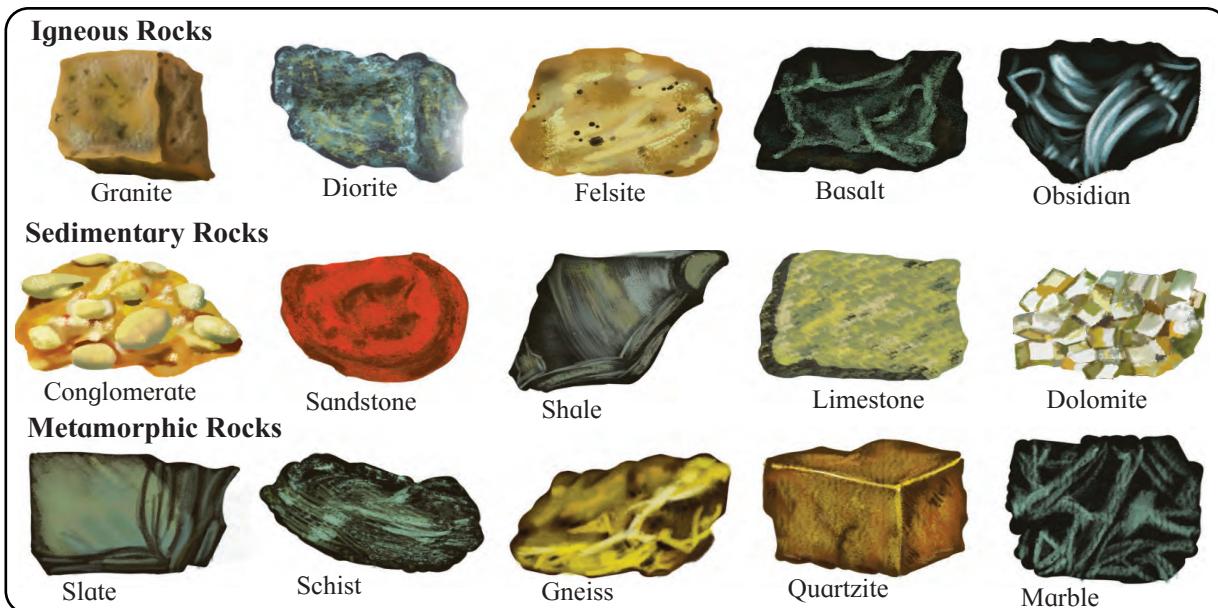


Fig 1.3 : Rock Specimens



Use your brain power

The approximate proportion of essential minerals in the earth crust.

Earth crust contains (approximately) Feldspar 58.7 %, Quarz 13%, Amphiboles and pyroxenes 10 % , Mica 4%.



Do you know ?

That soil is a non renewable resource and it takes few hundred years for building 1 cm layer of soil. But it can be lost within a year because of negligence of man.



Observe and Discuss

Observe the soil in the fields. Find whether it is coarse or fine, its colour, nature, etc. Do you know that it is necessary for growing any plant. It is the most important natural resource for every country, because it not only grows variety of food, fodder and fibre crops which are required for mankind and animals, but also provide raw materials for various agro-industries viz., sugar, jute, starch, textile, canning and processing units.



Mind and understand

It became evident that all soils share a number of characteristics. All have three phase open system to which substances may be added and lost. All have profile, some with more distinct horizons or layers than others.

Thus, soil is three dimensional, dynamic unconsolidated, natural body consisting of phases (solid, liquid and gaseous) and composed of mineral material and organic matter formed on the surface of earth crust under the set of soil forming factors such as climate, vegetation, topography, parent material and it acts as a medium for plant growth and processes.



Know the Scientist



Hans Jenny was born in Basel, Switzerland. He earned a diploma in agriculture from the Swiss Federal Institute of Technology (ETH Zurich) in 1922, and a D. Sc. degree in 1927 for a thesis on ion exchange reactions.

Following an appointment at the University of Missouri, he joined the faculty at Berkeley in 1936. International recognition came to Jenny after the 1941 publication of *Factors of Soil Formation: A System of Quantitative Pedology*. His synthesis of field studies with the abstract formalism of physical chemistry set down the generic mathematical relationship that connects the observed properties of soil with the independent factors that determine the process of soil formation.

1.5 Soil formation



Do you know ?

That weathering of rocks is necessary for soil formation. Material undergoes physical, chemical and biological processes. It converts complicated mass into simpler one.

Weathering means physical disintegration and chemical decomposition of rocks and minerals which takes place naturally at or near the surface of earth crust. Means the process of transformation of solid into soil is known as weathering.

Visit different sites and observe the weathering process

How the weathering is going on? You will find that physical, chemical and biological processes are going on simultaneously ?



In physical process due to temperature the rocks expand and during cooling it produces cracks. Ultimately the rocks are broken into big pieces, then to small and smaller particles. Water also applies tremendous pressure, hence, rock splits and disintegrates. The running water also acts mechanically and chemically on rocks. The waves, winds and glaciers also help in the process of disintegration of rocks.

Chemically, decomposition of rocks and minerals is brought about by water and due to the gases (CO_2) and salts which are dissolved in water. The chemical reactions involved are hydrolysis, oxidation, reduction, carbonation, hydration, solution, etc. The hydrolysis forms hydroxides, the oxidation oxides, the reduction reduces the salts, carbonation forms the carbonates and bicarbonates. In hydration and solution the complex compounds are changed to simpler ones.

In biological weathering man, animals, higher plants, macro and micro organisms due to their action and secretions hastens the process of decomposition.

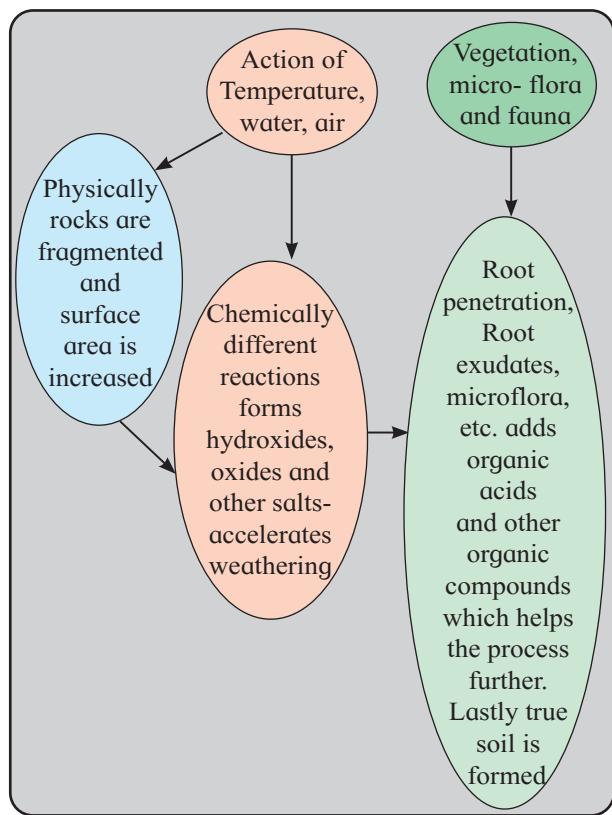


Fig. 1.4 : Process of weathering



Use your brain power

Mere weathering does not produce the soil. It is the result of the action of various agencies. It is a long time process. Weathering is a destructive process whereas soil formation is constructive process resulting into soil profile.

The natural agencies which are responsible for soil formation are called as soil forming factors. Soil formation is diversified and complex process which is considerably affected by five factors which are interacting with each other.

The soil forming factors are expressed by the Jenny's equation...

$$S = \Sigma f (Cl, b, r, p, t)$$

Where, S = Soil

Σf = sum of functions

Cl = Climate

b = biosphere or vegetation & micro organisms,

r = relief / topography

p = parent material

t = time / age



Can you think

Soil forming factors are grouped as passive and active. Parent material, topography and time do not have a dominating role in soil formation. They are only the source and conditions. Therefore, they are called as passive factors.

Whereas climate and biosphere i.e. Vegetation and microorganisms play a most dominating role hence called as active factors. They can change the nature of soil formed. In climate rainfall and temperature are important. The vegetation and micro organisms affects the amount of organic matter addition to soil. These helps in various decomposition processes.



Soil forming processes :

A set of soil reactions leading to the formation of soil are known as soil forming processes. The book references will reveal that calcification, podzolization, laterization, salinization / alkalinization are the important soil forming processes.

The percolation of rain water accumulates the carbonates of Ca and Mg in soil profile and is known as **calcification**.

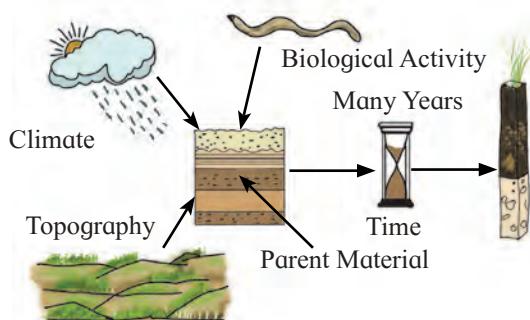


Fig 1.5 : Soil forming factors

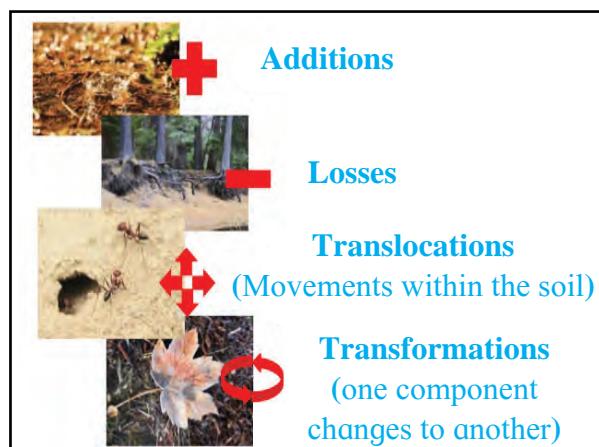


Fig 1.6 : Basic soil forming processes

In humid region large amount of organic matter is accumulated at the surface. The decomposition of the organic matter releases organic acids which removes Fe from upper layers and is fractionated at different horizons and this is known as **podzolization**.

Laterization means the hydrolysis of minerals and in this there is loss of aluminium oxides, silicates and soluble nutrients due to leaching. This process is prominent in tropical condition.

The accumulation of soluble salts of Na, Ca and Mg as chlorides, sulphates and bicarbonates is termed as **salinization**. After rainfall or irrigation these are removed from upper layer is known as **desalinization**.

1.5.1 Soil profile :

Definition : It represents succession of layers/horizons differentiated from one another but genetically related. Vertical section through the soil gives the clear picture of profile.



Try this

Dug a large pit ($1 \times 1 \times 1.5$ meter) and observe the sides of this pit and find the difference. You will observe different layers, some are distinct while some are mixed which are known as horizons.

Observe and draw a diagram : This will look like -

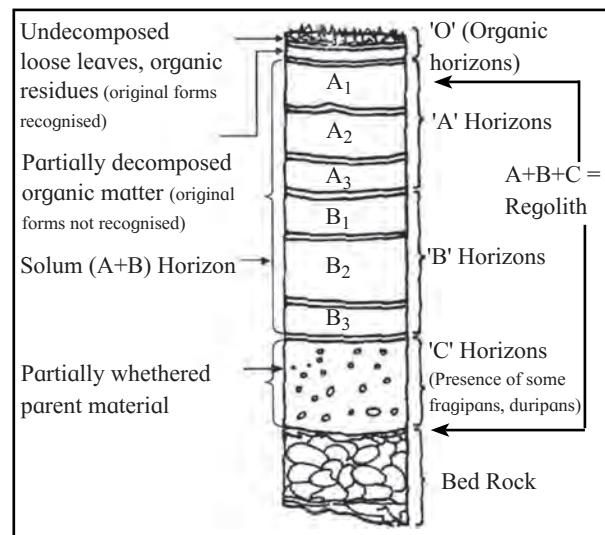


Fig 1.7 : Theoretical soil profile consisting of all horizons

1.5.2 Properties of soil :

Every soil has some important properties i.e. physical, chemical and biological.

I. Physical properties :- It indicates the coarseness or fineness of soil as determined by relative proportion of the various soil separates i.e., sand, silt and clay particles.

(a) Texture : Soils have different amount of sand, silt and clay particles which imparts coarse or fineness. Depending on the amount of a particular particle the soil is said to be sandy, loamy or clayey. In a clay soil, the percentage of clay particles is more, whereas in sandy, sand particles are in higher percentage. The soil textural class can be determined from the following triangle.

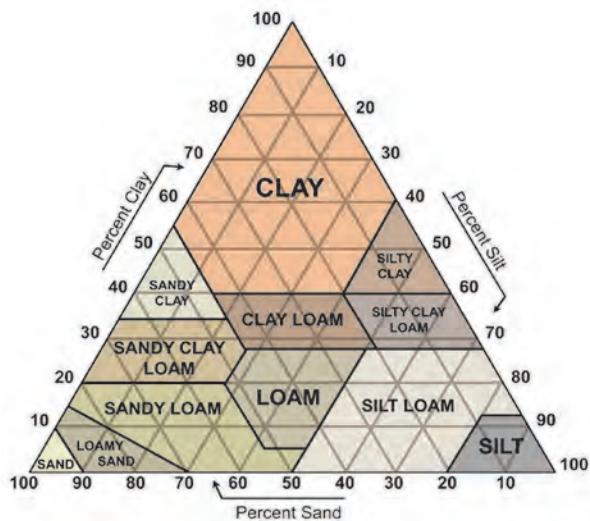


Fig. 1.8 : Determination of textural class (Textural Triangle)

Depending upon percentage of sand, silt and clay there can be intermediate classes of soil e.g. Sandy loam, clay loam, silty clay, loamy sand, etc.

Classification of soil separates as per International Soil Science Society System is as follows

Name of soil separate	Diameter limit (mm)
Sand particle	
(a) Coarse sand	2.00 to 0.20
(b) Fine sand	0.20 to 0.02
Silt particle	0.02 to 0.002
Clay particle	Less than 0.002

(b) Structure : The arrangement and organization of primary and secondary particles in a soil mass is known as soil structure.

When the arrangement is plate like i.e. one above the other then it is called as platey, when it has angles it is angular or when it is grain like then it is granular and like wise.

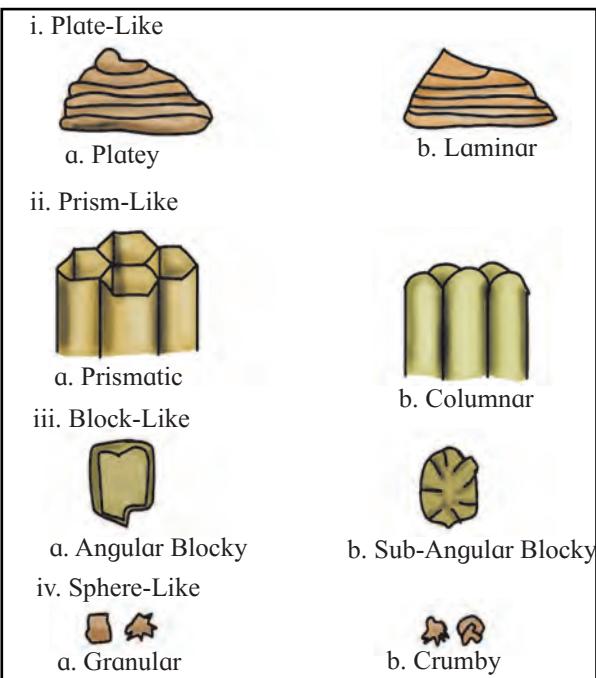


Fig. 1.9 : Different soil structures

- (c) Density of soil :** It represents weight (mass) per unit volume of substance. Soil density is expressed as particle density and bulk density.
- (d) Soil colour :** Different soil have different colours. The colour of soil is mostly due to iron, manganese compounds and also the organic matter present in the soil.
- (e) Soil temperature :** Soil temperature is measured with the help of soil thermometer. The favourable limit of soil temperature for biological activities and growth is from 27 to 32°C.
- (f) Plasticity :** Plasticity is the property of a material which when subjected to an external force allows it to be deformed rapidly without rupture of a plastic rebound and without volume change. Plasticity of soil is dependent on the amount of clay particles and the moisture percentage present in it.

(g) **Soil consistency** : It refers to the resistance of soil with various moisture contents to mechanical stresses. It is the best guide for tillage operations.

(i) **Soil Porosity** : It is the percentage pore space to total volume of the soil or porosity refers to percentage of soil volume occupied by pore spaces.

II. Chemical properties :- Soil pH, cation exchange capacity (CEC), organic carbon content are the chemical properties of soil.

(a) **Soil pH** : soil pH is defined as negative logarithm of hydrogen ion activity. Depending upon the concentration of hydrogen (H^+) or hydroxyl (OH^-) ions soil pH is determined. When the pH value is less than 7 the soil is said to be acidic and above 7 it is said to be alkaline.

(b) **Cation exchange capacity** : The capacity of soil to exchange the cations present in the surrounding medium is known as its CEC. Sandy soil have less CEC than silty and clayey soil.

(c) **Organic carbon**: The carbon present in the form of organic matter in soil is known as organic carbon. The organic matter may be present in different forms i.e. leaf litter, plant roots, crop residuals, microflora and fauna.

III. Biological properties :- In addition to physical and chemical properties the soil have also biological properties too. This is dependent on the amount of micro flora and fauna present in the soil. e.g. amount of bacteria, algae and fungi. This population is again dependent on the amount of organic matter because organic matter is the food of these micro organisms. The activities of some micro organisms are beneficial to each other. Some of the products of metabolism may serve as nutrients for plants / organisms. The organic acids liberated during biochemical changes are

useful to solubilize the plant nutrients. Thus the association between different organisms influences the activities of the soil population and there by the soil properties.

1.5.3 Functions of soil

Each soil have to perform specific functions. It has three fold functions to perform such as physical, chemical and biological.

Physical functions

It gives mechanical support for growth of plants. The plant is able to stand erect because of the hold exerted by the soil on plant roots. The roots are remified and they thus, anchored in the soil mass. The soil acts as reservoir of water and air. The plant absorb water through their roots. The roots breath oxygen from the air around soil mass. Soil also stores sun heat and applies it to the growing plant.

Chemical functions

Chemically the soil may be looked upon as a store house of plant nutrients. It contains organic and inorganic compounds. The weathering material of rocks and minerals constitutes inorganic compounds, while the decaying plant and animal remains furnish the organic compounds. The plant obtains its nutrients from these compounds. The different reactions going on in the soil causes decomposition of organic matter thereby brings the nutrients in soil solution and make them available for the plant nutrition.

Biological functions

Soil is the habitat of a very large number of organisms of both plant and animal origin. Some of the organisms like rodents, worms, insects, etc. are big while others like fungi, bacteria, etc are microscopic in size. Among the worms, nematodes and earthworms are important organisms. They aerate the soil and at the same time, disintegrate and mix its constituents by passing large quantities of soils through their bodies and ejecting the same on



the surface as “worm casts”. The quantity of soil passed through their bodies is enormous. About 25 tonnes of earth per hectare per year is turned over by the earth worms.

The ejected material is in a more pulverized condition and possess better fertility than the original soil.

This activity of earthworms leads to the transfer (inversion) of soil from lower layer to the surface.

These functions impart a dynamic character to the soil, which makes the soil fit for plant growth.

1.6 Soil health

Similar to human beings soil also have a health. Soil health is depend on the amount of plant nutrient content (soil fertility), soil productivity and the population of microorganisms.

Meaning



Remember this

Supply of nutrients depends upon soil fertility. Sustainability depends on productivity.

Doses of fertilizers are decided on the basis of fertility and the package of practices.

The presence of optimum population of microflora and fauna particularly the beneficial microflora is supposed to be responsible for good soil health. The soil rich in organic matter particularly the humified one possesses good soil health. The factors which affects the organic matter content of soil ultimately influence the soil health.

The results of long term fertilizer experiments indicated that, intensive cropping has declined the organic carbon content in soil, which resulted in reduced productivity. Some phosphatic fertilizers contain varying amounts of heavy metals which may accumulate and cause adverse long term effects on soil health.

Therefore, soil organic carbon is supposed to be the key nutrient for maintaining good soil health. Hence, the most logical way to manage soil health is the use of the Integrated Plant Nutrient Supply (IPNS).

Organic recycling also helps to improve soil health. It broadly includes-

1. Recycling in-situ i.e. green manuring, growing green manure crop
2. Recycling through external inputs (addition of green leaf manures, foliage, organic mulching etc.)
3. Recycling through composting.

1.6.1 Soil fertility :

It is considered as the capacity of soil to provide essential nutrients, in adequate amounts and in a proper proportion for the growth of plants, when other factors such as light, water, temperature and the physical condition of the soil are favourable. Soil fertility is an effect of soil-plant relationship viz., plant growth with reference to nutrients available in soil. In short, it is the inherent capacity of soil to supply nutrients for plant growth in adequate amounts and in a suitable proportions. Soil test indicate soil fertility.

1.6.2 Soil productivity :

Basically it is an economic concept and signifies the capability of soil to produce yield under specified system of management inputs and environmental conditions. This is not essentially a property alone, but a function of several factors. It is measured in terms of output i.e. production including management. It is the capacity of soil to produce per unit area under the given set of management practices. More simply it is the response to management in terms of yield per unit area.

All productive soils are fertile, but every fertile soil need not to be a productive. It may be due to some problems like water logging, salinity, alkalinity, adverse climatic conditions, etc. Soil test does not indicate soil productivity as a whole.



1.6.3 Difference between soil fertility and productivity

Soil fertility		Soil productivity
1.	It is considered as an index of available nutrients in the soil	It is the term used to indicate the yield of crops per hectare of land
2.	It is the property of soil to supply nutrients required by plants for their growth i.e. one of the factor of crop production	It is the inter relation of all these factors including soil fertility and the managerial techniques which determine the magnitude of yield.
3.	It can be determined by analyzing the soil in the laboratory for the content of nutrients in it	It can be assessed by conducting an experiment on field itself under a given set of management
4.	It is the potential / inherent status of the soil to produce crop which may or may not reflect in production.	It is the resultant of various factors influencing the production including the management skills.
5.	All fertile soils may not be productive	All productive soils are generally fertile.



Remember this

How to improve productivity

Fertility is the inherent property but productivity can be improved in various ways particularly with the sequestration of organic carbon. The maintenance of it should be considered both on a temporary and long term basis. The temporary measures include suitable cultural practices such as addition of organic manures, green manures, bio fertilizers, fertilizers, etc. Whereas longterm measures are the correction of problems such as reclamation, addition of amendments, adoption of suitable soil conservation practices, improved agricultural techniques, etc. All these will be helpful in improving fertility and thereby the productivity.



Mind and Understand

How soil fertility is affected ? There are many factors which if not handled properly, can adversely affect the soil fertility.

Tillage : If soil is not worked at the optimum moisture level, it may disturb soil structure, ill-drainage, etc. which will affect the soil fertility.

Fertilizers : The imbalanced use of fertilizers may hamper soil fertility. Soil salinity/sodicity can affect the soil fertility.

Erosion : the runoff can form gullies and the fertile soil can be lost.

Water stagnation also affects the soil fertility.

Weed infestation can reduce the yield of crop.

Exercise



Q.1 A. Fill in the blanks.

1. Hard mass of mineral matter comprising of two or more minerals is called as -----.
2. Naturally occurring inorganic substance having a definite chemical composition and physical properties is known as -----.
3. Acid igneous rocks contain ----- percent silica.
4. Earth crust contains ----- percent feldspar.
5. Basalt is an example of ----- type of rock.

B. Make the pairs.

'A' Group	'B' Group
1. Igneous rock	a. Primary mineral
2. Gabbro	b. Secondary mineral
3. Feldspar	c. Basic rock
	d. Granite
	e. Dolomite

C. State true or false.

1. The rock formed by metamorphism is known as metamorphic rock.
2. Magnetite is an example of accessory mineral.
3. Earth crust contain 13 % Quartz.
4. Soil texture indicates its coarseness or fineness.
5. Arrangement of soil separates in the form of aggregates is called as soil structure.

Q. 2 Answer in brief.

1. Give the examples of heavy and light minerals.
2. What is meant by soil texture?
3. List out the types of soil structure.
4. Name the factors affecting soil fertility.
5. Classify the soil separates as per international soil science society system.

Q. 3 Answer the following questions.

1. Explain chemical properties of soil.
2. Draw and label soil profile.
3. Complete the following chart

Sr. no.	Mineral	Any two examples
1	Essential	
2	Accessory	
3	Secondary	
4	Primary	

4. Describe with diagram the types of soil structure.
5. Explain biological functions of soil.

Q. 4 Answer in detail.

1. Define rock and give its classification.
2. What is meant by mineral and give its classification on the basis of different aspects.
3. What do you mean by soil ? Describe its physical properties.
4. Define soil and give its functions.
5. What is meant by soil fertility? Differentiate it from soil productivity.

Activity :

Collect soil samples from the field and label them with brief description.



2.

Weather and Climate



Do you know ?

- Which are the different cropping seasons in Maharashtra? How they are identified?
- What is the difference between weather and climate?
- What is the role of meteorological department in farming?
- What do you mean by meteorology, agrometeorology and atmosphere?



Remember this

The success or failure of crops is intimately related to weather condition during the crop growth period. People often confuse weather with climate, but both are not the same. Between these two, climate is of prime importance. It is often rightly said that 50% of the variation in crop yields are due to climatic condition alone. Weather has significant influence on every phase of agricultural activity from preparatory tillage to harvesting. Climate is a factor which is beyond the control of farmer. Therefore, a sound knowledge of weather and climate with their elements is essential for successful agriculture.

2.1 Definition : Weather and climate

2.1.1 Weather :

Weather may be defined as follows.

- Weather is the condition of the atmosphere at a particular place over a short period of time.
- Weather refers to every day changes in the behaviour of atmosphere at the given place and a given time.
- Weather pertains to smaller area like village, city or even district and smaller

duration of time i.e part of a day e.g. rainy day, hot day or cloudy weather, etc. It always differs from time to time.

2.1.2 Climate : Climate may be defined as follows.

- Climate pertains to average weather condition over a period of time or season.
- Climate is the weather conditions related to longer periods like month, season or year and is described by normal and average e.g. cold season, tropical, subtropical climate. It is more or less stable and differes from 'region to region'.



Always remember

Atmosphere : The earth has a thick layer of air called as the atmosphere.

It is colourless, tasteless and odourless mixture of gases that surrounds the earth. The atmosphere is present within a height of 32km from the earth surface.

Composition of Air

According to NASA the major gases found in earth's atmosphere include.

1. 78% Nitrogen
2. 21% Oxygen
3. 0.03% Carbon di-oxide
4. 0.93% Argon



Can you imagine?

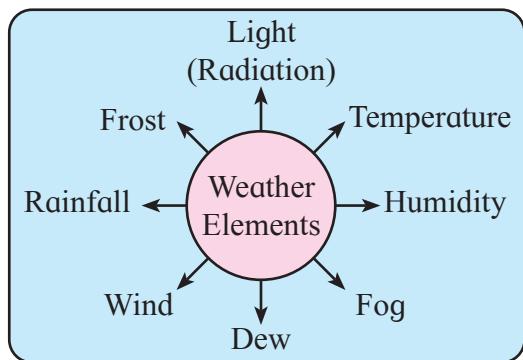
Why particular crop is grown in specific region and season?

2.2 Weather elements and their effect on crop growth.

2.2.1 Temperature: Temprature is the degree of hotness or coldness of a substance. Solar radiation is the main source of heat energy through which the atmosphere is indirectly heated up.



The rotation of earth cause the change in temprature during day and night. Temprature is measured by thermometer calibrated in the scale of celsius ($^{\circ}\text{C}$), fahrenheit ($^{\circ}\text{F}$) and kelvin ($^{\circ}\text{K}$).



Try this

Formulae to convert the reading from

$$\text{Celsius into Fahrenheit} \quad ^{\circ}\text{F} = \frac{9}{5} \cdot ^{\circ}\text{C} + 32$$

$$\text{Fahrenheit into Celsius} \quad ^{\circ}\text{C} = \frac{5}{9} \cdot (^{\circ}\text{F} - 32)$$

$$\text{Celsius into Kelvin} \quad ^{\circ}\text{K} = ^{\circ}\text{C} + 273$$

Effect of temperature: Temperature has great influence on the existence of plants. Each plant species has maximum and minimum limits of temperature for growth. Optimum temperature is essential for better growth and development of plants. Most of the crop plants make their best growth and development between 7°C to 32°C . Optimum temperature is necessary for seed germination, vegetative growth, flowering, fruiting, maturity and higher yields. Photosynthesis and respiration rate increases in high temperature. It also reduce sugar content, increase water requirements. Low temperature causes chilling/ freezing injuries.

2.2.2 Rainfall : Rainfall is precipitation in the form of liquid drops larger than 0.5 mm in diameter falling on earth. Ordinary rain drop varies from 0.5 to 4 mm in diameter.

Effect of rainfall : Rainfall has beneficial as well as harmful effects on crop growth.

It is the main sources of water for plant growth. Water performs number of vital functions in crop growth. Quantity of rainfall is not only important but its even distribution increases crop yield. Rainfall pattern determines cropping system. It reduces salt, maintains pH and nutrient availability.

Heavy and excess rain results in flood and waterlogged condition in the field. Flood causes soil erosion and damage to the crops on river banks. Water logging affects soil aeration and root function. Heavy rain affect pollination and fertilization. Long dry spell affect growth and yield of the crop. Heavy and continuous rains during harvesting period result in prolonged harvesting time. There may be mouldy grain formation on earhead, which reduce quality of entire produce.

2.2.3 Sunlight (Solar radiation) : Sun is the prime source of energy injected into the atmosphere. Solar radiation is received in the form of electromagnetic waves. It consist of stream or flow of particles. These particles are called quanta or photon.

Effect of sunlight : Growth of crop is favoured by sufficient sunlight and retarded by lack of sunlight. Quantity, duration and intensity of solar radiation influences plant development and plant processes. It is necessary for photosynthesis, the process in which green plant prepare their own food material. The life process of many plants is influenced by the length of day which is called photoperiodism. On the basis of photoperiod required for flowering plants are classified as short day and long day plants and day neutral plants. Red and blue colour light stimulate plant growth, flowering, while green light has minimum effect. Insufficient light produces weak plants which are susceptible to diseases.



Practice this

Conversion of figures from

- mm into cm.
- cm into inch.
- inch into mm.

2.2.4 Humidity: Humidity refers to the water vapour content of the atmosphere. Liquid water is converted into water vapour by evaporation. The amount of water vapour in the atmosphere depends upon wind and temperature.

Humidity are of two types (a) **Specific humidity (relative)**. It means weight of water vapour per unit weight of air (including water vapour).(b) **Absolute humidity** - It is actual quantity of water vapour by weight present in a given volume of air.



Do this

Distribute different agronomic crops as short day and long day crop on the basis of photoperiod. Also distribute crops which are grown as irrigated and rainfed.



Try this

Calculate absolute humidity (g/m^3) when 2 cubic metres of air contains 10 g of water vapour.

Use formula - Absolute humidity (g/m^3)

$$= \frac{\text{Weight of water vapour}}{\text{Volume of air}}$$

Effect of humidity : Relative humidity directly influences water relations of plants and affects crop growth. High humidity reduce transpiration and evaporation losses of soil water. Low humidity increases the water requirements of the crop and affect the growth and yield of crop. Atmospheric humidity affects pollination, photosynthesis, flowering, fruiting, etc.

Leaf enlargement is more in humid condition. High humidity increases the attack of pest and diseases.

2.2.5 Wind : Wind is the horizontal flow of gases from high pressure area to a low pressure area. The natural movement of air, especially in the form of current air blowing from particular direction. Lee ward - from which it blows and wind ward - where it blows.

Effect of wind : Wind increases crop water requirements by increasing evaporation. It is useful for pollination in cross pollinated crops. It helps to increase supply of carbon dioxide for photosynthesis. Wind alters balance of hormones. Wind helps in winnowing operation. Tall crops during high wind velocity lodge which adversely affect quality as well as quantity of yield. It also causes shedding of flowers and fruits, damages shoot, increases rate of evaporation and transpiration, reduces soil moisture, causes soil erosion.

2.2.6 Dew : Dew is water in the form of droplets that appears on thin object in the morning or evening due to condensation. The temperature at which condensation occurs is called the dew point. It is the form of direct condensation of water vapour to liquid drops. It occurs on grass cover, leaves, metallic surface, paper, window glasses, etc.

Effect of dew : It occurs in winter season during morning hours and useful for dry rabi crops like wheat, gram, etc. Foliar absorption of dew is an important factor in survival of natural vegetation in arid region. Dew reduces transpiration losses of water and minimizes crop water requirements. Dew formation increases humidity which increase incidence of pest and diseases.

2.2.7 Fog : Fog is a visible aerosol consisting tiny water droplets or ice crystals suspended in the air at or near the earth surface.



It can be considered as a type of low-laying cloud. Fog commonly occurs in the early morning hours during winter season. It is formed when air temperature near ground falls below dew point temperature, wind is calm and relative humidity is more than 75%.

Effect of fog : Prolonged foggy weather has adverse effect on vegetables and cause discolouration of leaves. It increases soil water availability and reduces physiological activities.

2.2.8 Frost : When the dew point is below 0° C, moisture passes directly from gaseous to solid state resulting in the formation of ice crystals called as ‘Frost’. It mostly occur in the valleys of the mountains.

Effect of frost : It affects the pollination and seed setting in most crops. It may cause cracking of fruits and bad effect on quality of fruits. It causes freezing injury to plants by extra cellular ice formation and cellular dehydration.



Try this

Visit to a meteorological observatory and observe how different weather parameters are measured.

2.3 Instruments of measuring weather elements :

The different instruments and the units used for measuring of weather parameters are as follows

2.3.1 Stevenson Screen : It is a wooden box, that made up of a double layer screens and is used to shield meteorological instruments. It shelters meteorological instrument against rainfall and direct heat radiation. However, it allows air to circulate free around them. It is painted with white colour to reflect sun radiations.



Fig. 2.1 : Stevenson screen

2.3.2 Thermometer : The thermometer is a device used for measuring atmospheric temperature.

The thermometer have two important parts i.e. sensor or bulb and a tube having visible scale. The unit used to record the readings are degree Celsius, degree Fahrenheit and degree Kelvin.

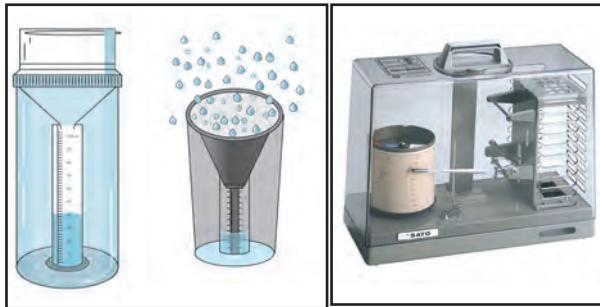
The thermometers are widely used in industry, meteorology, medicine and in scientific research. In meteorology it is used to record minimum - maximum, atmospheric i.e. air and soil temperature. Thermograph is a mechanical device which records air temperature and graphs continuously.



Fig 2.2 : Minimum and maximum thermometer

2.3.3 Rain guage : The instrument used for measuring the amount of rainfall is called as rain gauge. The rainfall is measured in terms of depths of rain water in millimetre, centimetre and inch.





(i) Non record-ing rain gauge (ii) Self recording rain gauge

Fig. 2.3 : Rain gauge

There are two types of rain gauge.

- (i) Non-recording or ordinary rain gauge.
- (ii) Self recording or automatic siphon rain gauge.

2.3.4 Pyranometer : The instrument used to record total incoming radiation is called as ‘Pyranometer’.

Solar radiations are expressed in terms of watts per square meter.

2.3.5 Sunshine recorder (Heliograph) : It is the instrument used to record the duration of bright sunshine during the day time.



Fig 2.4 : Sunshine recorder

2.3.6 Anemometer and wind vane : The speed at which wind is flowing is called as wind velocity. The wind velocity i.e. wind speed is recorded in knots (nautical miles per hour), meter per second (mps), kilometre per hour (kmph) and miles per hour (mph).

The 'anemometer' is a device that is used to measure wind speed or wind velocity. Whereas 'wind vane' is used to detect the direction of wind. The wind vane points the direction of wind.



Fig 2.5 : Anemometer

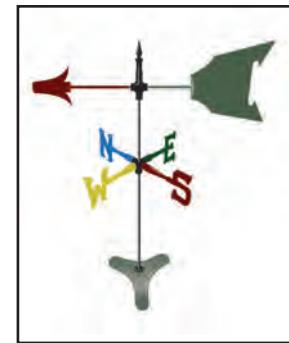


Fig 2.6 : Wind vane

2.3.7 Psychrometer / Hygrometer :

Relative humidity is the amount of water vapours present in the air. It is expressed in percentage of the amount needed for saturation at the same temperature.

The instrument used for measuring relative humidity is called as ‘hygrometer’ or psychrometer. Psychrometer consist of two bulbs with thermometer i.e. wet bulb and dry bulb and reads humidity based on the differences between two.

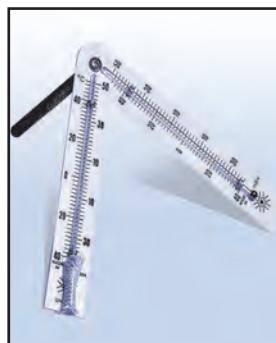


Fig 2.7 : Psychrometer



Fig 2.8 : Hygrometer

2.3.8 Dew gauge : Dew is recorded by using the instrument called as dew gauge. The unit of measurement is mm.

Table 2.1 : Weather elements, instruments and their units.

Sr.No.	Weather element	Instrument for measurement	Unit
1.	Temperature	Thermometer Thermograph	Degree Fahrenheit, Celsius and Kelvin
2.	Rainfall	Ordinary rain gauge Automatic siphon rain gauge	Millimeter, centimeter, inch
3.	(a) Solar radiation (b) Light	Pyranometer Sunshine recorder (Heliograph)	Watts per square meter Duration of bright sunshine
4.	(a) Wind velocity (b) Wind direction	Anemometer Wind vane	Knots, meter/sec, km/hr., miles/hr. East-west, North - south
5.	Relative humidity	Psychrometer or Hygrometer	Per cent (%)
6.	Dew	Dew gauge	mm

2.4 Weather forecasting

2.4.1 Meaning

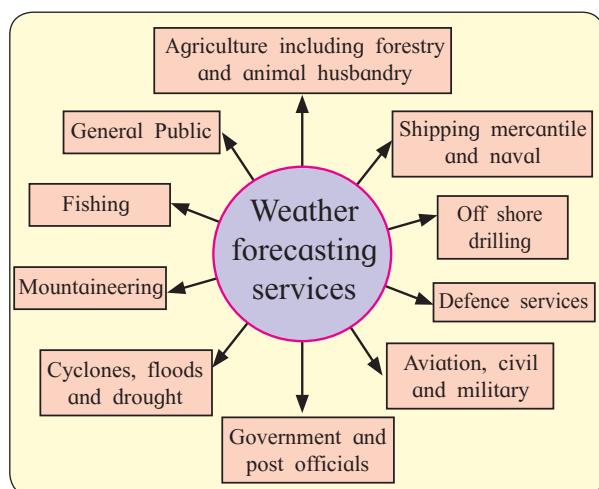
Weather forecasting is defined as prediction of state of the atmosphere for a given location. Weather forecasts are important as they are issued to protect life and property, to save crops and to tell us what to expect in our atmospheric environment.

As crop growth and its yield is highly influenced by weather elements or adverse climatic condition, the producer have to face huge losses of their crop.

Generally people have attempted to predict the weather from thousands of year ago, but scientifically it is done since 19th century. In the agriculture based country like India where, about 70% of farming is depending on rainfall, accurate weather forecast should have to be made available for farmers well in advance to minimize crop losses.

Accurate weather forecasting that is made well in advance can help the farmers in planning of timely land preparation, selection of crop, time of sowing, method and time of fertilizer application, other interculture operations and finally harvesting of his crop. Indian Meteorological Department (IMD) is established in 1875 with headquarter at Pune. Agricultural Meteorological Division is started in 1932 to conduct research on crop and weather relationships.

For this purpose a major step was taken to set up specialized meteorological observatories in a crop environment to inculcate weather consciousness among farmers. This has resulted in steady growth of observatories all over India, which at present numbers about 125.



Weather forecasting services for different purposes normally practiced in India

However, the weather reports are prepared by five regional forecasting centres which are situated at Chennai, Nagpur, Mumbai, Delhi and Kolkata.

2.4.2 Importance of forecast

Accurate weather forecasting helps the farmers in realising economic yields by minimising the crop losses by -

- (1) Planning for necessary inputs during the season.
- (2) Timely land preparation to take advantage of earliest rain.
- (3) Selection of crops and cultivation.
- (4) Efficient use of fertilizers.
- (5) Predicting pest and disease incidence.
- (6) Timing of weeds, pests and diseases control.
- (7) Reducing adverse effects of weather hazards.
- (8) Timely crop harvesting.

2.4.3 Types of weather forecasting

Based on time or duration of forecasting period, the weather forecasting can be divided into three types : (1) short range forecasting (2) medium range forecasting (3) long range forecasting

(1) Short range forecasting :

These forecasts are for a day or two. These daily forecasts are useful to irrigation engineers, mariners, aviation engineers and farmers.

(2) Medium range forecasting :

These forecasts are for a period of three to ten days.

(3) Long range forecasting :

These forecasts are for periods of more than four weeks. The long range forecasts are useful for choosing cropping pattern. These forecasts are issued thrice in a year.



Internet my friend

1. Collect information about agro climatic zones of Maharashtra.

2.4.4 Methods of forecasting : There are three methods of weather forecasting.

1. Conventional or synoptic method : Synoptic method involve detailed analysis of current weather reports, from a large area. The current patterns are related with the past analogous situations and forecast are prepared on the assumption that a current situation will match the past analogous situations. This method is useful for short range forecast.

2. Statistical method : Regression equation or other sophisticated relationships are established between weather elements and resulting climate. Normally selection of predictors or weather parameters is based on a possible relationship with the predictant. These techniques are useful for short as well as long range forecasting.

3. Numerical weather prediction technique : In this technique, the behaviour of atmosphere is represented by a set of equations based on physical laws governing air movement, air pressure and there information. This technique is found suitable for medium forecasts.



Fig 2.9 : Meteorological field laboratory

Exercise

Q. 1 A. Fill in the blanks.

1. Wind velocity is measured by using instrument.
2. Weather refers to changes in the atmosphere at given place.
3. Ordinary rain drop varies from mm in diameter.
4. The prediction of weather situation that is likely to develop is called
5. The mechanical device used to record air temperature continuously is

B. Make the pairs.

- | 'A' Group | 'B' Group |
|-------------|----------------|
| 1. Light | a. Anemometer |
| 2. Wind | b. Hygrometer |
| 3. Humidity | c. Thermometer |
| | d. Pyranometer |
| | e. Rain gauge |

OR. B. Find the odd out.

1. wind/ temperature / humidity / atmosphere / light
2. dew / climate / fog / rainfall / frost
3. thermometer / hygrometer / tensiometer / anemometer /rain gauge
4. thermometer / anemometer / hygrometer / lactometer / pyranometer

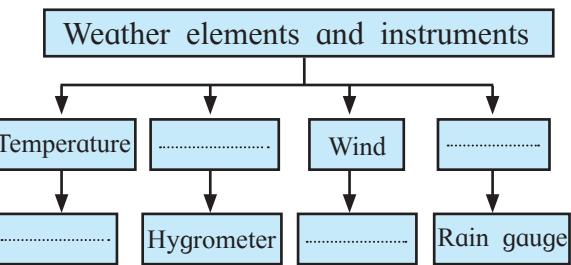
C. State true or false.

1. Hygrometer is used for measuring rainfall.
2. Short range forecasting is predicted for more than four weeks period.

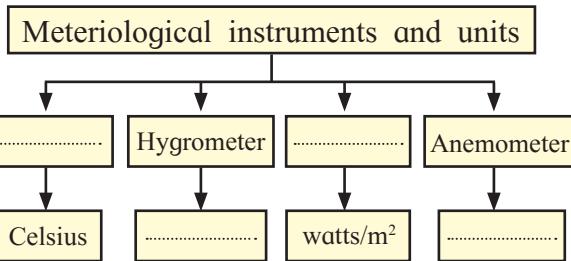
3. Stevenson screen is used to shield meteorological instruments.
4. Thermograph is used to record duration of sunshine.
5. High humidity reduces transpiration rate in plants.

Q. 2 Answer in brief.

1. Write a note on temperature.
2. What is weather forecasting?
3. Complete the following chart.



4. What are the types of weather forecasting?
5. Complete the charts.



Q. 3 Answer the following questions.

1. Explain effect of rainfall on crop growth.
2. Explain effect of humidity and sunlight on crop growth.
3. Differentiate weather from climate.

4. Convert the following from celsius into Fahrenheit.
 - (a) 35°C
 - (b) 10°C
 - (c) 25°C
 - (d) 37°C
5. Describe the methods of weather forecasting.

Q.4 Answer in detail.

1. Complete the chart.

No.	Weather elements	Instrument of measurement	Unit
1.	Temperature	(a) (b)
2.	Rain gauge	(a) (b)
3.	Wind
4.	Hygrometer

2. Explain the importance of weather forecasting for farmers ?
3. Write in detail about the services where forecasting is important.
4. Explain effects of rainfall, wind and fog on the growth of crop.
5. Give information about different instruments used for measuring weather elements with their unit?

Activity :

Record different weather elements by using respective meteorological instruments.



Courtesy : Indian Meteorological Department, Pune



Recall a little

- Agriculture is the back bone of Indian economy.
- Lack of technology adoption is the cause for low productivity in agriculture.
- Government is promoting organized farming in the form of Farmer Producer Organization / Company.
- Modern agricultural technologies have the potential to change this scenario.

Organised farming

Though India has agriculture as a major occupation, productivity and profitability is far below the expectations.

Organised farming is a group of producers coming together to pursue specific common interest of their members and developing technical/economical activities that benefit them.

Decrease in total land holding per capita is also a restricting factor for developments in agriculture. Need is to organise the farm and farmers for efficient farming. There are some patterns of organised farming which can be discussed.



Can you tell?

- Why farmers should be motivated to start organized farming ?
- Any example of organized farming in your region ?

3.1 Community farming

Meaning and Description

When number of individuals come together for collective farming on a certain piece of land, it is called as community farming. Here the land may be owned or leased by the participants.

Decisions and actual practices may be the responsibility of the group or of some authorised persons. Generally, the purpose of community farming is to reduce cost of cultivation, increase productivity and to harness the benefit of large scale farming. Farmers having small land holding also tend to unite for community farming.

Currently, people having interest in farming but do not have cultivable land also use to participate in community farming. Agencies providing such facility are active on websites. Here, the participants from different occupations can register their names, hire a piece of land and select the crops to be grown. Charges are applied according to crop selected. All operations are carried out by the agency, regular updates are provided on website and through messages. The participant can also visit the farm and enjoy actual working in the field. Produce from the hired land is delivered to the owner in the form of goods or money.

3.2 Farmers producer organization/company

3.2.1 Meaning

Farmers from a locality come together to form a Farmers Producer Organization (FPO). Through FPO, farmers adopt commercial practices like tie up with market, primary processing, branding, marketing, etc. For convenience of banking and to give professional framework, the FPO may be registered under company act as Farmer Producer Company (FPC).

3.2.2 Advantages

Following advantages can be obtained by formation of FPO / FPC

- (1) Limitations of decreased land holding are eliminated.
- (2) Minimizes cost of production by collective purchasing of inputs.

- (3) Production of uniform quality crop as per demand and market linkage gives premium rates to the produce.
- (4) Working together in the organization facilitate communication and exchange of ideas. This favours transfer of information and adoption of advanced technologies.
- (5) Funding agencies and government departments give support on priority.
- (6) Role and responsibilities can be devolved among members.
- (7) Resources and machinery can be utilized more efficiently e.g. lift irrigation, combine harvester, etc.

Key points for formation of FPO / FPC

Agency for Technology Management in Agriculture(ATMA) is a division of government agriculture department having authority to register such organization and support for further activities.

- (1) As per current guidelines, group of minimum 20 farmers is eligible to form FPO.
- (2) Application in format should be submitted to ATMA, Taluka Agriculture Office (TAO).
- (3) Project Director, ATMA / District Superintendent Agriculture Officer (DSAO) issues letter of registration.
- (4) Bank account can be opened in the name of registered FPO. Authorised signatories of the group can operate the account.
- (5) FPO can purchase inputs or sale the produce and have transactions through this account.
- (6) Registered FPO can apply for various schemes of government and avail the support.
- (7) Different activities like field day, farmers rally, visit to research stations and successful entrepreneurs, training programs, etc. can be conducted.
- (8) FPO can be registered as FPC under ministry of corporate affairs.

- (9) While formation of FPC, digital signature of director having signing authority and Director Identification Number (DIN) are essential.



Try this

- Visit nearby office of the agriculture department
- Collect information regarding government schemes & projects supporting farmers for organized farming

3.3 Corporate farming

3.3.1 Meaning

When farming is done by a company on its own farm or leased farm, it is referred as corporate farming. Main objective is production of agricultural goods as per market demand. Because of corporate farming, there is fast dissemination of advanced technology. The corporate sector may also have some research activities from such farming.

3.3.2 Advantages of corporate farming

- (1) Waste lands, uneconomic lands, fallow lands owned by farmers or government may be leased to a company and made productive.
- (2) New patterns of cultivation are popularized in the region.
- (3) Farmers may be demonstrated the advanced technologies applied at such farms.
- (4) Corporate farming may also help in agricultural education, extension and research activities.
- (5) There is overall increase in employment generation, productivity and economy of the region.
- (6) Some infrastructure facilities like marketing, transport, processing can be developed by corporate farming.
- (7) Availability of funds is not the limitation.

3.4 Contract farming

3.4.1 Meaning

In contract farming, an agreement is executed between the producer and the consumer / buyer. Certain parameters are fixed to define quality of the produce to be purchased. Stipulated time and quantity are also important aspects to be followed by both parties. Specific product or products are mentioned in the contract as per desire of the buyer and willingness of the producer to supply accordingly. In this way producer commits to supply agricultural goods and buyer commits to purchase it.

3.4.2 Contract farming business models

(i) **Informal model** - This model is short term and risky of all contract farming models, with a risk of default by both the promoter and the farmer. However, this depends on the situation - interdependance of contract parties or long-term trustful relationships may reduce the risk of opportunistic behaviour.

Special features of Informal Model are

- (1) Small firms execute simple, informal seasonal production contracts with small holders.
 - (2) The success often depends on the availability and quality of external extension services.
 - (3) Some services may be provided and are limited to the delivery of basic inputs, occasionally on credit; advice is usually limited to grading and quality control.
 - (4) Typical products: requiring minimal processing / packaging, vertical coordination; e.g. fresh fruits / vegetables for local markets, sometimes also staple crops.
- (ii) **Intermediary model** - In this model, the buyer subcontracts an intermediary (collector, aggregator or farmer organisation) who formally or informally contracts farmers (combination of the centralised/ informal models).

Special characteristics of Intermediary Model are

- (1) The intermediary provides selected services (usually through services provided by buyers against service charges) and purchases the crop.
 - (2) This model can work, if well designed and if incentive structures are adequate and control mechanisms are in place.
 - (3) This model can bear disadvantages for vertical coordination and for providing incentives to farmers (buyers may lose control of production processes, quality assurance and regularity of supplies; farmers may not benefit from technology transfer; there is also a risk of price drop and reduced incomes to farmers).
- (iii) **Multipartite model** - This model is development of the centralised or nucleus estate models. It involves various organisations such as governmental statutory bodies, alongside private companies and sometimes financial institutions.

Special characteristics of Multipartite Model are

- (1) This model may feature as joint ventures of organizations/ community companies with domestic/ foreign investors for processing.
- (2) The vertical coordination depends on the policy of the firm. Precaution is to be taken to avoid political interference.
- (3) This model may also have additional agreements with third party service providers (e.g. extension, training, credits, inputs, logistics, etc.).
- (4) Separate organisations (e.g. cooperatives) may organise farmers and provide embedded services (e.g. credits, extension, marketing, sometimes also processing).
- (5) This model may involve equity share schemes for producers.

(iv) **Centralized model** - In this model, the buyers' involvement may vary from minimal input provision (e.g. specific varieties) to control of most production aspects (e.g. from land preparation to harvesting). This is the most common contract farming model.

Special characteristics of centralized Model are

- (1) The buyer sources products from and provides services to large numbers of small, medium or large farmers.
 - (2) The relation / coordination between farmers and contractor is strictly vertically organised.
 - (3) The quantities (quota), qualities and delivery conditions are determined at the beginning of the season.
 - (4) The production and harvesting processes and qualities are strictly controlled, sometimes directly implemented by the buyer's staff.
 - (5) Typical products: large volumes of uniform quality usually for processing; e.g. sugarcane, tobacco, tea, coffee, cotton, tree crops, vegetables, dairy, poultry, etc.
- (v) **Nucleus estate model** - In this model, the buyer sources both from own estates/ plantations and from contracted farmers. The estate system involves significant investments by the buyer into land, machines, staff and management.

Special characteristics of nucleus estate model are

- (1) The nucleus estate usually guarantees supplies to assure cost efficient utilisation of installed processing capacities and to satisfy firm sales obligations respectively.
- (2) In some cases, the nucleus estate is used for research, breeding or piloting and demonstration purposes and/ or as collection point.

(3) The farmers are at times called 'satellite farmers' illustrating their link to the nucleus farm. This model was in the past often used for state owned farms that re-allocated land to former workers. It is now a days also used by the private sector as one type of CF. This model is often referred to as "outgrower model".

- (4) Typical products: perennials

3.4.3 Advantages of contract farming

Contract farming is looking towards the benefits both for the farm-producers as well as to the agro-processing firms.

- (1) Makes small scale farming competitive - small farmers can access technology, credit, marketing channels and information while lowering transaction costs.
- (2) Assured market for their produce at their doorsteps, reducing marketing and transaction costs.
- (3) It reduces the risk of production, price and marketing costs.
- (4) Contract farming can open up new markets which would otherwise be unavailable to small farmers.
- (5) It also ensures higher production of better quality.
- (6) Financial support is available in cash and /or kind and technical guidance to the farmers.
- (7) In case of agri-processing, it ensures consistent supply of agricultural produce with quality at right time and lesser cost.

3.4.4 Limitations in contract farming

- (1) Contract farming arrangements are often criticized for being biased in favour of firms or large farmers, while exploiting the poor bargaining power of small farmers.
- (2) Problems faced by growers like undue quality cut on produce by firms, delayed deliveries at the factory, delayed payments, low price and pest attack on the contract crop which raised the cost of production.

- (3) Contracting agreements are often verbal or informal in nature, and even written contracts often do not provide the legal protection in India that may be observed in other countries. Lack of enforceability of contractual provisions can result in breach of contracts by either party.
- (4) Single Buyer – Multiple Sellers (Monopsony).



Try this

- Visit a nursery, polyhouse, etc. and observe the modern technology.

- (5) Adverse gender effects - Women have less access to contract farming than men.

3.5 Commercial agriculture

3.5.1 Agriculture technology

Fast revolutions in technology are seen in the field of agriculture from last three decades. Though some technologies have contradictions regarding environment and sustainability, it is the need of time to feed the ever growing population of the world.

Advancements in technology include sensors, devices, machines, and information technology. Modern agriculture uses sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and Global Positioning System (GPS) technology. These advanced devices, precision agriculture and robotic systems allow agriculture businesses to be more profitable, efficient, safer, and more environment friendly.

Importance of agriculture technology

- (1) Instead of traditional farming, commercial agriculture is oriented to give maximum profit per unit area.
- (2) All inputs are targeted for specific increase in returns.
- (3) It helps to exploit capacity of the soil, crop variety and other resources and fulfill increasing needs of the population.

- (4) It gives higher crop productivity and ultimately profitability.
- (5) Judicious use of water, fertilizers, and pesticides keeps product prices down.
- (6) Reduced impact on natural ecosystems.
- (7) Less runoff of chemicals into rivers and groundwater.
- (8) Increased worker safety due to mechanization and automation.
- (9) Robotic technologies enable more reliable monitoring and management of natural resources.
- (10) Logistic management in handling, transport, storage and marketing minimizes losses of the produce.
- (11) Advanced processing and preservation technology allows value addition and increases profitability.

3.5.2 Innovations in agriculture

Innovative agricultural practices

Innovations in agriculture has opened new horizons for software industry and on the other hand, software has increased potential of modern agriculture in many folds. It involves use of data management, mechanization, automation, sensors, genetic engineering, drones, processing and packaging technology, logistics management, etc.

Declining natural resources and increasing population are alarming conditions to use advanced technologies for survival of human race.

Some of the innovative agricultural practices and technologies are :

1. Artificial intelligence and automation

The revolution of mechanization in agriculture helped farmer to get rid of tedious, labour consuming operations and also to curtail cost of cultivation. But still handling of the machines is main hurdle. Artificial intelligence (AI) is now used to command many farm operations. GPS based programmed tractors now make most of the heavy operations easy.

Sensor based equipments for irrigation, sowing, weeding, harvesting, etc. empowered with artificial intelligence eliminate human interference in agriculture. AI imparts accuracy and punctuality in operations resulting in the maximum utilization of inputs and increasing productivity.

2. Use of drones in agriculture

Foliar application of inputs like pesticides, fertilizers, growth regulators, weedicides, etc. is not only expensive but also full of risk for the operators. Restrictions in spraying due to wet soil, densely populated crops like sugarcane, can be overcome by the use of drones. Drones may be operated by remote control or by programming with GPS parameters. It is going to be a new opportunity of employment to provide drones on rent or contractual system.



Fig 3.1 : Use of drone for spraying operation

Drones are also used to get quick look of the field to observe attack of diseases and pest, nutrient deficiencies, water trace, etc. Very soon drones may be used for harvesting and delivery up to consumer.

Indiscriminate use of chemical pesticides has drastically decreased population of honeybees. Number of honeybee species are already became extinct and many are on the way. They are most important pollinating agents and in the absence of which human race can't get food for survival. In some crops drones are now used to pollinate the flowers by moving drones nearby the trees.

3. Urban agriculture

Because of crowding, pollution and hectic lifestyle, urban people are always in search of a hobby which can give scope for their creativeness and feel pleasure. Most of them have affection towards agriculture. But they have no agricultural land or other facilities. Novel concept of vertical gardening allows such people to grow flowers, vegetables and fruits also in their balconies, terrace, common places, etc. Use of cocopeat, hydroponics and aeroponic technologies are also adopted in urban agriculture. Municipal corporations, railway, corporate buildings, apartments, etc. are now covering their walls, pillars and terrace by vegetation. Here cocopeat is used as media for growing, as it is light in weight and having higher water holding capacity. Vertical gardens are expensive as compared with ground-level gardens. It requires panels and framework, specially designed pots, irrigation system and maintenance.



Fig 3.2 : Terrace garden



Fig 3.3 : Vertical garden

Advantages of urban agriculture

- (1) It improves aesthetic value of the place to spread pleasure.
- (2) Vegetation also helps to control temperature, absorb pollution, trap carbon dioxide and dust.
- (3) It also absorbs sound waves, avoids reflections ultimately decreasing sound pollution.
- (4) Indirectly helps to maintain biodiversity in the urban region where it is under high risk.
- (5) It gives scope for creativity to the urban people.
- (6) It gives higher productivity per unit area which can inspire the traditional farming.

4. Hydroponics

Hydroponics is a technique to grow plants on a base of water i.e. hydro. As no soil is used in this case, essential plant nutrients are added in the water to nourish the plants. Nutrients can be sourced from organic substances or chemical fertilizers. Roots are exposed in this solution or may be supported by an inert medium such as perlite or gravel. Sub irrigation or top irrigation is provided for continuous circulation of media solution. Containers other than metal i.e. made from plastic or glass are commonly used. Whole root zone is excluded from light to avoid algae and fungal growth in the solution.

Hydroponic can be classified as per maintenance of the media solution as below

(i) Static solution culture

In static solution culture, media solution is stable in the container. Particular level is maintained to keep some of the roots exposed in air for availability of oxygen or the solution may be aerated by using aquarium aeration pump system. When concentration of nutrients in the solution is decreased, new solution is added or previous one is replaced periodically. Static solution hydroponic method is generally followed for home scale or small units.



Fig 3.4 : Static solution culture

Containers like used drums, plastic buckets, packing materials, pvc pipes, etc. are used at home. It is simple and low cost method.

Green fodder production by sowing seed of Maize is commonly used hydroponic by dairy farmers in India. Fodders including maize, barley, oats, sorghum, rye, alfalfa and triticale (hybrid of wheat and rye) can be produced by hydroponics. By this method, on an average, 1 kg of seed can be converted in to 6 to 8 kg green fodder within 8 to 10 days. It has been reported that about 1.5-2 liters water needed to produce 1 kg of green fodder hydroponically in comparison with 73, 85, and 160 liters to produce 1 kg of green fodder of barley, alfalfa, and Rhodes grass under field conditions, respectively. Under hydroponic systems this equates to only 2-5% of water used in traditional fodder production.

(ii) Continuous-flow solution culture

In this type continuous flow of solution is maintained to ensure supply of nutrients, water and oxygen for roots of all plants. . It is much easier to automate than the static solution culture because, sampling and adjustments to the temperature and nutrient concentrations can be made in a large storage tank that has potential to serve thousands of plants. A popularly used container is the ‘Nutrient film Technique’ (NFT). It is arranged with fix slope so as to maintain flow of solution at the rate of 1 to 2 liters per minute. Large tanks or trays made from cement concrete or plastic are also used. It has more efficiency to produce as compared with static solution method.



Fig. 3.5 : The nutrient film technique being used to grow various salad greens

(iii) Aeroponics

Aeroponics is a system wherein roots are continuously or periodically kept in an environment saturated with fine drops (a mist or aerosol) of nutrient solution. The method requires no substrate and entails growing plants with their roots suspended in a deep air or growth chamber with the roots periodically wetted with a fine mist of atomized nutrients. Excellent aeration is the main advantage of aeroponics.

Aeroponic techniques have proven to be commercially successful for propagation, seed germination, seed potato production, tomato production, leaf crops, and micro-greens. Since inventor Richard Stoner commercialized aeroponic technology in 1983, aeroponics has been implemented as an alternative to water intensive hydroponic systems worldwide. The limitation of hydroponics is the fact that 1 kilogram (2.2 lb) of water can only hold 8 milligrams (0.12 gr) of air, no matter whether aerators are utilized or not.

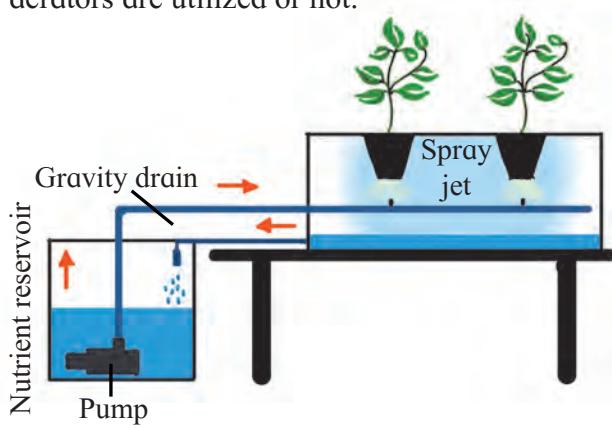


Fig 3.6 : Aeroponic technique

Another distinct advantage of aeroponics over hydroponics is that any species of plants can be grown in a true aeroponic system because the microenvironment of an aeroponic can be finely controlled. Suspended aeroponic plants receive 100% of the available oxygen and carbon dioxide to the roots zone, stems, and leaves, thus accelerating biomass growth and reducing rooting times. Aeroponics uses 65% less water than hydroponics. Aeronomically grown plants require $\frac{1}{4}$ th the nutrient input compared to hydroponics.

(iv) Fogponics

Fogponics is a derivation of aeroponics wherein the nutrient solution is aerosolized by a diaphragm vibrating at ultrasonic frequencies. Solution droplets produced by this method tend to be 5–10 μm in diameter, smaller than those produced by forcing a nutrient solution through pressurized nozzles, as in aeroponics. The smaller size of the droplets allows them to diffuse through the air more easily, and deliver nutrients to the roots without limiting their access to oxygen.

v) Genetic modification

Genetically modified crops (GM crops or biotech crops) are plants used in agriculture, the DNA of which has been modified using genetic engineering methods. In most cases, the aim is to introduce a new trait to the plant which does not occur naturally in the species. Examples in food crops include resistance to certain pests, diseases, environmental conditions, reduction of spoilage, resistance to chemical treatments (e.g. resistance to a herbicide), or improving the nutrient profile of the crop. Scientists have also begun engineering crops that require less water and that grow more food. Currently available food derived from GM crops possess no greater risk to human health than conventional food but that each GM food needs to be tested on a case-by-case basis before introduction.

Though GM technology for food production is not yet allowed in India, GM cotton varieties are introduced from year 2002. Now it is commonly accepted all over India. Aim is to reduce use of pesticides for bollworm control and to increase production.

Examples in non-food crops include production of pharmaceutical agents, biofuels, and other industrially useful goods as well as for bioremediation. Of course, there could be unforeseen consequences when it comes

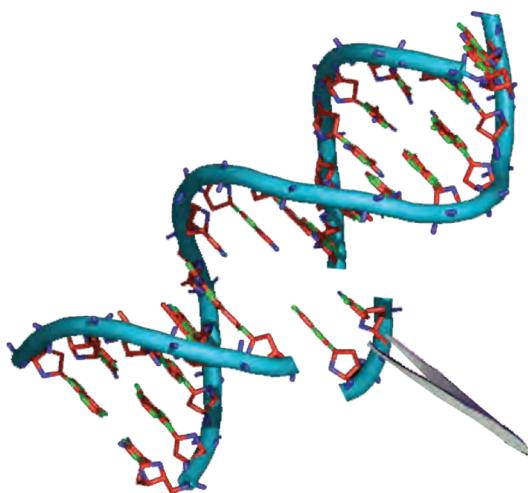


Fig 3.7 : Imaginary view of genetic engineering

to messing with genetics in any environment or ecosystem — we'll have to be extremely cautious that we don't create more problems in an attempt to solve a few.

These are just a couple of ways that innovative agricultural practices are changing our future, and making the world a more liveable place. Innovation in agriculture isn't just interesting — it's essential to our survival!



Internet my friend

- By knowing about advances in agricultural technologies, do you wish to get further education in this field ?
- Open the websites of different institutes related to agricultural education and acquire information of your interest.

3.5.3 Agricultural education

For survival of human race on earth, agriculture has prime importance. To feed growing population on our planet earth, continuous innovation and dissemination of agricultural knowledge and technology is necessary. In ancient period of India, agriculture was included in the curricula of Nalanda and Taxila Universities as one of the 18 arts.

The Indian Council of Agricultural Research (ICAR) is an autonomous body. It is under the Division of Agricultural Research and Education (DARE). Ministry of Agriculture, Government of India. The ICAR has its headquarters at Pusa, New Delhi.

The Council is the apex body for co-ordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. With 101 ICAR institutes and **71 agricultural universities** spread across the country, this is one of the largest national agricultural systems in the world. The ICAR has played a pioneering role in ushering Green Revolution and subsequent developments in agriculture in India through its research and technology development that has enabled the country to increase the production of **foodgrains by 5.4 times, horticultural crops by 10.1 times, fish by 15.2 times, milk by 9.7 times and eggs by 48.1 times since 1951 to 2017**, thus making a visible impact on the national food and nutritional security. It has played a major role in promoting excellence in higher education in agriculture. It is engaged in cutting edge areas of science and technology development and its scientists are internationally acknowledged in their fields.

Maharashtra government has established four agricultural universities. These universities are coordinated by 'Maharashtra Council of Agricultural Education and Research' (MCAER) established on 10th of September 1984.

Table 3.1 : Institutes and their websites

ICAR, New Delhi	http://www.icar.org.in/
MCAER, Pune	http://www.mcaer.org.in/
Government Of Maharashtra, Dept.	http://www.mahaagri.gov.in/
Mahatma Phule Agricultural University, Rahuri	http://mpkv.ac.in/
Dr. Punjabrao Deshmukh Agricultural University, Akola	http://www.pdkv.ac.in/
Vasantrao Naik Marathwada Agricultural University, Parbhani	http://www.vnmkv.ac.in
Dr. Balasaheb Savant Konkan Agricultural University, Dapoli	http://www.dbskkv.org
National Skill Development Corporation	https://nsdcindia.org
Maharashtra State Skill Development Society	https://kaushalya.mahaswayam.in/

Details regarding different courses, eligibility criterion, admission process, etc. are available on the websites of these organizations.

Most of the population in agriculture has lower educational level and don't have exposure to formal agricultural education. For this purpose different extension activities are conducted by agricultural universities,

department of agriculture, research stations, Krishi Vigyan Kendra (KVK), etc. National Skill Development Corporation (NSDC), Maharashtra State Skill Development Society (MSSDS), etc. provides training to the farmers for entrepreneurship development. Details of agricultural extension education are delt in separate chapter.



Courtesy : Sahyadri Farmers Producer Co. Ltd.

Do yourself

Prepare a chart of Agricultural Universities in Maharashtra with respect to Research work in Agriculture (Crops and their varieties, Fruits, etc.)

Sr. No.	University details	Research work details

Do yourself

Prepare a concept map of organised farming with characteristic features.

Exercise

Q. 1 A. Fill in the blanks.

1. In vertical gardening, most commonly used media is
2. Containers used for hydroponics are excluded from light to avoid growth of
3. Apex institute governing agricultural education in India is
4. In India..... crop is commonly used for production of green fodder by hydroponics
5. When farming is done by a company on his own land or leased farm then it is called as

B. Make the pairs.

'A' group	'B' group
1. MCAER	a. Spraying of pesticides
2. GM Technology	b. Agricultural education
3. Drones	c. Cotton varieties in India d. Hydroponics e. FPC

C. State true or false

1. Limitations of decreased land holding are eliminated in farmer producer organisation.
2. All crops can be cultivated by hydroponics technology.
3. Drones are used for ploughing the soil.
4. Productivity in aeroponics is more than hydroponics because of ample aeration in the root zone.
5. In contract farming an agreement is executed between the producer and the consumer.

Q. 2 Answer in brief.

1. Describe in brief Farmer Producer Organization.
2. Why government is promoting for processing of agricultural produce ?
3. How hydroponic fodder production saves water ?
4. State your view regarding further education in agriculture.
5. Write special features of informal model of contract farming.

Q. 3 Answer the following questions

1. Explain the scope of technology in agriculture.
2. Describe importance of green fodder production by hydroponics.
3. Write advantages of contract farming.
4. Classify the hydroponics as per the maintenance of the media solution.
5. Give the advantages of Urban agriculture.

Q. 4 Answer in detail

1. Explain advantages and disadvantages of contract farming.
2. Describe the use of drones in agriculture.
3. Write the advantages and key points for formation of farmer producer organisation.
4. Describe aeroponics and fogponics.
5. Describe about agricultural education in India.

Activity :

Obtain information on FPO, FPC, Agricultural Universities in Maharashtra by using internet.



Do you know ?

1. What is meant by seed botanically?
2. Material used for planting.
3. Types of seed and parts of seed
4. Different methods of propagation.

4.1 Definition and type

4.1.1 Definition

A fruit is defined as matured or ripened ovary which contains one or more ovules that develops into seed. Botanically seed is defined as matured (after fertilization) and ripened ovule which contains an embryo with food reserve and protective coat. As per seed technology science or agricultural point of view seed is any plant part which is used for raising or propagation or multiplication of new commercial crop. e.g. True seed, tubers, suckers, bulbs, cuttings, sets, grafts, etc.



Recall a little?

Major types of seed

- a. **Monocot seed** : Seed having single cotyledon i.e. wheat, jowar, maize, etc.
- b. **Dicot seed** : Seed having two cotyledons. i.e. groundnut, redgram, castor, etc.

4.1.2 Parts of seed

Structure of dicot seed

Castor seed:

Castor seed has two layers. The outer layer of seed coat is testa which is blackish and

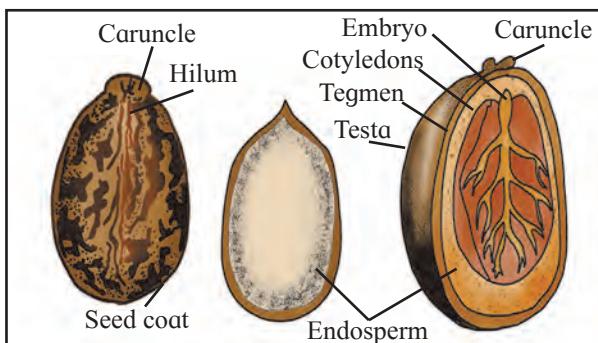


Fig 4.1 : Castor Seed

hard. The inner thin seed coat layer is tegmen.

The spongy whitish outgrowth present at one end of seed is called caruncle. Caruncle absorbs water during germination. Hilum which is covered by caruncle and raphe which run from hilum on the seed coat.

There is a whitish flattened body called endosperm. It acts as food storage tissue. Seed embryo consists of radical, axis and plumule. There are two cotyledons which have prominent veins. It acts as food absorbing organ.

Structure of monocot seed

Maize seed

Maize seed coat is membranous layer adherent to the grain and is fused with the wall of the fruit. Seed is somewhat flattened. It is broader at one end and pointed at other end. The flattened portion of the seed may be creamy white, yellow or dark red in colour with distinct deloid area. Note that scar is present at both ends of the seed. The scar present at the broader end of the seed is the position of attachment of style. The scar at the narrow end is hilum. Observe that ridge is present in the centre of the seed which is axis of the embryo by cutting the seed through the centre longitudinally and putting few drops of dilute iodine on it. Two distinct regions separated from each other by a layer. Separating layer is called epithelium which secrets enzymes.

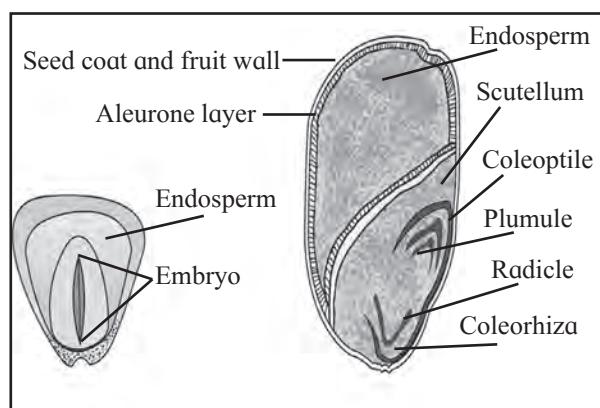


Fig 4.2 : Maize Seed

The bigger region which takes violet black stain is called endosperm. It is rich in starch. The embryo consists of radical, plumule and a single shield shaped cotyledon called scutellum. Scutellum absorbs food material from endosperm during germination.

Note that radical is towards pointed end and is surrounded by a sheath called coleorhiza. The plumule which is at the end of the embryo is surrounded by sheath called coleoptile.

4.2 Difference between seed and grain

Sr. No	SEED	GRAIN
1	It is the result of well-planned seed programme.	It is the part of commercial produce.
2	It is the result of sound scientific knowledge, organized effort, and investment on processing, storage and marketing facilities.	No such knowledge or effort is required.
3	The pedigree of the seed is ensured. It can be related to the initial breeders seed.	Its varietal purity is unknown.
4	During production, effort is made to rogue out off types designated plants, objectionable weeds and other crop plants at appropriate stages of crop growth which ensures satisfactory seed purity and health.	No such effort is made, hence the purity and health status may be inferior.
5	The seed is scientifically processed and packed and labelled with proper lot identity.	This is not labelled.
6	The seed is tested for planting quality namely germination, purity, admixture of weed seed and other crop seed, seed health and seed moisture content.	Routine seed testing is not done.
7	The seed quality is usually supervised by seed certification agency.	There is no quality control.
8	The seed has to essentially meet the "quality standards". The quality is therefore well known. The labels, certification tags on the seed containers serves as quality marks.	No such standards apply here. The quality is non descript and not known.
9	Genetic purity is important.	Genetic purity is not important.
10	Embryo is important in case of seed.	Endosperm or cotyledons are important in case of grain.
11	Seed is used for sowing purpose.	Grain is used for consumption purpose.
12	Isolation distance required to maintain genetic purity.	Isolation distance is not required.



Try this

- Collect the seed of maize and soak in water for 24 hrs.
- Take a longitudinal section of the seed by cutting the seed through the centre. Put few drops of dilute iodine on it.
- Study the external and internal part of maize seed.
- Draw the diagram of maize seed and label it properly.

13	Seed treatment is required.	Seed treatment is not required.
14	Field inspection is required to maintain genetic purity.	Field inspection is not required to maintain genetic purity.
15	Comes under preview of seed act.	Comes under preview of food act.



Can you tell?

The quality judging aspects of seed.

4.3 Characteristics of seed

Following are the characteristics of good quality seed

- (1) **Improved variety :** It should be superior to the existing variety i.e. the yield should be higher by 20-25% than the existing variety or it should have some desirable attributes like disease resistance, drought resistance, salt tolerance, etc. with good yield potential.
- (2) **Genetic purity:** The seed should be true to type. The seed should possess all the genetic qualities / characters, which the breeder has placed in the variety; genetic purity has direct effect on the yields. If there is deterioration, there would be proportionate decrease in the yield or performance.
- (3) **Physical purity:** Physical purity of a seed lot refers to the physical composition of the seed lots. A seed lot is composed of pure seed, inert matter, broken seed undersized seed, soil and dust particles, weed seed, other crop seed, etc. Higher the content of pure seed better would be the seed quality.
- (4) **Seed germination and vigour:** Higher germination percentage and vigour give adequate plant population and uniform growth which have profound effect on yield and determine the planting value of the seed.
- (5) **Freedom from weeds and other crop seed:** This is an extension of physical purity described earlier.

There are certain weeds species, which are very harmful to the crop and once established they are difficult to eradicate. An absolute freedom from seed of such species is highly desirable and is one of the important criteria for determining the planting quality of seeds.

- (6) **Seed health:** The quality of a seed lot depends on its health; hence the seed should be free from seed borne diseases, insects and pest.
- (7) **Seed moisture:** The seed moisture is the most important factor in determining the seed germination and viability during storage . At high seed moisture content there is high incidence of pest attack and at moisture content above 16% seed get heated and the viability is lost. Hence the seed should be stored at safe moisture levels of 11-13%.
- (8) **Seed size, weight and specific gravity:** Seed size, weight and specific gravity has been found to have positive correlation with seed germination and vigour in many crops. Therefore the seed should be bold with high specific gravity.
- (9) **Seed colour:** The colour of the seed often reflects the condition during seed maturation. The colour and shine deteriorate only when the weather conditions are adverse during maturation or when insects infest the crop or when it is handled badly.

The seed lot having high genetic purity, high germination and with a minimum amount of inert matter, weed seed and other crop seed and free from diseases is said to be of high quality .



Do you know ?

- Label and information on seed bag
- Process of seed multiplication.
- Precautions to be taken while purchasing the seed

4.4 Seed multiplication



Remember this

The process of development, release and notification of high yielding variety / hybrid is a continuous process. The spread of any improved variety or hybrid depends upon the quality of pure seed of that variety produced and supplied to the farmers every year.

The area under any crop is greater, it is not possible for the crop breeder or station to produce and supply entire quantity of seed required every year due to limited resources. It is therefore necessary to organize multiplication of the seed of varieties or hybrids through different stages by ensuring that the seed multiplied at each stage meets all seed certification standards prescribed for that crop variety or hybrid.

4.4.1 Stages of seed multiplication

(1) Nucleus seed

It is the initial amount of pure seed of improved variety or notified variety or parental lines of a hybrid produced under supervision of the plant breeder who has evolved that variety or hybrid. The nucleus seed is genetically cent percent pure and does not contain other physical impurities. The nucleus seed is produced strictly under isolation so as to avoid both genetical and physical contamination. Nucleus seed should retain vigour of the variety or parental line. There is no specific labelling for nucleus seed.

(2) Breeder seed

It is the progeny of nucleus seed. Generally breeder seed is produced in one stage. But if there is greater demand for breeder seed and there is low seed multiplication ratio, then breeder seed can be produced in two stages *viz.*; Breeder stage I and II in such cases breeder seed, stage I be becomes source for breeder stage II.

Breeder seed can be produced by original plant breeder and sponsored institute by ICAR and rarely on government farm. Breeder seed plots are inspected jointly by team.

Breeder seed produced should meet all prescribed standards *viz.* genetic purity (99.9% or more), physical purity (98% or more) Germination (as per crop) moisture content (less than 12 %) . After passing the seed lot, breeder seed tags in buff colour or Golden Yellow are signed by the concerned plant breeder and tagged to the breeder seed bags and size of tag is 12 × 6 cm.

(3) Foundation seed

It is the progeny of breeder seed and can be produced in two stages *viz.* Stage I and Stage II. Foundation seed is produced on the farms of State Agril. Universities, Taluka Seeds Farms, other Govt. farms, State Seeds Corporations, National Seed Corporation and private seed companies, Foundation seed plots are required to be registered for certification with State Seed Certification Agency. Seed plot of foundation seed jointly inspected by concerned crop breeder, District Seed Certification Officer, NSC and MSSC. If a foundation seed lot meets minimum seed certification standards including field tests It is certified as foundation seed and after processing and testing of seed completed bags are tagged with white coloured tag and opal green colour label together and sealed the bag by using lead seal and size of foundation tag is 15 × 7.5 cm.

(4) Certified seed

It is the progeny of foundation seed. Plots of certified seed are offered for certification with seed certification agency which inspects the plots during crop growth and at harvesting. After processing of seed lot seed sample is drawn by seed certification officer and sent the seed sample to Seed Testing Laboratory for seed testing. When seed lot meets minimum certification standards prescribed for that crop, then it is bagged, tagged with blue colour tag and opal green colour labels together and sealed by using lead seal and size of certified tag is 15 x 7.5 cm.

(5) Truthful seed

It is the category of seed produced by cultivators, private seed companies and is sold under truthful labels. But field standards and seed standards should maintain as per seed act and certified seed stage. Under the seed act, the producer and seed seller are responsible for the seed. The bags of truthful seed tagged with opal green and sealed with lead seal. Source of seed to be used for production truthful seed different stages of seed (B/S, F/S and C/S) and the size of opal green colour label is 15 x 10 cm.

4.5 Seed germination and seed dormancy

4.5.1 Definition of seed germination

Germination is the awaking of the dormant embryo and to resume growth. In mature angiospermic seeds, embryo lies in the dormant stage. As soon as favorable conditions are available dormancy is broken and germination begins, thus it is resumption of active growth of the embryo after a period of dormancy in presence of favourable conditions viz. moisture, air, temperature, light, medium.

4.5.2 Types of germination

1. Hypogeal germination

When cotyledons remain below soil surface due to rapid elongation of epicotyl

(portion of embryo above cotyledons) then it is termed as hypogeal germination. It occurs with the majority of monocotyledons (e.g. gramineae), some large seeded legumes (e.g. Pea and gram) and some trees like mango, jack fruit, coconut and arecanut.

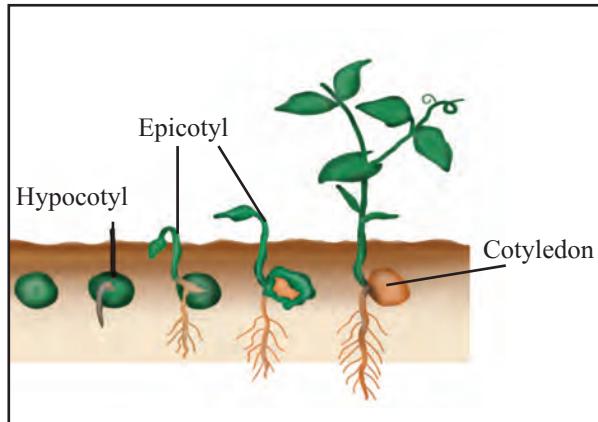


Fig 4.3 : Hypogeal germination

2. Epigeal germination

When cotyledons pushed above soil surface due to rapid elongation of hypocotyls (portion of embryo below cotyledons), then it is termed as epigeal germination. It is mostly observed in horticultural and woody plant species e.g. Cotton, cucumber, castor, sunflower, groundnut, tamarind and french bean.

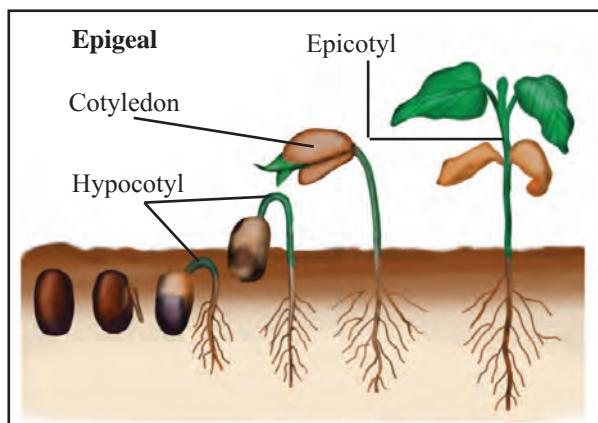


Fig 4.4 : Epigeal germination

3. Viviparous germination

Germination of seed inside the fruit attached to the mother plant (which also nourishes the seedling at initial stages just after germination) is known as 'Vivipary' and

it is observed in many plants which grows along sea coasts e.g. *Mangroves, Rhizophora*.

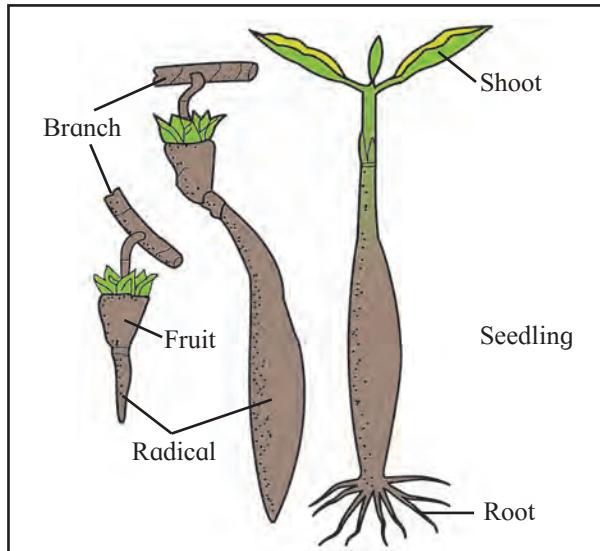


Fig 4.5 : Viviparous germination



It may happen

Pre-harvest sprouting

Sprouting of seed due to high moisture on the matured plants standing in the field is known as pre harvest sprouting and it is different than vivipary. e.g. Groundnut, Bajra, and Green gram

Hypo - epigeal germination

A dicot species leaves one cotyledon beneath the soil as hypogea germination while the other cotyledon comes out above soil as epigeal germination, e.g. *Paperomia peruviana*.

4.5.3 Factors affecting germination

Following factors are essential for normal germination of seed.

(A) External factors

- Water (Moisture):** It enables the resumption of physiological activities. Swelling of seed due to absorption of moisture causes bursting of seed coat, softening of the tissue due to which embryo awakes and resumes its growth.
- Temperature:** A suitable temperature is necessary for proper germination.

Germination of seed does not take place beyond certain minimum and maximum temperature i.e. 0 °C and above 50°C. Optimum temperature range for satisfactory germination of seed is 25 to 30°C.



Try this

- Take a gram seed
- Plant the seed on germination paper
- Make three replications
- Put these bundles at different temperatures for germination in germinator
- Observe germination and decide optimum temperature for germination

3. **Oxygen:** It is essential during germination for respiration and other physiological activities which are vigorous during the processes.
4. **Light:** It is not considered as essential for germination and it takes place without light. The seedling grows more vigorously during darkness rather in light. However, for survival of germinating seedling, light is quite essential.
5. **Substratum:** Substratum is the medium used for germinating seeds in the laboratory. It may be absorbant paper (blotting paper, towel paper, tissue paper) soil and sand. Substratum should be free from toxic substances. It should not act as a medium for growth of micro organism.

(B) Internal factors

1. **Food and auxin:** Embryo feeds on the stored food material until young seedling prepare its own food. Auxins are the growth promoters hence quite essential during the germination.
2. **Viability:** All seed remain viable for certain definite period of time and thereafter embryo becomes dead. It depends on maturity of seed, storage

conditions, vigour and type of species. Generally, it is for 3 to 5 years and they remain for more than 200 years also as in lotus.

- 3. Dormancy:** It is failure of mature viable seed to germinate under favorable conditions of moisture. Many seeds do not germinate immediately after their harvest, they require rest period for certain physiological activities.

(C) Agronomic and other factors

1. Stresses during preharvest stage, harvesting and storage condition, unfavourable environmental conditions during seed setting, maturity and harvesting stage may affect viability and germination capacity. Mechanical injury to seed during pre harvesting and post harvest processing also affect germination. The structure made for storage, prevailing conditions during storage also cause loss in germination.
2. Special Treatments : Soaking of seed in water and other chemicals, X-ray and gamma ray treatment, etc. also have influence on seed germination.
3. Ecology : Special ecological conditions are essential for proper germinanation of certain seed.
4. Soil salinity : Some seed needs high salinity conditions of soil for germination.

4.5.4 Definition of seed dormancy

Failure of fully developed and mature viable seed to germinate under favourable conditions of moisture and temperature called resting stage or dormancy and the seed is said to be dormant.

4.5.5 Types of seed dormancy

There are several types of seed dormancy suggested by different scientists

(1) Primary dormancy

The seed gets dispersed from the mother plant, the dormancy may be induced before maturing, during maturity and after maturity.

The viable seed that does not germinate immediately after maturity under favourable conditions it seems germination under favourable condition after resting period is known as primary dormancy.

(2) Secondary dormancy

Some seeds are capable of germination immediately after they are shed. Such seeds, however can become dormant if they are placed in unfavorable conditions for some time. This type of induced dormancy is termed as Secondary dormancy. It can be induced by very low temperature, high CO₂ concentrate and absence of light.

(3) Exogenous dormancy

This is due to seed factors which are located out side of the embryo. The causes of this type of dormancy are

- (i) Physical : Seed coats are impermeable to water and gases.
- (ii) Chemical : Certain types of inhibitors of germination are present in seed coat.
- (iii) Mechanical : This may be due to mechanical resistance of seed coat to germination.

(4) Endogenous dormancy

This type of dormancy is due to factors located in the embryo.

- (i) Due to low or high temperature requirement.
- (ii) Incomplete development of embryo in the seed.
- (iii) Photoblastism: Light dependent dormancy

(5) Combined dormancy

This dormancy may be due to combination of two or more factors.

4.5.6 Methods of breaking seed dormancy

A. Scarification

1. **Pre-chilling :** the seeds are placed in contact with the moist substratum at a temperature of 5°C to 10°C for 7 days for germination e.g. cabbage, cauliflower, sunflower, broad bean.

- 2. Pre-drying :** The seeds should be dried at a temperature not exceeding 40°C with free air circulation for a period of 7 days before they are placed for germination e.g. maize, lettuce.
 - 3. Pre-washing:** In some seeds, germination is affected by naturally occurring substances which act as inhibitors these can be removed by soaking and washing the seeds in water before placing for germination e.g.sugar beet.
 - 4. Pre-soaking :** Some seeds fail to germinate due to hard seed coat such seeds should be soaked in warm water for some period so as to enhance the process of imbibition e.g. chilli, subabhu and winged bean.
 - 5. Rubbing / puncturing seed coat:** Some seeds are subjected to mechanical scarification either by rubbing them against rough surface (sand paper) or puncturing the seed coat with pointed needle e.g. coriander, castor or chilli.
- B. Stratification -** In some seeds, after ripening low temperature and moisture condition require in artificial stratification. Seed layer altered with layers of moist sand/ appropriate material to store at low temperature e.g. *Brassica juncea* and *Arachis hypogaea*.

C. Use of chemicals

1. Potassium nitrate treatment

The material used for placing the seeds for germination i.e. substratum may be moistened with 0.2 per cent solution of KNO_3 (2 g KNO_3 + 100 ml water) e.g. rice, tomato, chillies, etc.

2. Gibberellic acid treatment:

The substratum used for germination may be moistened with 500 ppm solution of GA_3 i.e. 500 mg in 1000 ml. of water. If dormancy is stronger GA_3 solution upto 1000 ppm may be used e.g. wheat, oat, etc.

3. Thiourea

Treatment generally 0.5 % thiourea solution is used for soaking seeds for short time and then transferring them to water e.g. gladiolous.

4.6 Seed testing

4.6.1 Germination tests

Germination test in laboratory indicates planting value of seed and its capacity of emergence as good and normal seedling in the field.



Observe and Discuss

- Home cleaning of grains
- Working of Seed testing laboratory
- Routine tests in STL

4.6.2 Methods of germination testing

At least four hundred seeds should be tested for germination. Seed selected for germination should be from 'pure seed' component separated in purity analysis and should be counted without discrimination as to size or appearance, by hand, counting boards or by vacuum seed counter.

1. Top paper (T.P.)

In this method seeds are germinated on top of one or more layers of paper which are placed either in enclosed transparent petri dishes or boxes and are kept in an incubator or germinator.

2. Between paper method (B.P.)

The seeds are germinated between two layers of germination paper which are placed directly on germination trays in cabinet or room type germinator or in metal, plastic or glass boxes. In former method, relative humidity in the cabinet, or room should be maintained to the saturation. The paper can be folded or rolled and placed in an upright position. Metal, glass or plastic frames can be inserted between papers to ensure ventilation However, paper should not be too wet to form water film if pressed with finger.

3. Germination in sand

Seed are planted in uniform layer of moist sand 1 to 3 cm deep and then covered with loose sand or seed are pressed into the of the sand, certain amount of water is added e.g. maize, groundnut and castor.

4. Germination in soil

Soil or an artificial compost is used instead of sand. This method is used to confirm the evaluation of seedlings, in doubtful cases and testing samples which produce seedlings, with phototoxic symptoms when germinated on paper or sand. Soil should be kept wet.

4.6.3 Procedure for germination tests

I. Germination on towel paper

1. Take rectangular germination paper (crape craft paper) and soak it in water, remove excess water.
2. Put it on polythene paper slightly bigger than germination paper.
3. Place seed of given sample on germination paper with the help of counting board in four replications of 100 seeds each.
4. Cover the seed with another moist germination paper and roll along with polythene paper and tie both ends of roll by rubber bands.
5. Keep the count of seedlings on the prescribed day and report the percentage of normal, abnormal, dead, hard and fresh ungerminated seeds.

II. Germination in petri-dish:

1. Take germination paper (blotting) and prepare round pieces as per inner diameter of dishes.
2. Place cotton wool at the bottom of dish and cover the piece of blotting paper, add water till paper becomes wet and remove excess water from the dish.
3. Put either 50 or 25 seed in each dish on moist paper at proper distance.

4. Cover petri-dish with lid and put it in germinator / incubator maintained at appropriate constant temperature.
5. Take the germination count and calculate the germination percentage.

III. Germination in sand or soil

1. Take earthen or plastic pots filled with sand or soil
2. Add water to obtain sufficient moisture in soil/sand
3. Put the seed of variety to be tested at appropriate depth with proper spacing.
4. Cover the seed with soil or sand and give water if necessary and put them in germinator at appropriate constant temperature.

4.6.4 Evaluation of seedling after germination

Observe the following from the germinated seed and report the results.

1. Normal seedling

Seedling which shows the capacity for continued development into normal plants when grown in good quality soil.

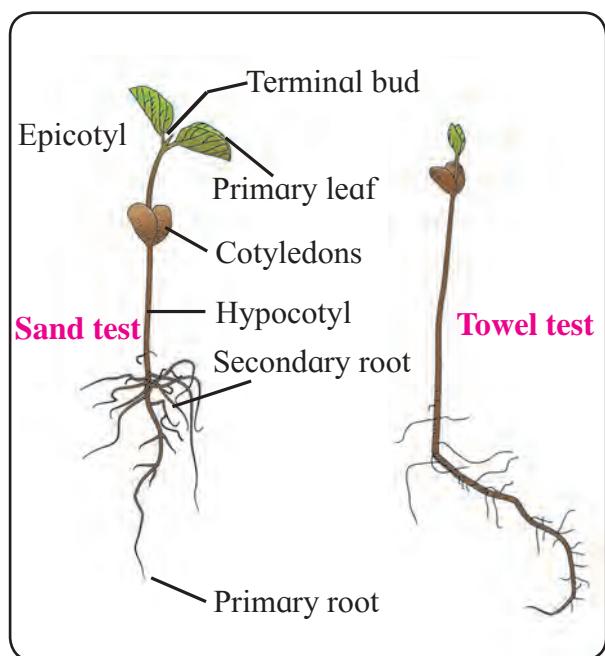


Fig. 4.6 : Normal seedling

Following seedlings may be treated as normal seedlings.

- (a) Seedlings with well developed system of root with primary root intact hypocotyl, epicotyl, and a normal plumule and cotyledons.
- (b) A well developed primary leaf within or emerging through the coleoptile in monocotyledons.



Fig. 4.7 Seed germinator

2. Abnormal seedlings

Seedling which do not show the capacity for continued development into normal plants when grown in good quality soil under favourable conditions of water supply, temperature and light.

Following seedlings may be treated as abnormal seedlings

- (a) Seedlings without cotyledons, constrictions, splits cracks and lessions.
- (b) Seedlings without primary root
- (c) Seedlings having stunted root and plumules, coleoptile without primary leaves.
- (d) Seedlings with decayed essential structure and discoloration.

3. Ungerminated seed

It consists of following seeds.

a. Hard seed : The seeds belonging to leguminoseae and malavaceae family which remain hard at the end of prescribed period of test Because they have not absorbed water due to impermeable seed coat are called hard seed.

b. Fresh ungerminated seeds

Seeds other than hard seeds which do not germinate even after appropriate treatment for breaking dormancy are classified as fresh ungerminated seeds.

c. Dead seeds

Seeds at the end of test period are neither hard nor fresh and have not produced seedlings, classified as dead seeds.

4.6.5 Physical purity test

The purity test is done with following objectives

1. To determine the composition of sample by dividing each sample into 4 components namely pure seeds, other crop seed, weed and inert matter and to judge the quality of seed sample on the basis of proportion of pure seed and other components as per prescribed norms of SCA.
2. To identify objectionable weed seed and other crop seed found in sample and to give them botanical names.
3. To determine eligibility of seed sample for seed certification.
4. To get the pure seed for further seed tests like germination.

Material required for physical purity test

Seed blower, purity work board, forceps, magnifying lens, spatula, dishes, sieves, needles and weighing balance etc.

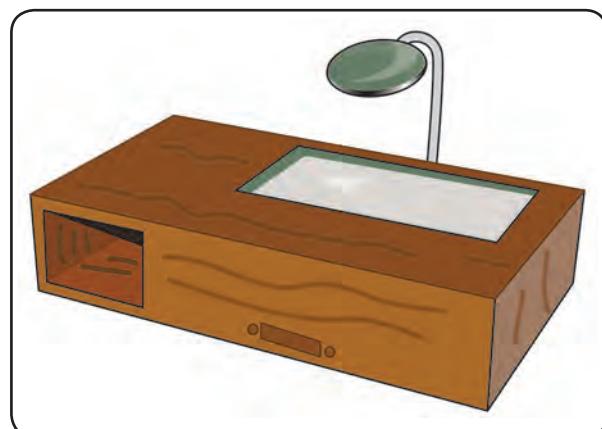


Fig. 4.8 Physical purity work board

Procedure

1. The working sample of desired weight is prepared.
2. Use seed blower, if seed sample is chaffy or grass species after adjusting air flow.
3. Place the working sample on a board or glass plate and with the help of forceps, needles and magnifiers, separate out the seed sample into following components.
(i) Pure seed (ii) Other crop seed
(iii) Inert matter (iv) Weed seed



Remember this

Inert matter: It includes mainly pieces of broken or damage seed, achenes and caryopsis, empty glumes, other matter mainly soil, sand, stone, chaff, stems, leaves, pieces of bark, flowers, fungi bodies, etc.

4. After complete separation of components of sample, retain the pure seed on purity work board for rechecking. After re-checking the pure seed separate other seed and inert matter.
5. Weigh the each of the three components.
Wt. of working sample (g)
6. Calculate the percentage of each component on the basis of the sum of weights of the components and not on the basis of the original working sample. The sum total of percent of all components should be 100.
7. If percentage of seed of any other crop species or weeds together is more than 0.1 per cent or if the number of seed is more than 20, separate out all seed of that species from working sample as well as submitted sample.



Try this

Calculate the percentage value of each component on the basis of sum of weights of all components and not on the basis of the original sample.

(i) Pure seed (%) =
$$\frac{\text{Wt. of pure seed}}{\text{Total wt. of all seed components}} \times 100$$

(ii) Inert matter (%) =

$$\frac{\text{Wt. of inert matter}}{\text{Total wt. of all seed components}} \times 100$$

(iii) Other crop seed (%) =

$$\frac{\text{Wt. of other crop seed}}{\text{Total wt. of all seed components}} \times 100$$

(iv) Weed seed (%) =

$$\frac{\text{Wt. of weed seed}}{\text{Total wt. of all seed components}} \times 100$$

4.6.6 Seed health test - (Seed pathology)

Seed health refers to the presence or absence of disease causing organisms such as fungi, bacteria and viruses and animal pests. Hence, seed health testing is necessary to obtain information regarding health of seed lot.

Methods of seed health testing

A. Examination without incubation

It reveals presence or absence of pathogens examined., however does not give any indication about the viability of the pathogen.

1. **Direct examination** - Seed are directly examined with or without stereoscopic microscope. The ergot and sclerotin bodies, nematodes, galls, smut balls, insects, mites damage to seed etc. as well as discoloration of seed.

2. **Examination of imbibed seeds** - Seed are immersed in water or other liquid in order to liberate the spores and fruiting bodies more visible and after imbibition, they are examined with microscope.

3. **Examination of organisms removed after washing** - Seed are immersed in water or other liquid or alcohol and shaken vigorously to remove fungal spores, nematodes, etc. The excess liquid is removed by filtration, evaporation and extracted material examined by microscope.

B. Examination after incubation

In this method, the seed is incubated for a specific period.

The following media are commonly used for incubation.

- (i) Blotters
- (ii) Sand
- (iii) Agar plate

- (i) **Blotter method** - In this method, seed are placed of moistened blotting papers at 20 mm apart. The blotters are rolled or placed in containers and incubated for specific number of days. Then it is examined under magnification for the presence of pathogen.
- (ii) **Sand method** - Sand or similar media is used and seed without pre-treatment are suitably placed so as to avoid secondary spread of organism and incubated in conditions favourable for symptom development.
- (iii) **Agar plate** - Seed after treatment are placed on the surface of 2% malt extract sterilized agar in petridishes and incubated. The colonies of fungi can be identified on agar directly or by lense.

C. Examination of growing plants

The growing of plants from seed for examination for disease symptoms is most practicable procedure for determining whether bacteria, fungi or viruses are present in the sample. Seed may be sown in the field or inoculums may be used for infection test with healthy seedlings.

4.6.7 Seed moisture test

Moisture content of seed is one of the important factor affecting viability and quality



Do you know ?

Seed entomology includes the study of pest of seed, their nature of damage and control measures in order to maintain viability and germination of seed.

of seed. It is loss in weight when the seed is dried or the quantity of water collected when it is distilled. It is expressed as a percentage of the weight of the original sample.

4.6.7 Methods of moisture determination

The basic methods are-

1. Drying without heat

Samples are dried without heat or moderate heat in vaccum using phosphorus pentoxide (P_2O_5) as desiccant.

2. Lyophilization

(Freeze dried)- Biological materials are frozen and water removed by sublimation in vaccum.

3. Reversibility method

(a) **Red drying** - This method determines drying time and temperature so that loss of weight by decomposition is accounted for.

(b) **Karl Fisher titration method** - In this method water is extracted from finely ground seed with methyl alcohol and then determined by titration by a special reagent. This is most accurate method. However, these methods require much time, equipments and high skills of operation and hence not practically used.

4. Hot air oven method

Method is most practical and commonly used for moisture determination.

Objective: To determine moisture content of a given sample.

Material

Grindingmill, hotairoven, chemicalbalance, crucible with lid, desiccators, spoon, trays and seed sample.

Procedure

1. Take 4 to 5 g of duplicate working sample for determination of moisture from submitted sample accurately.

2. Crops of larger seed size (e.g. cotton, maize, sorghum, paddy, wheat, etc.) are ground with grinding mill in such a way that at least 50 per cent of the ground material should pass through a wire sieve of 0.5 mm mesh and not more than 10 per cent remain on a top of wire sieve. For leguminous crop seed (e.g. pea, soybean, chickpea, etc.) coarse grinding is necessary i.e. 50 percent ground material should pass through sieve with 4 mm mesh.
3. If moisture content of seed is more than 17 percent (Rice-13% soybean-10%) pre-drying is obligatory. Similarly, high moist seed of maize (above 25%) and others, samples should be dried at 70°C for 2 to 5 hours depending on initial water content.
4. Weigh the clean and dry crucible with lid accurately.
5. Put the ground seed sample prepared earlier (4-5 g) in a crucible with help of spoon and again take the weight of crucible with lid very accurately.
6. Place the crucible rapidly in hot air oven as under
 - (i) In low constant temperature oven method, keep the container at temperature $103^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and dry for 17 ± 1 hrs. (e.g. onion, chillies, soybean, radish and brinjal, etc.).
 - (ii) In high constant temperature oven method, keep the material at $130^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 2 ± 1 hrs.

Table : 4.1 Temperature for oven dry method

Oven dry method recommended for different crops	Oven dry method
Rice, wheat, pearly millet, maize, sorghum, chickpea, lathyrus, pea, pigeonpea	High constant temperature ($130 \pm 2^{\circ}\text{C}$)
Groundnut, rape seed and mustard, soybean, sesame, linseed, castor and cotton	Low constant temperature ($103 \pm 2^{\circ}\text{C}$)

7. Remove the crucible with lid and cool in dessicator

8. Weigh the crucible with lid and contents.

9. Calculate the percentage of moisture content in seed sample by using formula-

$$\text{Moisture\%} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M_1 = Weight of empty crucible with lid

M_2 = Weight of crucible with seed sample

M_3 = Weight of crucible with seed sample and lid after drying

$M_2 - M_1$ = Weight of sample

$M_2 - M_3$ = Loss in weight after drying

5. Use of moisture metre

The moisture determination is based on the principle on that the moisture content in the seed is directly proportional electrical conductivity of seed. The various types of moisture metre are

- (a) Universal electric moisture metre
- (b) Steinlite moisture tester
- (c) Marconi moisture tester
- (d) Digital moisture metre

Laboratory work -

Determine the moisture percentage of seed sample given to you.

4.6.8 Seed vigour test

Seed vigour is the sum of those properties of seed which determine the potential level of activity i.e. rapid and uniform production of healthy seedling and stand establishment under a wide range of field conditions.

Objects -

- (1) Main object of this test is to differentiate range of quality levels i.e. high, medium, low vigour seeds.
- (2) This test evaluate seed performance under wide range of field conditions.



The test for determination of seed vigour

1. Direct tests

(a) **Brick gravel test:** A porous brick gravel of 2 to 3 mm size is used. About 30 mm layer of moist gravel is placed above the seed. This layer impedes the emergence of weak, partially diseased seedlings as well as coleoptile injured seedlings. Vigorous seedlings are these emerged from layer of brick gravel.

(b) **Paper Piercing test:** This test involves the use of sand plus a special paper disk through which seedlings penetrate. It is used for cereal crops in which seeds are placed on top with 1.25 cm moist sand and covered with special paper and kept for eight days.

2. Indirect tests

1. First count:

The number of normal seedlings counted at the first count (4/5th day) represents the faster germinating seeds. Higher percentage of normal seedling during the first count indicates the seed vigour.

2. Speed of germination

Number of germinated seeds are counted every day from the first day and the cumulative index is made by the formula.
 $n_1/1 + n_2/2 \dots \dots + n_x/x = N$

Where,

$n_1 \dots n_x$ are the number of seed germinated on day 1 to day x.

1 ... x are the number of days.

3. Seedling growth rate

Twenty seeds are placed in straight line on a paper towel moistened with distilled water and kept at an angle of 75° in a germinator at optimum temperature. Only 10 competitive normal seedlings are selected for observation. The remaining seedling are removed. For the next 10 days the length of each seedling is measured daily in cm.

Seedling growth rate is determined by dividing the mean increase in length from each previous measure by the number of days the seedling had been in the germinator. Sum of each count at the end of the test period is expressed as seedling growth rate.

4. Seedling length

Length of 10 normal seedling grown in moist towel paper kept at optimum temperature is measured in cm on the day of final count. The lot showing maximum seedling length is considered as vigorous.

5. Seedling dry weight

The weight of seedling excluding the cotyledon is taken on 10th day after oven drying at 100°C for 24 hr in g. The lot exhibiting the maximum seedling dry weight is considered as vigorous.

6. Vigour index length

A combination of standard germination test with seedling length provides broad evaluation of seedling vigour, seed lot with high vigour index is considered as vigorous.

7. Vigour index mass

Vigour index in terms of mass is determined by the multiplication of germination percentage with seedling dry weight on the day of final count.

4.6.9 Seed viability test

Viable seed is a seed that is capable of germination under suitable conditions.

Object

Object of the biochemical test is to determine quickly the viability of seeds of certain species which germinates slowly by regular germination process.

(1) Topographical Tetrazolium test or TZ test

Principle

In a biochemical test the reduction process which takes place in living cells are made visible by the reduction of an indicator.

The indicator used in the tetrazolium test for seeds is a colourless solution of the tetrazolium salt which is imbibed by the seed. Within the seed tissues it interferes with the reduction process of living cell and accepts hydrogen from the dehydrogenases. By hydrogenation of the 2, 3, 5 triphenyl tetrazolium chloride, a red stable and non-diffusible substance, triphenyl formagane, is produced in living cells. This makes possible to distinguish the red coloured living parts of seed from a colourless dead ones. In addition to completely stained viable seed and completely unstained non-viable seed, partially stained seed may occur. Varying proportions of necrotic tissues occur in different parts of these partially strained seed. Localisation and spread of necrosis in the embryo and on endosperm and the intensity of colour determine whether such seed are classified as viable or non-viable.

General directions

Reagents

A 1% aqueous solution (pH 6.5 - 7.0) of tetrazolium chloride or bromide is used. If the pH of the distilled water is not within the range of 6.5 - 7.0, the tetrazolium salt should

be dissolved in buffer solution. The buffer solution is prepared as follows.

Procedure

Each 4 replications of 100 seeds each from the pure seed fraction of physical purity test. To facilitate penetration of Tetrazolium solution, the seed are fully immersed in distilled water or kept in paper towel for 18 hrs. The testa of the dicot is removed and the monocot is exposed by dissecting the seed longitudinally or laterally. The seed are then completely immersed in 1% tetrazolium solution for 3 hrs. During treatments two preparations are kept in darkness at 20°C. After termination of the tetrazolium test, the solutions are decanted and the preparation is mixed with water prior to evaluation. For examination the preparations are spread on a plate and kept wet throughout the determinations. The seeds are evaluated with the help of magnifying devices. Individual seed is evaluated as viable or dead on the basis of staining pattern in embryo.

Calculation

The results are reported as percentage of viable seed in relation to total seed tested.

Do yourself

Collect information about seed testing laboratory



Exercise

Q.1 A. Fill in the blanks.

1. The matured and ripened ovule after fertilization is known as -----.
2. Breeder seed is the progeny of ----- seed.
3. The awaking of the dormant embryo is called as -----.
4. The test used to determine the viability of true seeds is ----- test.
5. The brick gravel test is used for determining -----.

B. Make the pairs

- | A | B |
|-------------------|------------------------|
| 1. Seed dormancy | a. Moisture test |
| 2. Crucible | b. TZ Test |
| 3. Certified seed | c. KNO_3 |
| | d. Brick gravel method |
| | e. Blue colour tag |

C. State true or false

1. Castor seed is dicot and non endospermic seed.
2. Genetic purity of breeder seed is 99.8 percent.
3. Gram is an example of epigeal type of germination.
4. TZ test is used for testing seed viability.
5. Physical purity test used for testing germination of seed.

Q.2 Answer in brief

1. Write short notes on
 - (i) Seed structure of castor
 - (ii) Foundation seed
 - (iii) Seed viability test
 - (iv) Types of germination
2. List out seed multiplication stages.

3. Give difference between

- (i) Seed and grain
- (ii) Nucleus seed and Breeder seed
- (iii) Breeder seed and foundation seed
- (iv) Foundation seed and certified seed
- (v) Physical purity test and germination test
- (vi) Seed vigour test and seed viability test
- (vii) Hypogea germination and epigeal germination

4. Give scientific reasons

- (i) Why cotyledon remains below the soil surface?
- (ii) Why cotyledon remains above the soil surface?
- (iii) Why foundation and certified seed multiplication seed stages are called as quality stages?

5. Give examples of

- (i) Endospermic seed
- (ii) Non endospermic seed
- (iii) Type of epigeal germination
- (iv) Hypogea type of germination
- (v) Germination in sand

Q.3 Answer the following questions

1. Complete the following table

- (a) Seed multiplication stages.

Sr. No.	Name of stage	Source of seed	Genetic purity
(i)	Breeder seed		
(ii)	Foundation seed		
(iii)	Certified seed		
(iv)	Truthful seed		

(b) Seed type and germination

Sr. No.	Name of seed	Type of seed	Type of germination
(i)	Bean		
(ii)	Maize		
(iii)	Castor		
(iv)	Gram		

2. Describe the structure of dicot seed.
3. Draw and label structure of monocot seed.
4. Calculate pure seed percentage when weight of pure seed is 180 gms and total weight of all component is 200 gms.
5. Write the procedure of germination test on towel paper.

Q. 4 Answer in detail.

1. Explain the different stages of seed multiplication.
2. Describe the different types of seed germination.
3. Define seed dormancy and explain the methods of breaking seed dormancy with examples.
4. What is meant by seed health and give details regarding examination without incubation.
5. Write the procedure of seed moisture test by hot air oven method with formula.

Activity :

Classify seed from given seed sample by using physical purity work board and determine their percentage.



All these are called as seed. Identify and label them.



Fig. 4.9 : Different seed material



Recall a little

- You already know that soil and seed both go hand in hand
- Soil provides medium for plant growth
- A seed will develop into a healthy seedling only when it is placed in proper medium, at proper depth, time and spacing.
- The prime objective of seed treatment is to protect seed from soil borne disease and to promote the growth of plant.

5.1 Sowing

Sowing can be defined as the process of placing seed into the well prepared soil at proper place (depth) for growth OR The process of putting seed in the ground soil for growing crop plant is known as sowing.

5.1.1 Sowing time, depth and spacing

Proper and healthy stand of a crop is essential for getting its higher yield. It depends on the time, depth and method of sowing.



Can you recall?

- Which are the common seasons of sowing in Maharashtra and their approximate time of sowing ?
- Which crops are prominently grown in those seasons in your locality ?

Time of sowing

The exact or proper time of sowing depends upon different factors, such as sowing season, atmospheric as well as soil temperature and moisture content in seeding zone of soil. The common sowing seasons in Maharashtra are *Kharif*, *rabi* and summer.

The *Kharif* crop is usually sown after the regular onset of monsoon in the month of June to July. Very early sowing may not be advantageous, as it may result in failure of crop due to prolonged dry spell. However in certain situations early sowing may be advantageous, particularly for *rabi* crops. Usual sowing time of *rabi* crop is October to November. In certain cases advancing sowing in September to October may be helpful for taking advantage of available soil moisture. Time of sowing for summer crop varies from January to February. For most of the crops it is preferably first fortnight of January.



Try this

- Prepare a schedule of sowing dates in different seasons as per your opinion.
- Practice the sowing by any one method.
- Observe the changes in growth of plants at different dates of sowing.
- Determine the proper time of sowing based on crop stand and difference in growth performance.

There should be sufficient moisture in seeding zone, so that it would help in proper germination of seed and emergence of crop plants. Similarly, each crop needs definite range of temperature for proper germination and also for further vegetative growth. The sowing time should be such that moisture stress period (due to long dry spell) may be avoided at critical stages of crop growth. High soil moisture and atmospheric temperature at the time of sowing not only affects the seed germination but also favours the effect of different insects – pest and diseases e.g. stem borer of sugarcane, shootfly of jowar, etc. In short optimum time of sowing is therefore, a time which provides suitable environment at all the stages of crop growth.



The optimum time of sowing differs not only from crop to crop but also within different varieties of the same crop.

Depth of sowing

Sowing of seed at the appropriate depth is an important factor affecting establishment of good stand of crop.



Can you tell?

- Why seed depth is important?
- Which depth is safe for sowing?
- Do we need seed to be soaked in water before they are sown?
- How does planting depth affect germination?

The optimum depth of sowing depends upon soil moisture, size of seed, seed reserve and coleoptile length. For getting good vigour, it is necessary that the germination of seed should be good and for proper germination, it is always important that the seed should be placed in the moist zone of soil. Too shallow or too deep sowing results in large number of gaps and less plant population. Due to shallow sowing the seed germination is poor because of inadequate moisture in the upper layer of soil. Too deep sowing may also affects crop stand because in many cases seedling may not be able to push their shoots above the ground level from greater depth. Besides affecting plant population, the weed problem also becomes serious under such conditions.

The size of seed also have great influence on the depth at which seed should be sown. The crops like groundnut, castor, etc having bigger size of seed can be sown to a greater depth up to 6 cm. On the other hand crops like finger millet, pearl millet, tobacco, etc. having small sized seed have to be sown as shallow as possible. The thumb rule is to sow the seed to a depth approximately 3 to 4 times their diameter. For most of the crops the optimum depth of sowing ranges between 3 to 5 cm.

Shallow sowing depth of 2 to 3 cm is needed for the crops like pearl millet and finger millet. For small sized seeds which are sown shallow needs to be irrigated frequently to ensure good emergence of crop.

In the case of deep sowing, the seed reserves should be sufficient to put forth long coleoptile for emergence. The coleoptile length also differs from variety to variety of the same crop. For example – tall traditional varieties of wheat having long coleoptile length can be sown deep. On the other hand Mexican varieties with short coleoptile length need to be sown shallow.

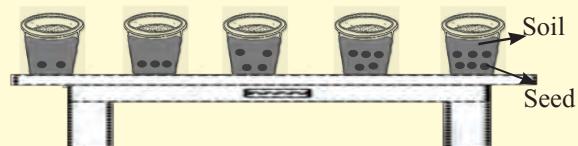


Try and think about it

- Take 5 containers (pots)
- Fill them with soil.
- Sow the seed in each pot at different depth and water it.
- Observe the result regarding emergence and discuss.



Observe and Discuss



Take few earthen pots of same size and fill them with soil. Sow the seeds in each container with increased number i.e. two seed in first, three in second, four in third and so on. Observe the growth parameters of plant in each pot. Discuss the result.

Spacing

The full yield potential of an individual plant is achieved when sown at optimum spacing. Too dense or wide planting may result in reduction of yield per unit area. If sown densely, the growth of individual plant will be affected due to competition among plants for space, food, water, etc. Similarly, yield from individual plant cannot be increased beyond certain limits. As such the spacing between two rows and two plants within a row should be optimum. It depends upon different factors such as growth habit of plant, soil type, purpose for which crop is grown and also the sowing season. The crop with branching habit or with good tillering capacity will require more space. Individual plant growth may be vigorous in rainy season. Hence, in rainy season the spacing may be wider than in summer season. On the same line wider spacing is required on heavy soil as compared to light soil. The spacing also depends upon the purpose for which crop is grown. Increase in plant height with less diameter is preferable for fodder crop and therefore, fodder crops are generally sown dense than grain crop. In crops grown on stored soil moisture under rainfed conditions, the spacing should be such to avoid overcrowding of plants that may deplete most of the moisture before crop matures. In short spacing should be so adjusted to have optimum plant population under different conditions.



Do this

How theoretically plant population is calculated by using figure of spacing for a particular area. Use following formula

$$\text{Plant population} = \frac{\text{Area m}^2}{\text{Spacing m}^2}$$



Try this

Calculate the plant population of 1 hectare Jowar crop when spacing is 30 cm × 25 cm.

5.2 Seed treatment

5.2.1 Definition

Seed treatment is the procedure of treating the seed with different insecticides, fungicides or combination of both for protecting their health. It also includes treatments subjecting seed to solar energy exposure, immersion in water, etc.

In short seed treatment is the treatment given to the seed to improve germination, vigour potential and to maintain good health of seed.



Fig. 5.1 : Seed treatment



Fig. 5.2 : Seed treatment

5.2.2 Objectives of seed treatment

The various objectives of seed treatment are as follows

(1) Protection of seed from seed rot and seedling blight

Rotting of seed, seedling blight and other seed and soil borne diseases can be prevented by giving appropriate seed treatment prior to sowing. Coating seed with certain chemical is done for this purpose.

(2) Prevention of the spread of disease

The infection from systemic diseases during different growth stages of crop and also during storage is prevented by appropriate seed treatment. Treatment is also helpful in preventing non systemic diseases.

(3) Protection of seed from insects in soil and in storage

The seed treatment with various insecticides alongwith fungicides is effective against storage pest and certain insects in soil.

(4) Improvement in seed germination

Germination of seed is improved by controlling seed surface flora, by breaking dormancy, removing inhibitors and treating seed with germination promoters.

(5) Reduction in cost of production

The cost of plant protection can be reduced by using treated seed for cultivation.

This helps in minimizing the cost of crop production to a greater extent.

(6) Production of good quality seed

Good quality seed can be produced when crop stand is uniform, vigorous and healthy. This can be achieved by using properly treated seed for sowing.

(7) Increase in nitrogen fixation:

Seed of leguminous crop is treated with rhizobium culture (nodule bacteria) for increase in nitrogen fixation through increased nodulation on the root. The seed of cereals or monocotyledons such as jowar, wheat, bajri, paddy, cotton, vegetables, etc. is treated with azotobacter. For sugarcane sets acetobacter and azospirillum species are useful for the same reason i.e. 'N' fixation.

(8) Convenience in sowing

The seed of cotton crop is intermingled into each other due to fuzz. This fuzz difficulty can be avoided by treating the seed with paste of soil and fresh cow

dung or by delinting with concentrated sulphuric acid.

(9) Induction of earliness and variations:

The maturity period of crop can be minimized by giving vernalization treatment to the seed. Similarly variations in original morphological and general structure of seed can be achieved by giving radiation treatment to the seed.

(10) Protection of beneficial insects

The insects like honey bee are beneficial to plants for pollination, fertilization, etc. The chemicals used for plant protection kill such insects. This can be avoided by using properly treated seed for sowing.

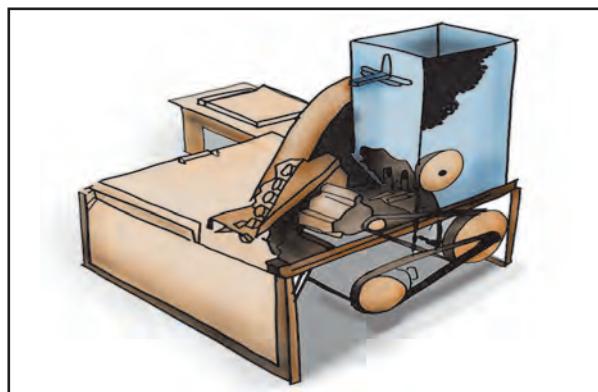


Fig. 5.3 : Slurry seed treater

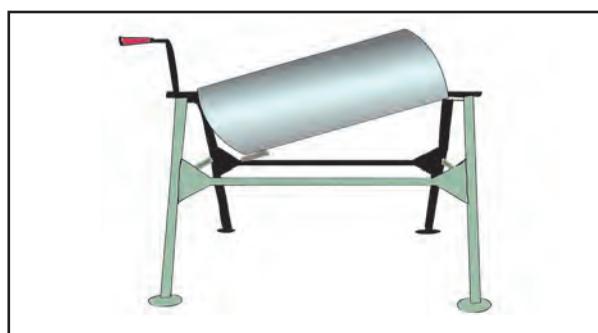


Fig. 5.4 : Seed treating drum

(11) Hardening of seed

Drought and cold tolerance can be achieved by treating seed with chemicals like calcium chloride (CaCl_2), Potassium chloride (KCl), monopotassium phosphate (KH_2PO_4).

(12) Seed fortification

This treatment is given for achieving high vigour to overcome soil reactions.



Do you know ?

Following equipments are used for seed treatment

- Seed treating drum (Home made drum / mixers)
- Slurry seed treater
- Mist – o – matic treaters
- Grain auger
- Shovel

5.2.3 Types of Seed treatment

Different types of seed treatments are as follows –

(1) Treatments for improving seed germination and vigour

- (a) **Soaking of seed in water** – Cotton seed is soaked in water for 4 to 6 hours in case of deshi and 10 to 12 hours in case of American varieties
- (b) **Use of chemicals** – Treatment of common salt NaCl or KH_2PO_4 (1%) for 12 hours is given to jowar seed for improving germination and vigour.
- (c) Treatments such as pre chilling, pre drying seed and rubbing seed against hard surface, low and high temperature treatments are done for breaking seed dormancy.

(2) Seed treatment with fungicides and insecticides

Advantages of such treatments are as follows

- It protect seed from seed rot.
 - It controls the attack of soil insects.
 - Protect seed from store grain pest
 - It prevents the spread of plant diseases.
- The three main types of fungicidal and insecticidal treatments are as follows

- (a) **Seed Disinfection:** It means eradication of fungal spores that have established within the seed coat or in deep seated tissues. The chemicals used must penetrate in to the seed to kill the fungus.

(b) Seed Disinfestation:

Seed disinfection refers to the destruction of surface borne organisms that have contaminated seed surface but not infected the seed surface. Chemicals are applied through soaks, dusts or dips.

- (c) **Seed Protection:** This is done to protect the seed and young seedlings from the organisms present in the soil.

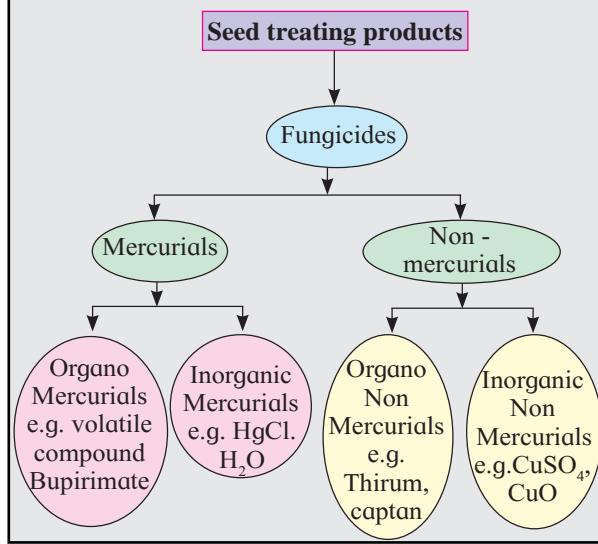


Remember this

Following precautions should be taken while treating the seed

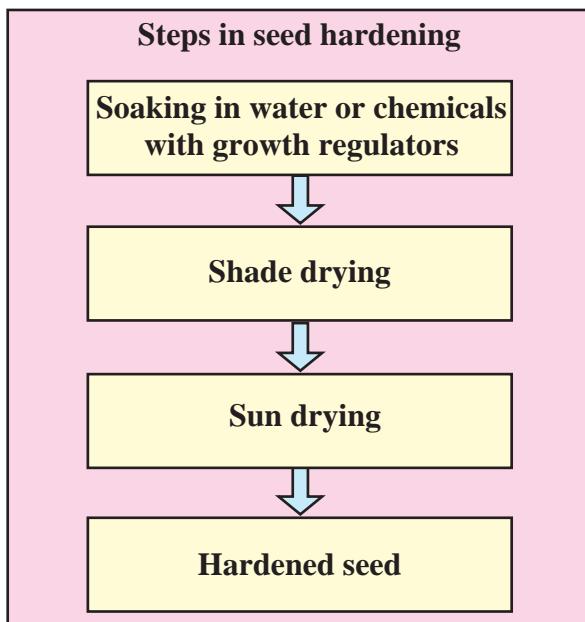
- (i) Treated seed should never be used as food for human or cattle.
- (ii) For avoiding use of treated seed as a food, the seed bag should be clearly labelled as 'poisonous and dangerous, if consumed.'
- (iii) The proportion of seed and chemical should be as per recommendation.
- (iv) Seed with high moisture content is susceptible to injury, when treated with concentrated products.
- (v) Treat only actual quantity of seed required for sowing.
- (vi) Wear safety kit while treating seed and avoid contact of chemicals with skin and respiratory tract.

Make a list and discuss the use of following fungicides.



(3) Special seed treatments:

- (a) **Seed hardening:** - This treatment given is for achieving drought and cold tolerance. Chemicals like CaCl_2 , KCl , and KH_2PO_4 are used for this treatment.
- (b) **Seed fortification:** - This is done to achieve high vigour to overcome soil reactions. The chemicals useful for this treatment are manganese sulphate, copper sulphate, etc.
- (C) **Seed pelleting:** This treatment consists of coating the seed with nutrients. This is generally used for forest tree seed.
- (d) **Moist sand conditioning:** This seed treatment is given for minimizing loss of seed viability.
Soybean seed is mixed with moist sand @ 5 to 10% moisture content. This is done for cocoa seed also.



5.3 Methods of sowing

Crop can be sown by different methods as described below:

- (1) **Broadcasting:** The seed is spread or scattered by hand on the soil surface and later on mixed in to the soil by working with wooden plough or harrow. This method is usually followed for irrigated crop. Majority of cereals and fodder crops are sown by this method.



Fig. 5.5 : Broadcasting

This method is cheapest, simplest and fastest. However, it has some disadvantages. The seed rate required by this method is relatively high. The crop stand is not uniform, as the distribution of seed by this method is uneven. Some places remains gappy and on the other hand some places become crowded. In the case of fine seeded crops, the seed is usually mixed with sand, ash, etc. Inter culturing is also not possible be implements. The crops sown by this method are jowar, bajra, wheat, paddy, red gram, sannhemp, etc.

- (2) **Drilling:** Drilling means sowing of seed to certain depth in lines by seed drills. The seed drills may be two coultered (dufan), three tyned (Tifan) or four tyned (Chaufan). As the seed is placed in lines at uniform depth, the crop stand is more uniform. Inter cultivation operations can be done by bullock drawn implements because of definite space between two rows of crop. This method needs less seed rate as compared to broadcasting. The examples of crop grown by this methods are bajra, jowar, wheat, green gram, pigeon pea, etc.



Fig. 5.6 : drilling by tractor drawn implement



Fig. 5.7 : Drilling by bullock drawn implement

(3) Dibbling: In dibbling method of sowing seed is placed at specific depth and spacing by a dibbler, planter or mostly by hand. This method requires more time and more labour for sowing. However this method has certain advantages. The seed rate required is less and crop stand is more uniform.

The interculturing is also possible in both directions by implements. The vigorously growing crops which need wider spacing are usually sown by this method. This method is useful for cotton, sunflower, groundnut, etc.



Fig. 5.8 : Dibbling

(4) Planting: When crop is sown by using vegetative plant parts such as tuber, rhizomes, cuttings, sets, etc, the sowing is referred as planting.



Fig. 5.9 : Planting of Sugarcane

The seed material is placed in soil and covered with soil by manual labour. The most common crops sown by this method are sugarcane, turmeric, potato, ginger, etc.

(5) Sowing in plough furrows: This method of sowing is commonly followed in dry land farming. This method is useful to take the advantage of moisture in lower layer of soil. The seed is placed at the bottom of the plough furrow and is covered, when succeeding furrow is turned over. This method is used for crops like gram, pea, wheat, maize, red gram, etc. This is slow and laborious method.

(6) Transplanting: Transplanting method consists of raising seedling in the nursery and then replanting them in main field. This method is usually followed for crops having small seed like paddy, chilli, tomato, tobacco and most of the vegetables as well as flower crops. The seed is sown in the nursery beds with all extra care needed for tender seedlings. While the seedlings are in the nursery, the farmer get sufficient time to prepare his land thoroughly. When the crop attains specific height or grown to a specific stage, they are pulled out from nursery bed and planted in the main field. The nursery bed should be irrigated properly prior to uprooting of seedlings from nursery. This is necessary for their easy removal. Similarly, main field should be irrigated lightly after transplanting, so that the seedlings get established faster.



Fig. 5.10 : Transplanting of paddy seedlings

Exercise

Q.1 A. Fill in the blanks.

1. The process of putting seed in the ground soil for growing crop plant is called as -----.
2. *Kharif* crop is usually sown in the month of -----.
3. The thumb rule is to sow the seed to a depth approximately ----- times their diameter.
4. For increased nitrogen fixation, leguminous crops are treated with --- ----- culture.
5. The maturity period of crop can be minimized by giving ----- treatment to the seed.

B. Make the pairs

- | 'A' group | 'B' group |
|------------------|--|
| 1. Broadcasting | a. Sowing by seed drills |
| 2. Dibbling | b. Sowing by hand using planter |
| 3. Drilling | c. Scattering seed on soil surface |
| | d. Raising plant in the nursery |
| | e. Sowing by using vegetative plant part |

C. State true or false

1. Water soaking treatment to cotton seed is given for improving seed germination.
2. Seed disinfestations means eradication of fungal spores that have established within seed coat.
4. Seed disinfection means destruction of surface borne organisms.

4. Moist sand conditioning is given for minimizing loss of seed viability.
5. Good quality seed is produced, when crop stand is uniform, vigorous and healthy.

Q. 2 Answer in brief.

1. Give the examples of crops sown by planting method.
2. What is meant by seed treatment?
3. Why it is necessary that seed should be placed at optimum depth?
4. Give the disadvantages of broadcasting.
5. Write the advantages of dibbling.

Q. 3 Answer the following questions

1. Explain broadcasting with examples of crops
2. Complete following chart.

Sr. No.	Name of the Crop	Method sowing
1	-----	Broadcasting
2	-----	Dibbling
3	-----	Planting
4	-----	Transplanting
5	-----	Sowing in plough furrows
6	-----	Drilling

3. Calculate the plant population for 1 hectare jowar crop when spacing is $30\text{ cm} \times 15\text{ cm}$
4. Describe the depth of sowing.
5. Explain with examples the different treatments given for improving seed germination and vigour.

Q. 4 Answer in detail

1. Define seed treatment and give its objectives.
2. Read the following information and answer the questions.

Seed treatment materials are available in the form of dusts, wettable powders and liquids. Dust fungicides are applied at the rate of 2 to 2.5 gm per kilograms of seed. They are mixed by mechanical mixer. Slurry fungicides applied in a water suspension, which is mixed with seed in a slurry seed treater. Use of liquid solution is known as the quick wet method. A solution of a volatile fungicide is applied to the seed and is thoroughly mixed with them. Most seed treatments contain dyes which serve two purposes. First as a warning that seeds have been treated and second as a visible means of evaluating the completeness of treatment coverage. Some important causes of poor seed treatments are use of wrong or inappropriate fungicide, use of inadequate dosages and carelessness in the treatment procedure.

- a. In which forms the seed treatment material is available?
- b. What is the rate of application of dust fungicides?
- c. How slurry type of fungicides are applied?
- d. Give the purpose of using dye in seed treatment.
- e. List out any two causes of poor seed treatment.
3. Explain the different methods of sowing and give examples.
4. State the advantages of seed treatment with fungicides and insecticides and explain their types.
5. Describe the different factors useful in deciding proper time of sowing.

Activity :

Practice the different methods of sowing in the field.

Do yourself

Write the precaution taken from you regarding the activity of sowing.



Recall a little

1. Any living thing requires food (nutrition) for their growth, development and maintenance.
2. The food of plant is composed of certain chemical elements which are referred as essential nutrients.
3. These elements are absorbed by plant roots principally as inorganic ions derived mostly from mineral constituents of the soil.
4. Depending upon the availability of the nutrients in soil, the nutrient content in a plant could be deficient, insufficient, sufficient, excess or toxic.

6.1 Essential elements

6.1.1 Definition

The elements needed by the plant for their growth, development and completion of life cycle, without which plant will not be able to survive are called as essential elements.



Know the Scientist

Dr. Daniel Israel Arnon
14 Nov 1910 to
20 Dec 1994



American plant physiologist whose research led to greater insights into the operation of photosynthesis in plants. He was awarded national medal of science in 1973. He suggested criteria of essentiality in 'plant nutrition', (1954).

6.1.2 Criteria of essentiality

For an element to be regarded as an essential nutrient the following three criteria have been suggested by the scientist Arnon (1954).

1. The plant may be unable to grow normally or complete its life cycle in the absence of the element.
2. The element is specific and can not be replaced by any other element.
3. The element plays a direct role in the process of metabolism.

The following elements are recognized as essential (major) for plant growth. They are Carbon (C), Oxygen (O), Hydrogen (H), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo) and Chlorine (Cl).

Now a days Sodium (Na), Cobalt (Co), Silicon (Si) and some other elements are also being added to this list as supporting ones (minor).

6.1.3 Sources of elements

The deficiency symptoms of an element can be corrected by the application of that element. (see table 6.1)



Can you tell?

1. Can we consume variety of food items in our daily diet i.e. vegetables, fruits, rice, milk, salt, etc. in equal quantity?
2. What is the food of plants?
3. Whether the plants require all nutrients in equal quantity?

Table 6.1 : Sources of elements

Natural Source	Nutrient	Usable / available form by plant	Specific source
Air	Carbon (C), Oxygen (O)	CO_2 , O_2	Air, Water
Water	Oxygen (O) Hydrogen (H)	H_2O , O_2	Air, Water
Soil	Nitrogen (N)	NO_3^- (Nitrate - anion) NH_4^+ (Ammonium - cation)	Fertilizers, manures and also atmospheric N-Fixation
	Phosphorus (P)	H_2PO_4^- (Monophosphate - anion) HPO_4^{2-} (Diphosphate - anion)	Apatite Rock Phosphate
	Potassium (K)	K^+ (K-cation)	Feldspar, Mica, Illite
	Calcium (Ca)	Ca^{+2} (Ca-Cation)	Calcite, Dolomite, Gypsum
	Magnesium (Mg)	Mg^{+2} (Mg-cation)	Dolomite, Sandstone
	Sulphur (S)	SO_4^{2-} (Sulphate - anion) SO_3^{2-} (Sulphite - anion)	Iron pyrite, Gypsum
	Zinc (Zn)	Zn^{+2} (Zn-cation)	Sphalerite Smithsonite
	Copper (Cu)	Cu^{+2} (Cu-cation)	Chalcocite, Cuprite
	Iron (Fe)	Fe^{+2} (Ferous cation) Fe^{+3} (Ferric cation)	Haematite, Pyrite, Olivine
	Manganese (Mn)	Mn^{+2} (Mn-cation))	Magnetite, Pyrolusite
	Boron (B)	H_3BO_3^- (Metaborate - anion) H_2BO_3^- (Borate - anion)	Borax, Tourmaline
	Molybdenum (Mo)	HMnO_4^- (Molybdate - anion)	Molybdenite, Ferrimolybdate
	Chlorine (Cl)	Cl^- (Cl-anion)	Muriate of Potash, Sodium Chloride

6.2 Classification of essential elements

On the basis of quantity required by plants, the elements are classified as follows.

1. Major or macronutrients

Major or macronutrients, are required by plants in large quantity. These include C, H, O, N, P, K, Ca, Mg and S. These are further subdivided as follows.

(a) Basic nutrients - C, O, H

Carbon, oxygen and hydrogen constitute about 95% weight of plant. Field crops obtain most of their carbon and oxygen directly from the air. Hydrogen is derived either directly or indirectly from the soil water.

(b) Primary nutrients -

Nitrogen, Phosphorus and Potassium are termed as primary nutrients as they are required in large amount by the plants. Their wide spread deficiencies can be corrected by the application of chemical fertilizers. Hence they are sometimes designated as 'fertilizer elements'.

(c) Secondary nutrients -

Calcium, Magnesium and Sulphur are termed as secondary nutrients because they are required in moderate amount by the plants. Secondary nutrients are as significant as primary nutrients in plants but they are needed in moderate quantity.



Deficiency of secondary nutrients can be corrected through application of Calcium nitrate, Magnesium sulphate, Sulphur, etc. and fertilizers containing primary nutrients e.g. single super phosphate contains both Ca and S, likewise ammonium sulphate, a nitrogenous fertilizer also supply S.

2. Minor or micronutrients

(Trace elements)

The nutrients that are required relatively in smaller quantities are termed as ‘micronutrients’. These include Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo) and Chlorine (Cl). The micronutrients are subdivided into micronutrients cations and anions depending upon the form in which plants absorb them.

- (a) Micronutrient cations - Fe, Mn, Zn and Cu
- (b) Micronutrient anions - B, Mo and Cl

The sources used to supply micro nutrients are called micronutrient fertilizers. They are supplied through inorganic salts e.g. Ferrous Sulphate, Zinc Sulphate, Borax, etc.

6.3 Functions and deficiency symptoms

The essential elements play an important but different role/functions in plants. The better known important functions of the essential elements are :

- 1. They act as structural constituents and support the frame work of the plant body.
- 2. They are components of cell constituents and metabolically active compounds of the cell.
- 3. They help in maintenance of cellular organisation.
- 4. They help in energy transformation and enzyme action.

When the quantity of nutrients is low/deficient in the growing medium, such nutrients limit the growth of plants. This

deficiency produces specific symptoms on the plant. The deficiency symptoms are characteristic to the specific nutrient.



Remember this

1. Nutrient content is considered **deficient** when it is so low that it severely limits the growth and produces deficiency symptoms on plants.
2. Nutrient content when associated with only growth reduction and not by appearance of deficiency symptoms are termed as **insufficient**.
3. Range of nutrient content in plant associated with optimum crop yields is called as **sufficient**.
4. When the concentration of a nutrient element rises too high to cause significant growth reductions, it is termed as **toxic**.



Do you know ?

1. How healthy plant is different from sick plant?
2. Morphological difference between normal plant and abnormal plant in respect of appearance, height, growth, modification, etc.

The general functions of the specific elements carried out in the plant body as well as the specific symptoms exhibited on plant when that element is deficient in the soil are given in short in the following table.

Table 6.2 : Functions and deficiency symptoms of nutrients.

Element	Functions	Deficiency Symptoms
Macronutrients		
Carbon (C)	<ul style="list-style-type: none"> (i) Carbon forms backbone of most of the plant biomolecules including protein, starch and cellulose. (ii) Carbon forms the skeleton of the plant 	--
Hydrogen (H)	<ul style="list-style-type: none"> (i) It is necessary for building sugars in plant. (ii) It maintains turgor rigidity (iii) It helps for electron transport chain in photosynthesis and for respiration. 	--
Oxygen (O)	<ul style="list-style-type: none"> (i) It is component of many organic and inorganic molecules within the plant. (ii) It is required for aerobic cellular respiration and breakdown of glucose to produce ATP 	--
Nitrogen (N)	<ul style="list-style-type: none"> (i) It is a constituent of chlorophyll (ii) Nitrogen imparts dark green colour to plant. (iii) It increases vegetative growth (iv) It is required for formation of amino acids, proteins and nucleic acid. (v) It increases acceleration, utilization of the constituents. 	<p>It's deficiency causes</p> <ul style="list-style-type: none"> (i) Stunted growth (ii) Restricted foliage (iii) Pale yellow or light green colour to leaves (iv) Low yields of crops (v) Shedding of leaves and fruits
Phosphorus (P)	<ul style="list-style-type: none"> (i) It is constituent of nucleic acid, co-enzymes, phospho proteins and phospholipids (ii) It increases root nodule formation on roots of pulses (iii) Increases tillers and ratio of grain to straw in crops (iv) It induces early maturity (v) It makes plant tolerant to drought, cold, pests and diseases (vi) It increases root growth 	<ul style="list-style-type: none"> (i) Restricts growth of plant shoots and roots (ii) Imparts bluish green or dark green colour to older leaves (iii) It suppresses growth of lateral buds (iv) Delays maturity of crops (v) Potato tubers show rusty brown lesions in the flesh

Potassium (K)	<ul style="list-style-type: none"> (i) It increases leaf efficiency in manufacturing sugar and starch (ii) It controls the stomatal movement (iii) It plays catalytic role in activating number of enzymes (iv) It is required for maintenance of cellular organisation (v) It increases resistance to diseases, heat and moisture stress (vi) It improves quality of fruits (colour, flavour and size, etc.) 	<ul style="list-style-type: none"> (i) Deficiency causes stunted and bushy plant growth. (ii) Leaf margins turn brown (iii) It causes shortening of internodes and drying of shoot (iv) Deficiency causes blackening of potato tubers and damage in storage
Calcium (Ca)	<ul style="list-style-type: none"> (i) It is a constituent of cell wall (ii) It is required for mitotic activities (iii) It activates enzymes phospholipase and ATPase, etc. (iv) It plays primary role as soil amendment (v) It helps to translocate the sugar in the plants (vi) It neutralises organic acid which may become poisonous to plants 	<ul style="list-style-type: none"> (i) It affects the meristematic portions of root and terminal buds of plant die. (ii) Root growth is stunted (iii) Marginal chlorosis occurs in younger leaves (iv) Premature falling of flowers and fruits in leguminous crops
Magnesium (Mg)	<ul style="list-style-type: none"> (i) It is a part of chlorophyll molecules (ii) It is required by enzymes involved in carbohydrate metabolism (iii) It is essential for activity of enzymes (iv) It is usually needed by plants for synthesis of oils and fats (v) Increases crop resistance to drought and diseases 	<ul style="list-style-type: none"> (i) It increases chlorosis between the veins of older leaves and they may turn brown (ii) It may cause necrosis in severe deficiency.
Sulphur (S)	<ul style="list-style-type: none"> (i) It is a constituent of amino acid and vitamins involved in synthesis of chlorophyll (ii) It is required for the activities of enzymes (iii) Pungent odour of onion and garlic is due to sulphur compounds' (iv) It stimulates seed formation 	<ul style="list-style-type: none"> (i) It causes chlorosis (ii) It develops antho-cyanine pigmentation (which is first in younger leaves) (iii) Fruit becomes abnormal-shaped, thick skinned and less juicy
Iron (Fe)	<ul style="list-style-type: none"> (i) It takes part in chlorophyll synthesis (ii) It has a catalytic role in activities of many enzymes (iii) It is active in biological oxidation 	<ul style="list-style-type: none"> (i) It causes interveinal chlorosis which first appears in younger leaves (ii) Leaves become dry and papery later turn brown and necrotic (iii) Chlorosis and mottle leaf in sugarcane

Manganese (Mn)	(i) It is the activator of enzymes in respiration and metabolism (ii) It also activates many other enzymes (iii) It helps in synthesis of chlorophyll as it is a part of chlorophyll	(i) It causes interveinal chlorosis of young leaves (ii) The necrotic spots appear on leaves (iii) Causes marsh spots on peas and blight on sugarcane leaves
Zinc (Zn)	(i) It is required in auxin and protein synthesis (ii) It takes part in synthesis of chlorophyll (iii) It is essential for RNA synthesis and seed production	(i) It causes interveinal chlorosis (ii) Chlorosis is followed by necrosis in older leaves (iii) It results in short internodes, Khaira disease in rice, 'White bud' in maize. (iv) Plants show rosette appearance
Copper (Cu)	(i) It is required in carbohydrate and protein metabolism (ii) It is activator of enzyme (iii) It is essential for synthesis of vit.-A in plants (iv) It is involved in the respiration of plants	(i) The young leaves become necrotic at tip point (ii) Dead tissue appears on tips of leaves (iii) Multiple bud formation in the leaf axil (iv) Gum formation and dieback in citrus
Boron (B)	(i) It is involved in transportation of carbohydrate in plants (ii) It helps in flower and pollen grain formation (iii) Essential for translocation of sugar in plants	(i) Its deficiency causes death of shoot tips (ii) Causes stunted leaves (iii) Also causes cracking of fruits (iv) Associated with sterility and malformation of reproductive organs
Molybdenum (Mo)	(i) It is essential in symbiotic 'N' fixation and nitrate assimilation (ii) It is the constituent of nitrate reductase enzyme	(i) It causes chlorotic interveinal mottling of the basal leaves which is followed by necrosis. (ii) Its deficiency causes 'Whip tail' in cauliflower. (iii) It reduces activities of nitrogen fixing organisms.
Chlorine (Cl)	(i) It is involved in primary photosynthetic reaction. (ii) It is also involved in cyclic photo phosphorylation	(i) It gives wilted appearance to foliage (ii) It causes stuffy roots with lateral branching

6.3.2 Integrated Nutrient Management (INM)

It is the combined application of chemical fertilizers along with organic resource materials like organic manure,

green manures, biofertilizers and other decomposable material for crop production. The basic concept of INM is the adjustment of plant nutrient supply to an optimum level for sustaining the desired crop productivity.

Integrated nutrient management (INM) is the consideration of all the factors responsible for increasing available nutrients in the soil.

Those factors are as follows.

- (1) Physical condition of soil – The availability of nutrient depends on the physical condition of soil such as good structure, aeration, etc.
- (2) Soil moisture - Plants absorb nutrients from the soil in the form of solution and which require sufficient moisture in the soil.
- (3) Soil pH – The nutrients remain generally available in the soil at neutral pH (6.0-7.0).
- (4) Manures and nutrient management– Manure provide organic nutrients and moisture in the soil. It improves physical, chemical and biological properties of soil.
- (5) Fertilizer and nutrient management– The fertilizers are acidic or basic in nature. Application of fertilizer constantly makes the soil acidic or alkaline according to nature of fertilizer used. Fertilizer should be applied on the basis of the soil analysis.
- (6) Bio - fertilizer and nutrient management - Bio-fertilizer are the culture of microorganism capable of fixing or solubilizing the nutrients.

Integrated Nutrient Management (INM) is actually the technical and managerial component which is one of the policy of ICAR. Organic materials are the potential source of major nutrients besides containing fair amounts of micro nutrients. The indirect effects include augmentation of beneficial microbial population, their activities and improvement of soil health. Incorporation of crop residues as well as other organic material like press mud cake, biogas slurry, green manuring, vermicompost, etc. seems

to be quite promising for increasing organic matter in the soil.

To achieve the objectives of INM the strategies are-

- i. Use fertilizer recommendations based on soil analysis. Use optimum and balanced fertilizers for the cropping system as a whole.
- ii. Integrated use of all sources of nutrients as per soil and crop need.
- iii. Use of crop rotations involving legumes
- iv. Remove deficiencies of nutrients as and when first detected and ameliorate problematic soils with appropriate amendments.
- v. Encourage farmers to use bio-inoculants, bio-fertilizers, organic manures and promote farmer to evaluate soils for quality, fertility and overall productivity.

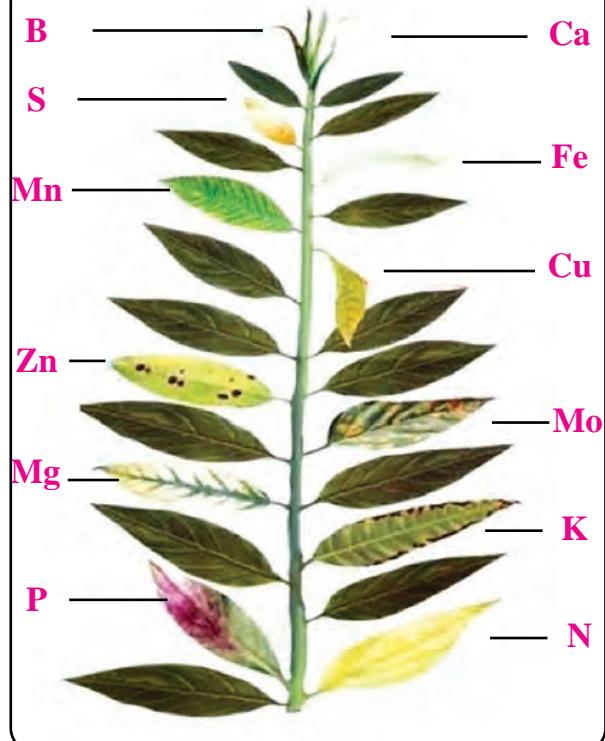


Fig. 6.1 : Deficiency symptoms of nutrients



Can you tell?

1. Different materials which supply nutrients to plants
2. Naturally available source and artificial compounds supplying nutrients

6.4 Manures and fertilizers

6.4.1 Meaning

1. Manures

These are the organic substances of plant or animal origin and capable of supplying plant nutrients in small quantity per unit weight as well as provide food for soil micro organism. Examples are FYM, compost, green manure, vermicompost, organic waste, crop residues, etc. (The value

of these manures, however, depends on the amount of humus they add to the soil.)

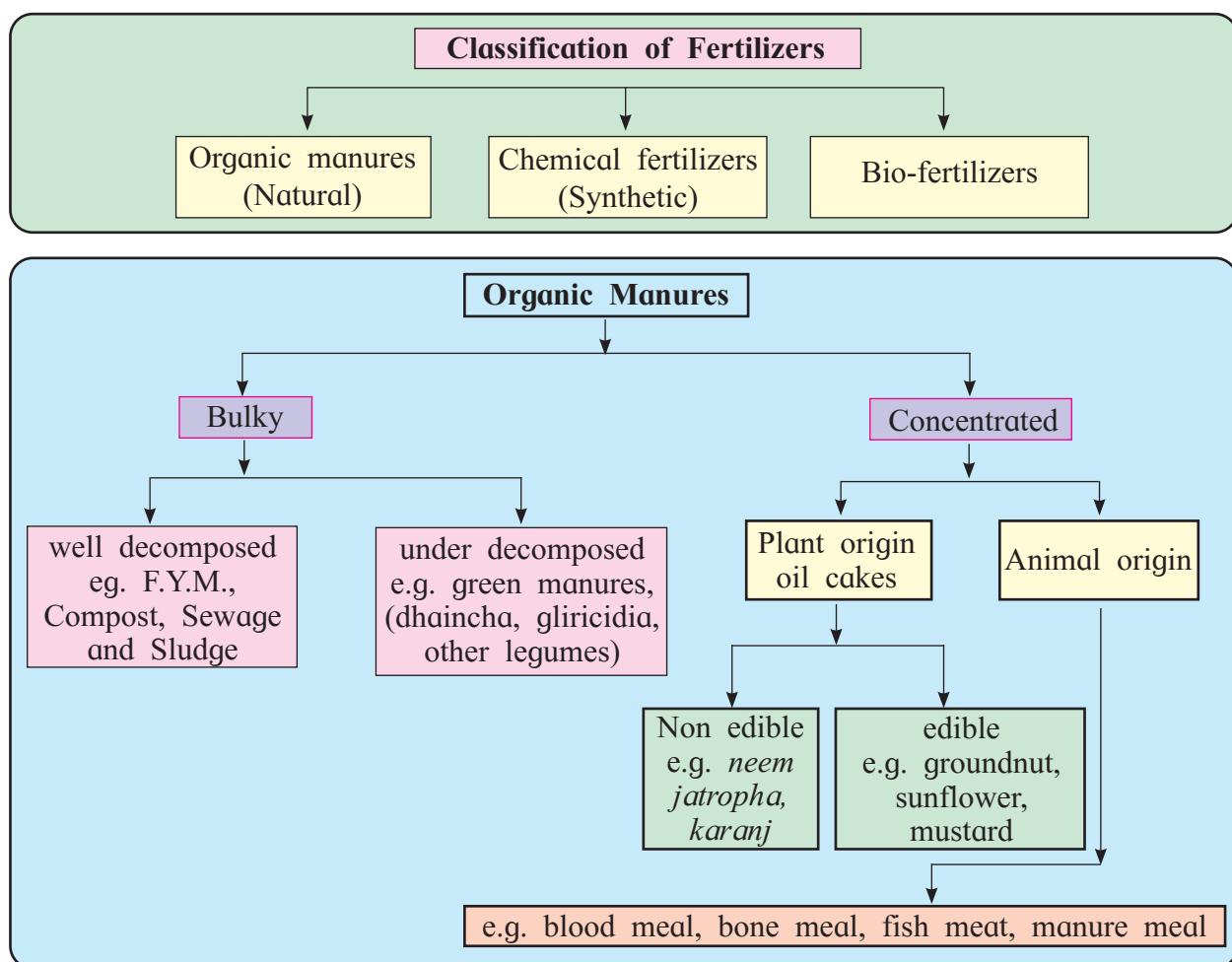
2. Fertilizers

These are the inorganic substances added to soil to supply certain elements essential for crop growth. They contain large amount of nutrients per unit weight and in a definite composition e.g. urea, single super phosphate, muriate of potash, etc.

3. Bio-fertilizers

These are the substances which contain living micro organisms which, when applied to seed, plant surfaces or soil colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. e.g. *Rhizobium*, *Azotobacter*, Blue green algae (BGA) etc.

6.4.2 Classification of Manures and Fertilizers



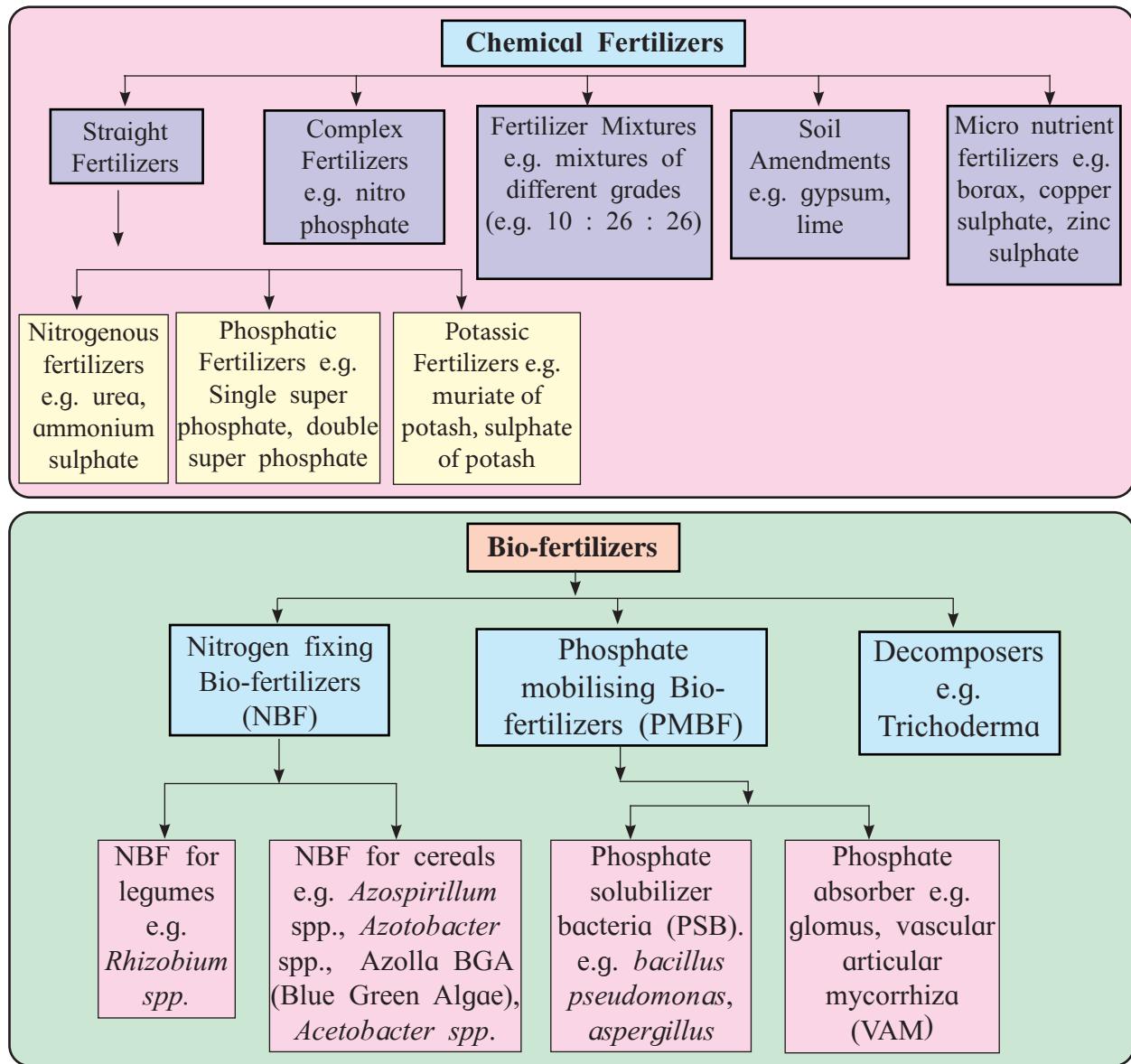


Fig. : 6.2 : Classification of manures and fertilizers

6.4.3 Brief study of Manures and Fertilizers

Bulky Organic Manures

These manures contain plant nutrients in small quantities and organic matter in large quantities.

1. Farm Yard Manure (FYM) : It is decomposed mixture of the solid and liquid excreta of farm animals along with litter (e.g. materials used for bedding purpose of cattle) and left over material from fodder fed to the cattle, e.g. cattle manures, sheep penning, poultry manure, etc.

- 2. Compost :** This is the bulky organic manure obtained from the decomposition of organic wastes with the help of the action of microorganisms. e.g. rural compost (made from farm waste and house refuses), urban compost (made from town wastes).
- 3. Vermicompost :** The compost prepared by using earthworms is called vermicompost.
 - Selection of earthworms - *Eisenia fetida* being a most active species hence, commonly used for vermicompost production.

- Earthworms which are the native of the local soil can be used.
- (ii) Size of pit : 3.0 m long, 1.5 m wide and 0.6 m deep pit may be prepared. The distance between two pits is 0.6 m.
- (iii) Preparation of vermibed - At the bottom of the pit 15 cm layer of raw organic material from farm, household refuse, etc. should be placed.
- (iv) Organic layering - Compost pit is then layered about 15 cm with partially decomposed cow dung and soil in 3:1 proportion. Moisture level is maintained (without flooding) by spraying of water.
- (v) Wet organic layer - Cow dung slurry (or biogas slurry) is to be prepared and spread over it to a thickness of 10 cm and cover the pit with 15 cm organic material (dry and green leaves). After 3-4 days inoculation of earthworm is done.
- (vi) Inoculation of earthworm - About 1000-1500 earthworms are introduced as an optimum density into a compost pit.
- (vii) Harvesting - At maturation, moisture content is brought down. This ensures drying of compost and migration of worms towards base of the vermibed. Mature compost is removed, sieved, dried and packed.
- 4. Sewage and sludge :** (i) Sewage - This is the liquid collected from the closed drains usually contains urine and washings in addition to night soil and other solid ingredients. Sewage has two components.
- (a) Solid portion - sludge
 - (b) Liquid portion - sewage
- (ii) Sludge - The settle sewage solid combined with varying amounts of water and dissolved materials removed from sewage by screening, sedimentation, chemical precipitation or bacterial digestion is called sludge.
- 5. Green manuring :** It is the practice of incorporation of green succulent plant material into soil for improving physical structure as well as the fertility of soil. It consists of raising quick growing crops upto flowering stage and incorporate them into the soil by ploughing. There are two types of green manuring.
- (i) **Green manuring *in situ*** - Green manure crops are grown *in situ* either as a pure crop or as an intercrop with the main crop and then buried in the same field at flowering stage e.g. sannhemp, dhaincha, cowpea, cluster bean, etc.
 - (ii) **Green leaf manuring** - This refers to turning into the soil the green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste land and near by forest area e.g. Glycicidia.
- ### Concentrated organic manures
- 1. Plant origin :** These are organic in nature and contain relatively higher percentage of plant nutrients as compared to bulky organic manure. These are generally undecomposed material.
 - (i) **Oil cakes** : Richest source of plant nutrients of all organic manures. These are of two type.
 - (a) **Edible oil cakes** - These types of oil cakes are generally used for feeding the cattle as concentrates, but low grade ones can be used as manure for crops e.g. groundnut cake, mustard cake, sesame seed cake, linseed cake, etc.
 - (b) **Non edible oil cakes** - These types of oil cakes are not suitable for feeding cattle and mainly used for manuring e.g. neem cake, karanj cake, mahua cake, castor cake, etc.

- (ii) **Animal origin - (a) Waste products of slaughter house :** (a) **Blood meal** Dried blood is a very quick acting manure and is effective for all type of crops and soil.
- (b) **Bone meal :** It is the oldest phosphatic fertilizer as bones contain calcium phosphate. It is more effective with PSB.
- (c) **Fish meal :** This is available either as dried fish or as fish meal or powder where in fish oil is extracted. The residue contains nutrients hence can be used as manure.

Chemical fertilizers

(A) Straight fertilizers : Chemical fertilizers which contain only one primary or macro nutrient are called as straight fertilizers e.g. urea, single super phosphate, MOP, etc.

(B) Compound or complex fertilizers: Fertilizers which contain more than one primary or major nutrient elements and produced by the process of chemical reactions. These fertilizers are usually produced in granular form e.g. diammonium phosphate (DAP), Suphala (15:15:15, 20:20:00), Monoammonium phosphate, 10:26:26, 12:32:16, etc.

(C) Mixed fertilizers or fertilizer mixtures: These are prepared by physical mixing of two or more fertilizers. Such mixtures can be prepared by mixing two or more straight fertilizers. Usually fertilizer mixtures are prepared to meet specific needs of crop e.g. NPK 10:5:5, 20:20:00, 20:10:10, etc.

(D) Soil amendments : Any material which is used to correct the soil acidity/alkalinity or any problematic property of soil is called as soil amendment e.g. Gypsum, lime, iron pyrite etc. lime stone is used to correct acidic soil and gypsum to correct alkaline soil.

(E) Micronutrient fertilizers : Micronutrient fertilizers are those which contain micro nutrients. They are the salts like Zinc Sulphate, Ferrous sulphate, manganese sulphate, etc.

Bio-fertilizers

(1) Nitrogen fixing bio-fertilizers (NBF)

Atmosphere contains 78 percent nitrogen and 0.03 percent Carbon dioxide. Plants are capable to assimilate carbon dioxide through photosynthesis even when carbon dioxide content in air is less, but most of the plants cannot fix atmospheric nitrogen though it is abundant.

NFB bacteria play a very significant role in improving soil fertility by fixing atmospheric nitrogen both in association with plant roots and also without it. e.g. *Rhizobium*, *Azotobacter*, *Azospirillum*.

(2) Phosphate mobilising bio-fertilizers (PMBF)

These micro-organisms are mainly bacteria and fungus. They possess the ability to bring insoluble soil phosphates into a soluble forms by secreting several organic acids, under favourable conditions and also by the biological reactions.

(3) Decomposers

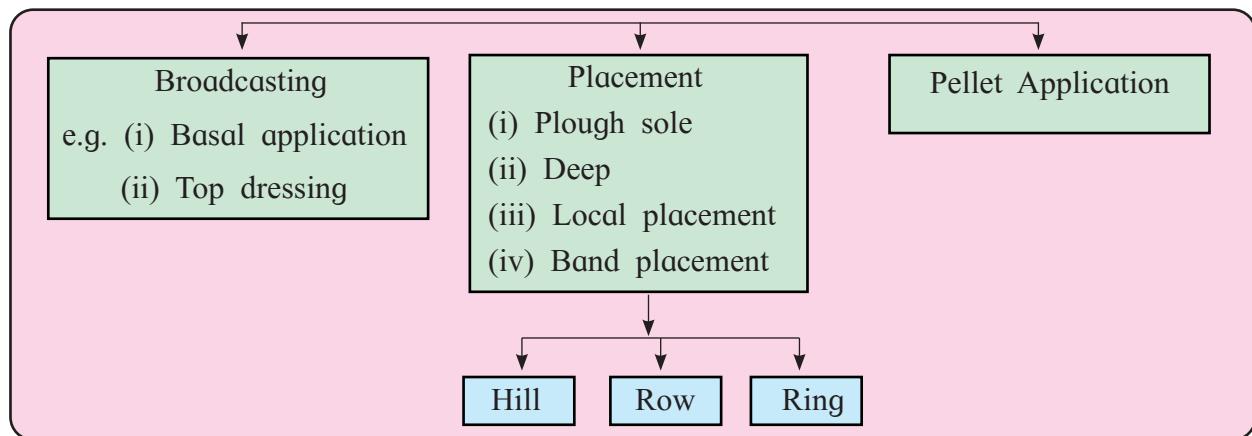
Decomposing bio-fertilizers when added with organic matter increases the rate of decomposition of the organic matter hence, they are used for preparation of compost, FYM and in situ decomposition of organic residues in field.

6.4.4 Methods of fertilizer application

Fertilizers are costlier inputs in agriculture. They need to be applied at proper time and also by correct method to get maximum benefits from this input. Otherwise, the objective of fertilizer application may not be fulfilled. Fertilizers are generally applied in the following two forms.



1. Application of fertilizers in solid form



Types of fertilizer application in solid form

(a) **Broadcasting** : Even and uniform spreading of manure or fertilizer by hand over the entire surface of field while cultivation or after the sowing in standing crop is termed as broadcasting. Depending upon time of fertilizer application there are two types of broadcasting.

(i) Broadcasting at planting or sowing e.g. concentrated organic manures, potasic fertilizer, citric soluble phosphatic fertilizers, etc.

(ii) Top dressing : Braodcasting fertilizers in standing crop is known as top dressing. Care must be taken that do not apply when leaves are wet e.g. Urea, ammonium nitrate.



Fig 6.2 Broadcasting fertilizer

Disadvantages of broadcasting

(i) Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.

(ii) The weed growth is stimulated all over the field.

(iii) Nutrients are fixed in the soil as they come in contact with large mass of soil.

(b) **Drilling** : Granular fertilizers are applied through seed-cum-fertilizer drill at sowing time. The phosphatic and potassic fertilizers are applied to cereal crops and cotton. But this method is not suitable for pulse crops.

(c) **Placement or spot application** : It is the method of placing fertilizer in the soil before or after sowing the crops. The roots of young plants can get nutrients as per their requirement from the fertilizer applied by this method.

(i) **Ring/Circle method** : Fertilizer application can be done by making circle or ring around the plant trunk with sickle/khurapi and covering it with soil by hand.

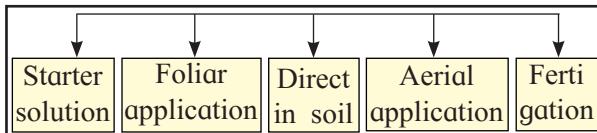
(ii) **Band method** : Fertilizer is placed in bands or hills near the plant (3-5 cm away) and cover with soil.

(iii) **Row placement** : The fertilizers are placed on one or both sides of the row by hand e.g. potato, sugarcane, etc.

(d) **Pellet application** : It refers to the placement of nitrogenous fertilizers in

the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop. The fertilizers mixed with the soil in the ratio of 1:10 and small pellets of convenient size are made to deposit.

2. Application of fertilizers in liquid form



Types of fertilizer application in liquid form

- (a) **Starter solution :** Starter solution is prepared by mixing N, P and K fertilizers in the ratio of 1:2:1 or 1:1:2. This is applied to the vegetables seedlings at the time of transplanting and it helps rapid establishment and quick early growth of seedlings.
- (b) **Foliar application :** This is method of spraying leaves of growing plant with suitable fertilizer solution having low concentration. It is effective for micro nutrient fertilizers.
- (c) **Direct application to the soil :** Liquid fertilizers are directly applied to the soil with special injection equipment e.g. unhydrous ammonia, liquid manure such as urine, sewage water and cowshed washings are let into field.
- (d) **Application through irrigation water (Fertigation) :** It refers to the application of water soluble fertilizers through irrigation water generally nitrogenous fertilizers are applied through irrigation.
- (e) **Aerial application :** In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest land, in grass land or in sugarcane field.

3. Application of bio-fertilizers

- (a) **Seed inoculation method** - Bio-fertilizer is mixed in wheat flour with suitable amount of water and then seeds are dipped. Treated seeds are kept in shed for 30 minutes and used for sowing. For 20 kg seed use 200 gm bio-fertilizer and 250 gm wheat flour.

(b) Root inoculation method - Bio-fertilizers mixed in water and roots of clean seedling are dipped in solution for 120 minutes before transplanting. Use 200 gm biofertilizer for 5-6 lit. water.

(c) Soil application - Bio-fertilizer mixed with compost and soil mixture and then spread in field. Use 5 kg biofertilizer for one hectare field and mix it with 25 kg compost and 50 kg soil before spreading.

Precautions adopted in using bio-fertilizers

- (i) No other fertilizer or insecticides/fungicides should be mixed with seed that are treated with bio-fertilizer.
- (ii) The seed treatment, if required should be done at least 24 hours before mixing the seeds with bio-fertilizers.
- (iii) Organic manures should not be kept in dump place and in bright sun.
- (v) The bio-fertilizers should be used before expiry date.

Benefits of bio-fertilizers

There are various benefits in using bio-fertilizers as follows -

- (i) It increases the yield of the crop by supplying nitrogen in soil.
- (ii) It improves the soil condition and health through micro-organisms.
- (iii) The environment cannot be polluted in any way due to the use of biofertilizers.
- (iv) Bio-fertilizers are considered ecofriendly. Bio-fertilizers save the crops primarily from seed, soil and water borne diseases.
- (v) It helps in turning the fixed phosphorus to soluble form and increases yield of crops upto 10-30 percent.
- (vi) It increases the rate of decomposition in composting process.

Exercise

Q.1 A. Fill in the blanks.

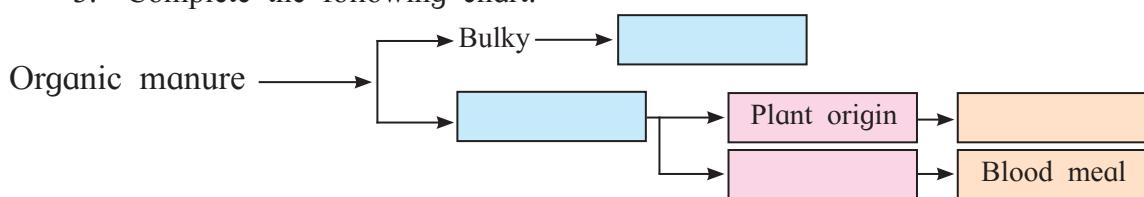
1. The essentiality criteria of element in plant is established by
2. Nitrogen, phosphorus and potassium are the plant nutrients.
3. Deficiency of plant nutrients causes cracking of fruits.
4. Any material which is used to correct the soil acidity or alkalinity is known as
5. BGA is fertilizer.

B. Make the pairs.

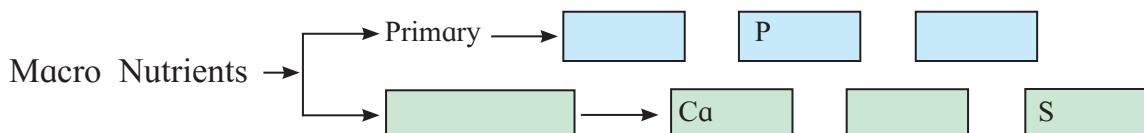
'A' Group	'B' Group
1. Suphala	a. organic manure
2. Azolla	b. soil amendment
3. Neem cake	c. chemical fertilizer
	d. fungicide
	g. biofertilizer

Q.2 Answer in brief.

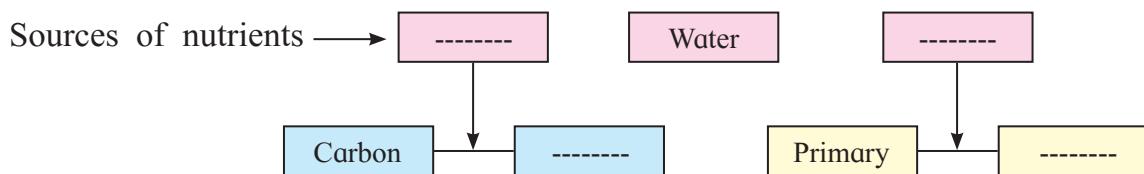
1. Give difference between manure and fertilizer.
2. Write note on biofertilizers.
3. Complete the following chart.



4. Complete the following chart.



5. Complete the following chart.



C. Find the odd out.

1. Rhizobium / suphala / Azolla / BGA / Trichoderma
2. Nitrogen / Calcium / Magnesium / Boron / Phosphorus
3. Urea / gypsum / borax / neem cake / suphala
4. Iron / Calcium / Boron / Zinc / Chloride
5. Compost / FYM / BGA / Green manure / neem cake

D. State true or false.

1. Straight fertilizer contains only one primary nutrient.
2. Biofertilizers are applied by seed inoculation method.
3. Vermicompost is prepared by using earthworms.
4. Khaira disease in paddy is caused due to deficiency of zinc.
5. Compost is the concentrated organic manure.

Q.3 Answer the following questions.

1. Explain INM.
2. Explain vermicomposting.
3. Complete the following table.

Chemical fertilizers				
Straight	---	---	---	Micronutrient Fertilizers
e.g.	Nitro Phosphate	N P K 10 : 26 : 26	Gypsum	---

4. Explain classification of essential nutrients with examples.
5. Complete the following table.

Methods of fertilizer application		
Solid form		Bio fertilizers
Broadcasting	Starter solution	
--	--	Root inoculation
Drilling	--	--
--	Fertigation	

Q.4 Answer in detail.

1. Read the given paragraph and answer the following question.

Compost is an organic manure prepared from plant residues and animal waste by decomposition. The process of making compost is known as composting. It is largely a biological process in which aerobic (which requires air or oxygen) and anaerobic (which function in absence of air or free oxygen) microorganisms decompose organic matter and lower the Carbon Nitrogen ratio. In the aerobic process, the mixed farm residues are collected in the pits of convenient size, say 15' × 5' × 3' (450 × 150 × 90 cm). Each days collection

is spread in a thin layer and sprinkled with a mixture of fresh cow dung. Compost manure is reinforced with super phosphate @ 25 kg per ton of manure. When the pit is filled to a height of 1.5 to 2.0 feet (45-60 cm) above ground level the surface is plastered with one inch layer of a mixture of mud and cow dung. The compost becomes ready in about three to four months without any further attention.

1. Define compost.
2. What is the size of compost pit?
3. Explain composting method.
4. Which chemical fertilizer is mixed in pit?
5. What is aerobic decomposition?

2. Complete the given table.

	Nutrient	Usable form by plant	Mineral source
1.	Boron	--	--
2.	--	Ferrous – ion	Haematite
3.	Chlorine	--	Sodium chloride
4.	--	NO_3	--
5.	--	Ca^{++}	--
6.	--	H_2PO_4	Apatite
7.	Potassium	--	Feldspar

3. Complete the following table.

	Functions of Nitrogen	Functions of Calcium	Functions of Phosphorus	Functions of Boron
1.
2.
3.

4. Write in detail classification of essential elements with explanation.
5. Explain the different methods of fertilizer application.

Activity :

Apply fertilizers to the crop in the field by different methods.



Courtesy : Rastriya Chemicals and Fertilizers, Mumbai



Can you recall?

- (1) What are the basic needs of plant for their survival?
- (2) What is the difference between water and irrigation?
- (3) About Soil, water and plant relationship.

For successful crop production water must be supplied to plant as required by them through irrigation. Plant receives water required for their growth from soil moisture. The soil moisture can be replenished whenever it gets depleted. Irrigation helps to maintain soil water balance during stress period.



Do you know ?

- What is the main source of irrigation in India?
- What efforts are made to distribute water uniformly ?

7.1 Definition of irrigation

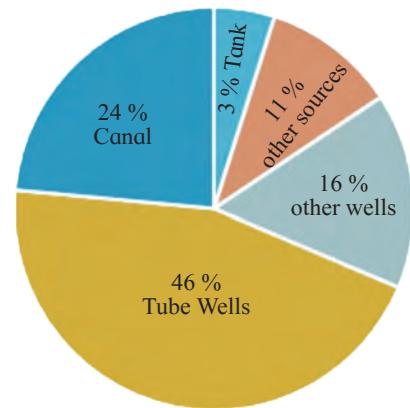
The artificial application of water for supplying moisture essential to plant growth is known as irrigation.

It is the artificial provision of water to supplement rainfall for crop production. Irrigation provides favourable environment for higher crop growth and yield. Effective irrigation is the controlled and uniform application of water to crop land in the required amount at the required time, with minimum cost to produce optimum yields without wastage of water and any adverse effect.

7.2 Advantages and adverse effects of irrigation

7.2.1 Advantages of irrigation

- (1) Irrigation provides insurance against short duration drought during crop season.



Different sources of irrigation



Remember this

Largest Dams in Maharashtra

1. Koyana, Satara
2. Jayakwadi, Aurangabad
3. Ujjani, Solapur
4. Isapur, Nanded
5. Totladoh, Nagpur

- (2) Yield of crop is increased and it maintains soil temperature.
- (3) It maintains soil water balance completely and plant water balance partly.
- (4) Irrigation is necessary for raising winter and summer season crops.
- (5) It improves the ground water storage.
- (6) Water supplies two essential elements, hydrogen and oxygen to the crops.
- (7) It is necessary for the absorption of mineral nutrients by the plants from the soil.
- (8) It brings biological equilibrium and enrichment of soil.
- (9) Irrigation ensures choice of efficient valuable crop and increases efficiency of inputs.

7.2.2 Adverse effects of irrigation

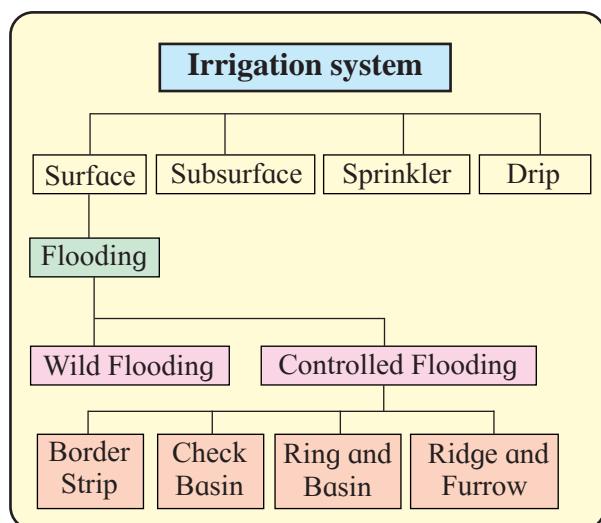
- The indiscriminate use of water leads to the problem of waterlogging and salt imbalance making the agricultural land unproductive.

- The root growth is restricted in irrigated soil and therefore nutrients that leach downward are not extracted by the crops.
- Irrigated soil becomes more compact on drying and thus tillage requirements are high.
- Erosion of soil and loss of plant nutrients and wastage of water in sloppy land.
- In deep clay soils a huge quantity of water is lost in filling up cracks before it reaches at saturation level.
- Preparation of boundary bunds, plot bunds, channels for irrigation and drainage reduce effective sowing area.
- The requirements of costly inputs such as fertilizer and tillage are considerable in irrigated agriculture.
- Irrigation water is often acidic or alkaline and contains injurious salts, impurities and weed seeds that affect crop production.
- Incidence of insects, pest, pathogens, parasite and weed are high in irrigated areas.

7.3 Systems of irrigation

Different systems are used to apply irrigation water to the crop depending upon

- Topography (present condition of land)
- Soil type
- Crop water resources
- Climatic condition
- Cost



Do you know ?

Why irrigation is indispensable in India?

- Uncertain monsoon rain.
- Spatial variation in rainfall.
- Low winter rain.
- Low retaining capacity of soil.
- Cultivation of high yielding variety.
- Multiple cropping

These systems are as follows :

7.3.1 Surface irrigation system :

In this system water is applied and distributed over the soil surface by gravity. It is often referred as flood irrigation in which applied water moves over the land surface freely and also infiltrate into the soil.

The various methods of surface irrigation systems are

Flooding : It includes (a) Wild flooding
(b) Controlled flooding

(a) Wild flooding : In this method water from channel is allowed to flood in the entire field in an uncontrolled way. This practice is followed where water is abundant and inexpensive. It is followed on smooth lands like wet land of rice and close growing crops like leafy vegetables and fodder crops.

Advantages	Disadvantages
1. It is less expensive and does not require any skill	1. The main drawback of this method is loss of huge quantity of water.
2. Except land levelling and boundary bund preparation, no other field layout is necessary	2. It is the most inefficient method in which high lying patches remain dry and low lying once are submerged in water
3. Supervision of water application may not be required	3. All types of field management practice are very poor i. e. nutrient management

(b) Controlled flooding

(i) Border strip method

In this method the field is divided into long, narrow strips with small parallel ridges on the sides. Length of the strip ranges from 30 to 150 meters long and 6 to 8 meters wide, which depend upon field condition and crop type. The borders are laid out along the general slope.

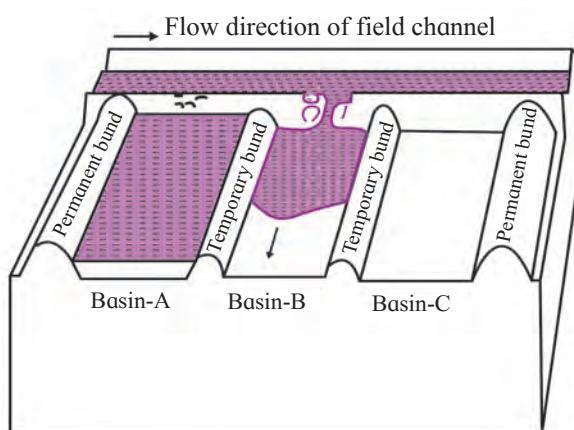


Fig 7.1 (a) : Border strip method



Fig 7.1 (b) : Border strip method

This method is suitable for close growing crops like wheat, legume, fodder crops etc. in medium to heavy textured soil. Intercultivation is possible. Labour requirement is less for field layout, large irrigation streams can be efficiently used. It is not suitable in coarse texture soil. Repairing and supervision during irrigation is needed.

(ii) Check basin method

It is the most common method among surface methods of irrigation.

In this method field is divided into small plots surrounded by bunds at all the four sides. The size of check basin ranges from 4×3 m to 6×5 m. The shape may be rectangular or square depending upon topography and soil texture. It is suitable for crops like groundnut, wheat, finger millets, etc. In this method water can be applied uniformly but more labour is required to prepare layout. Land is wasted under channels and bunds. Intercultivation by implement is difficult.



Fig 7.2 : Check Basin method

(iii) Ring and Basin method

This method is suitable for orchard and other high value crops. The basin may be square, rectangular or circular in shape.

Basin method - A small bund of 15 to 22 cm high is formed around the stump of the tree at a distance of about 30 to 60 cm depending upon water quantity to be supplied. In this method water is applied in controlled way, to the restricted area around the stem.



Fig 7.3 : Basin method

Ring method - These are circular beds. Heap of soil around plant trunk is made to avoid direct contact of water to the plant trunk. This helps in avoiding water borne diseases.

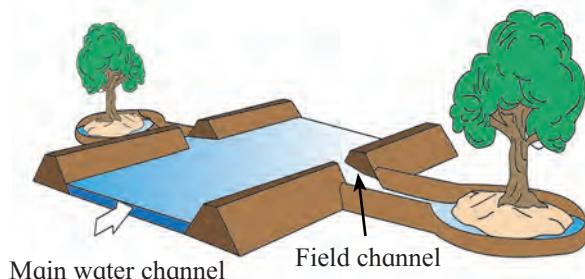


Fig 7.3 : Ring method

(iv) Ridges and furrow method

Furrows are small parallel channels made to carry water in small streams between the rows of crops grown on ridges or furrow sides. This method is suitable for crops like sugarcane, cotton, tobacco, sorghum, maize, vegetables, etc. The size and shape of the furrow depends upon spacing adopted for the crop, soil type and slope. The length ranges from 30 m to 300 m. In this method uniform application of water is possible. Cost of furrow preparation is more. Furrow can be open using ridger or by manual operation.



Fig 7.4 : Ridges and furrow method

- How do you reduce water loss by evaporation?
- Do you know modern methods of irrigation?

7.3.2 Subsurface irrigation system

In this system water is applied into a series of field ditches or through under ground perforated pipes deep down to impervious layer. The depth of ditches varies from 30 cm to 1m and 15 to 30 cm apart. Water through ditches or perforated pipes gradually saturates the root zone through capillary movement. This system is practiced in sandy soil for coconut garden in Kerala and for vegetables in Kashmir. In artificial sub irrigation water passes through underground perforated pipe in the root zone. This system avoids water loss through evaporation and reduce weed problem. It may causes heavy loss of water through deep percolation. Maintenance is required and it causes interference in cultivation.

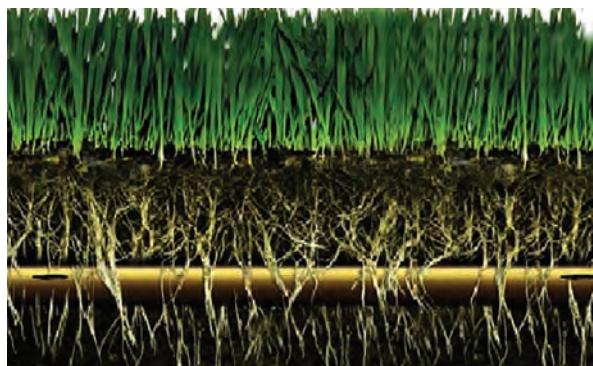


Fig 7.5: Subsurface Irrigation system

7.3.3 Sprinkler irrigation system

This is a method of applying irrigation water under controlled manner as like natural rainfall. It is also called as overhead irrigation. It acts as spray.



Fig 7.5: Sprinkler Irrigation system



The important components of a sprinkler irrigation system are the pump, pressure gauge, control valves, main pipeline, lateral line, T-coupling, bend, end plug, riser pipe and sprinkler head. The height of riser pipe depends on the height of the crop. Sprinkler heads of rotation type are fixed on the riser pipe. Sprinkler heads generally have two nozzles, one to apply water at long distance and other for short distance.

Advantages

- (1) It is used for almost all crops and for all types of soil.
- (2) Water can be applied at a controlled rate with uniform distribution and high efficiency.
- (3) Land levelling is not essential.
- (4) Run off and soil erosion is less.
- (5) Soluble fertilizers, herbicides, insecticides and fungicides can be applied through this method.
- (6) Saving of water about 30 - 40 per cent.
- (7) Accurate and easy measurement of distributed water.

Disadvantages

- (1) Sprinkler irrigation does not work well under high wind velocity.
- (2) High initial equipment cost.
- (3) It is not suitable where water contains large amount of salt, sand and debris.



Remember this

Rain gun – It is high pressure, high volume, large diameter sprinkler irrigation. It covers more area for irrigation .There are semi – permanent and permanent rain guns. These sprinklers have radius of discharge throw from 24 m to 36 m. This can be used for various agronomic crops, vegetables, flowers, etc. It is available in portable and fixed form.



Fig 7.6 : Rain gun

7.3.4 Drip irrigation system

Drip irrigation is a method of controlled irrigation in which water is slowly delivered drop by drop to the root system of multiple plants. The water is applied to the soil from the emitters. The emitters which are attached to laterals distribute water for irrigation. The number of emitters on laterals depends on plant spacing of the crop, soil characteristics, root development and discharge of emitter. The main components of drip system are—pump set, pressure gauge, control valve, pressure regulator, primary filter, secondary filter, main line, lateral line, multi outlet distributor, end plug and emitters. This method is most suitable for arid and semi-arid region with limited availability of water. It is best suited for wide spaced fruit crops, vegetables, sugarcane, cotton, etc.

Advantages

- (1) Saves water upto 70% and labour also.
- (2) Water losses due to percolation, runoff and evaporation are quite minimum.
- (3) Weed population is less due to limited surface wetting.
- (4) No land levelling is necessary and can be followed in hilly terrain areas.
- (5) Fertilizes can be applied along with water.
- (6) Plant growth is better and higher yield can be obtained.
- (7) Less incidence of disease.

Disadvantages

- (1) High initial cost.
- (2) It requires specific skill.
- (3) Need regular maintenance and high repair cost
- (4) Damage to lateral system by rodents, clogging of emitters and accumulation of salt near plant are the limitations.

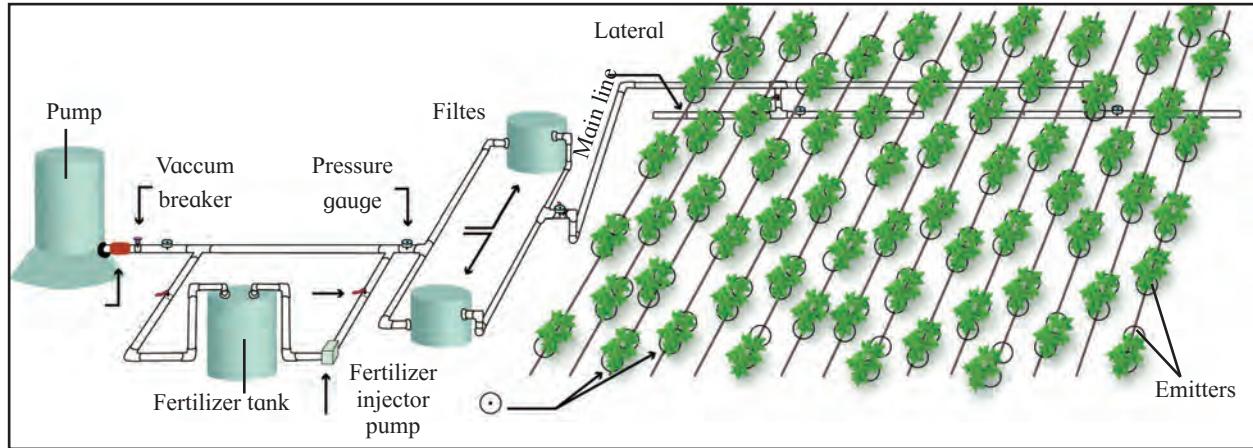
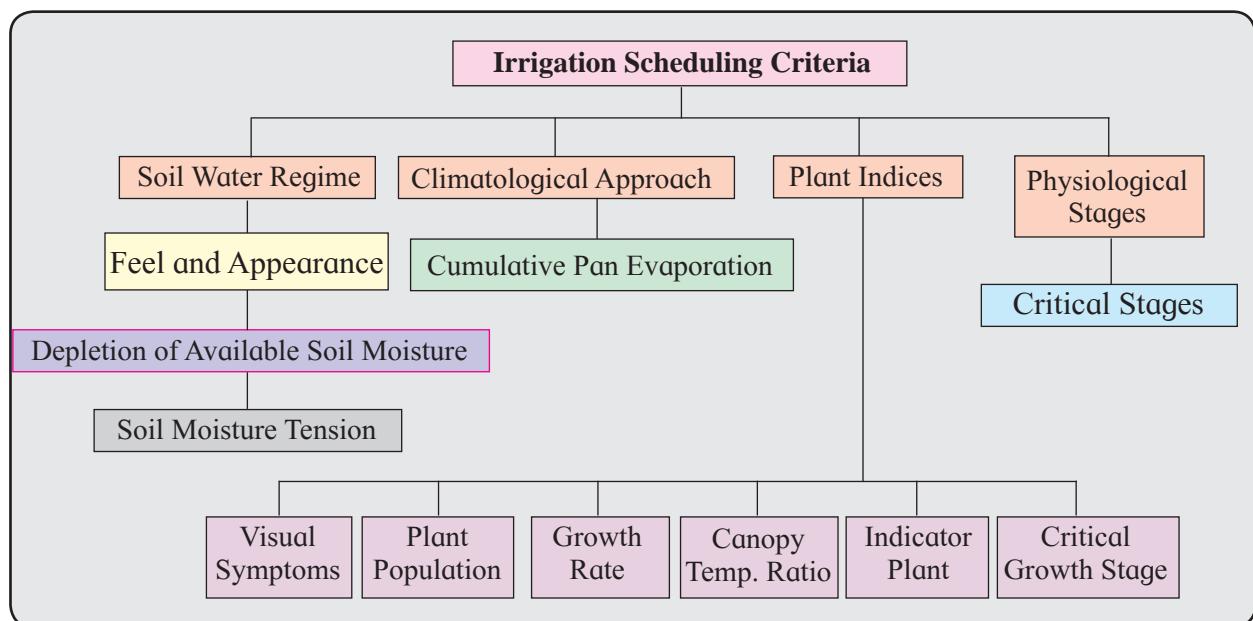
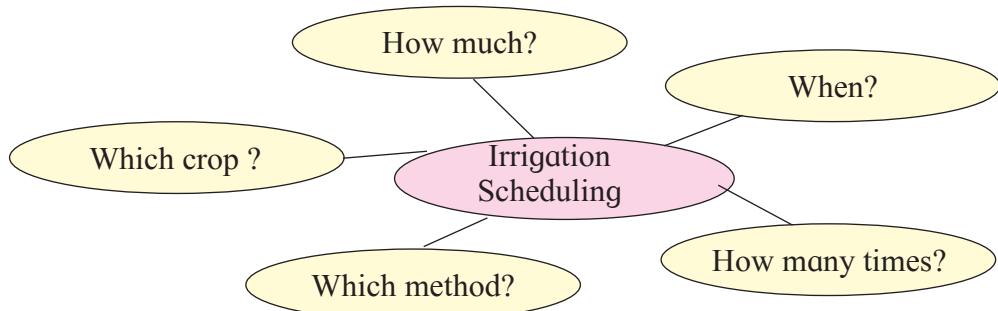


Fig 7.7 : Drip Irrigation system

7.4 Criteria for scheduling of irrigation



There are several approaches of scheduling irrigation based on soil, crops, climate and plant – water relationship.

- (1) **Soil water regime (depletion)** - In this method soil moisture content is estimated to know the deficit in available soil moisture at which it is proposed to irrigate at particular level. It can be measured either by direct gravimetric method or indirect measurement such as tensiometer and resistance block method.
- (2) **Climatological approach** - Evapo transpiration (ET) mainly depends upon climate. The amount of water lost by evapo-transpiration is estimated from climatological data and when ET reaches at particular level, irrigation is given.
- (3) **Plant indices** - Any plant character, related directly or indirectly to plant water deficit which responds readily to integrated influence of soil water, plant evaporative demand of the atmosphere, may serve as criteria for timing of irrigation. Visual sign of plant wilting can be used to schedule irrigation to crops. Farmer frequently use dropping, curling and rolling of leaves as visual signs.
- (4) **Physiological stages** - The critical growth stages of some important field crops at which irrigations are given after considering the rainfall are used for scheduling irrigation.

Critical stages of different crops:

Crop	Critical stages	No. of irrigation
Rice	Early tillering, panicle initiation, flowering	3
Wheat	Crown root initiation, tillering, flowering, grain development, dough stage	5

Sorghum	seedling, flag leaf, flowering	3
Groundnut	Germination, pegging, flowering, pod development	4
Redgram	Flowering, pod formation	2

Basic unit of water measurement (motion)

- (1) **Cusec**- cubic feet per second,
1 cubic feet =7.4805 gallons
- (2) **Acre inch**- Quantity of water that will cover one acre of surface and one inch deep soil
- (3) **Duty**- Denotes the number of acres covered by 1 cusec of water flowing continuously throughout the growing season of crop.
- (4) **Delta**- It is total depth of water required for a crop during entire period of the crop.



Do you know ?

- Which irrigation method is mostly used in India?

7.5 Drainage



Can you recall?

Why water is stored in the field?

How will you remove stagnated water in the field?

7.5.1 Meaning of drainage

Excess soil moisture or water logging occurs due to heavy and continuous rains or due to faulty irrigation practices. Water logging causes several changes in the soil and plant resulting in reduced growth and in some cases, death of the plants.

Drainage is the removal of excess gravitational water from the soil by artificial means to enhance crop production.



Fig 7.8 : Drainage channel

Drainage is the provision of suitable method for removal of excess irrigation or rainfall water from the field to facilitate favourable moisture condition for the growth of plants.

The removal of excess water (free or gravitational/standing or stagnant water) from the surface of soil or below the surface of the soil so as to create favorable soil conditions for plant growth is known as drainage.

Surface drainage means removal of excess water from the surface of soil.

Subsurface or internal drainage means removal of excess water from-within the soil surface (mainly from saturated soil pores).

7.5.2 Importance of drainage

For healthy growth of most of the crops and for getting higher yield soil should not only be fertile but it should be well drained also.

The various advantages of good drainage are as follows.

- (1) The field will not get waterlogged and the crop can get sufficient water and air.
- (2) The soil comes in proper tilth earlier after rainfall and it is possible to carry out agricultural operations properly and in time.
- (3) Good drainage helps to improve physical structure of soil.
- (4) Proper drainage prevents salt accumulation and degradation of irrigated lands.
- (5) There should be good balance among moisture, air and temperature at root zone.
- (6) Microbial activity is induced and resulted in accelerated organic matter decomposition.

- (7) Desirable chemical reactions take place and nutrients become available to the plant easily.
- (8) There is proper root development and absorption of nutrients is increased.
- (9) Seed germinates faster and a better stand of the crop is obtained.
- (10) Interculturing operations can be done at proper time.
- (11) There is healthy growth of plants and plant resists the attack of pest and diseases.
- (12) Roots can draw moisture from greater depth and withstand against drought condition.

7.5.3 Causes of improper drainage

If the soil is not well drained then there is water logging or stagnation of water takes place which affects, growth and yield of crop. The causes of such bad or improper drainage are as follows.

- (1) If soil is fine textured such as clay with poor permeability the water cannot move downward fast enough and accumulates on the surface in a thin layer obstructing aeration.
- (2) The water table may be high and additional gravitational water accumulates and chokes the airspaces and saturates the surface and sub-soil.



Fig 7.9 : Water logging

- (3) There may be hard pan which affects seepage of water to lower strata.
- (4) There may be salts affecting water absorption by roots.

- (5) Due to low lying area excess rain water cannot be carried away as surface runoff rapidly into the drain.
- (6) Faulty use of irrigation water leads to creation of water logged condition and raising of ground water table.
- (7) Humid regions with continuous and heavy rainfall raises water table and saturates the pore spaces.
- (8) The area under saline and alkali soils with poor permeability.

7.5.4 The remedies for drainage improvement

Surface drainage

Surface drainage is the simplest and the common method in India. In this method large outlet channels or field ditches are formed on the surface to remove the excess water due to heavy rainfall or over irrigation. Irrigation channels also serve as drainage channels. These drains cause hindrance to field preparation and intercultivation. They are subjected to silting and weeds growths which are to be removed regularly. Open drains are damaged by rodent and farm animals. Different methods of surface drainage are adopted depending on topography of the land, soil characteristics and crops grown.

(1) Random field ditches

Field ditches of shallow depth are formed randomly over the field. The depressions are connected by means of shallow channels or ditches and these are led into an outlet.

(2) Land smoothing

In this method, the elevated area is cutoff and the excess soil is spread over low areas so that the surface will be even with uniform slope. Excess surface runoff is collected and conveyed into the field ditches provided at the lower end of the field.

(3) Bedding

Small furrows are formed at known interval parallel to the slope for draining out water.

These furrows are known as dead furrows and land between these furrows is known as beds. Small ridges or bunds are made at the center of the bed with gradual slope to drain water into the dead furrows.



Tell us

What is difference between surface and subsurface drainage?

(4) Parallel field ditches

It is similar to bedding system but the parallel ditches of greater capacity are formed instead of dead furrows. This system is suitable for flat lands with number of small impressions.

7.3.5 Sub surface drainage or underground drainage:

A subsurface drainage will remove excess water as it percolates into themselves, just like open drain. It avoids wastage of land and do not interfere with farm operation.

Sub surfaced systems are

(1) Tile drain: It consists of digging a narrow trench, placing short section of tiles at bottom and covering the tiles with earth.



Fig 7.10 : Subsurface drainage



Fig 7.11 : Tile drainage

- (2) **Rubble drains:** It is made by cutting narrow 'V' shaped drains or rectangular section, as for box drains, filling them up with rough stone (large and small) and covering the whole up with soil level with surface field soil. Depth may be 90 cm.
- (3) **Perforated pipe drains:** In this a perforated pipe is designed to allow water to enter or exit through small holes along the pipe.

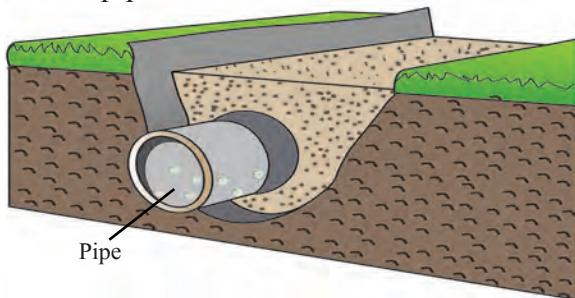


Fig 7.12 : Perforated pipe drainage

7.6 Watershed Management



Can you recall?

- (1) What is flooding and reason for flooding?
- (2) What kind of damages take place in flooding?
- (3) Why Maharashtra always suffers from drought condition?
- (4) What kind of measure will you suggest to overcome the drought condition?

7.6.1 Definition of watershed and watershed management

Watershed is the area of land that drains off shed water into specific receiving water body such as lake or river. It is the drainage area on the earth surface from which runoff resulting from precipitation flows or passed through a single point to a large stream, a river, a lake or an ocean.

It is the area of land that drains water, sediment and dissolved material through a common outlet to a some point along the stream. In another word watershed is natural hydrological unit.



Fig 7.13 : Typical watershed

Watershed management is an adaptive, comprehensive, integrated multi-resource management planning process that seeks to balance healthy, ecological, economic, and social conditions within watershed.

Watershed management serves to integrate planning for land and water. It takes into account both ground and surface water flow recognizing and planning for the interaction of water, plants, animals and human land use found, within the physical boundaries of watershed.

7.6.2 Types of watershed?

Watershed area is classified in to different categories based on size, drainage, and shape and land use pattern

- (1) On the basis of area.

Sr. No.	Types of watershed	Area covered
1.	Mini watershed	1 to 100 ha
2.	Micro watershed	100 to 1000 ha
3.	Mili watershed	1000 to 10000 ha
4.	Sub watershed	10000 to 50000 ha
5.	Macro watershed	More than 50000 ha

- (2) On the basis of shape

Sr No.	Shape
A	Square
B	Triangular
C	Rectangular
D	Oval
E	Fern leaf shaped
F	Palm shaped
G	Polygon shaped
H	Circular Sector Shaped

7.6.3 Objectives of watershed management

- (1) To control damaging run off and degradation and thereby conservation of soil and water.
- (2) To promote sustainable farming and stabilize crop yield by adopting suitable cropping and crop management system.
- (3) To check soil erosion and increase water infiltration rate.
- (4) To cover non- arable area effectively through afforestation and pasture land
- (5) To restore ecological balance
- (6) To enhance the income of the individuals by adopting alternate enterprises
- (7) To minimize the risk of flood, drought and land slide.
- (8) Supply and securing of clean and sufficient drinking water.

7.6.4 Components of watershed management

- (1) There are four important components of watershed management.

(I) Soil and water conservation
(II) Water Harvesting
(III) Crop management
(IV) Alternate land use system

(I) Soil and water conservation

The main object of soil and water conservation is to check soil erosion and to increase availability of ground water. This can be achieved by three ways,

- (a) Temporary
- (b) Moderate method
- (c) Permanent

(a) Temporary method: In this method simple measures like cultivation practices across the slope. It requires time to time renovation of measures.

(b) Moderate method: It includes levelling of land having breadth of 4 to 5 m , growing grass on bunds to slowdown the speed of water flow (for every 4-5 year).

(c) Permanent method: This method helps to stop soil erosion and slow down speed at water flow by constructing check dam, percolation pond, etc.

(II) Water harvesting

It is nothing but accumulation and storage of rainwater for reuse on site, rather than allowing it to run off. Water is collected in farm pond , percolation tank, Nala bund and deep tank for domestic and agricultural use.



Try this

Experiment - How much rain water quantity will be collected from 10 mm rainfall that received on your roof ?

- Which cropping system is useful on sloppy land?

(III) Crop management

This component is related with increasing crop production and to give sustainability by using different cropping patterns. It involves monocropping, inter cropping, strip cropping, mixed cropping, crop rotation, cultivation practiced against slope, etc.

(IV) Alternate land use system

Land not useful for growing agronomic crop can be brought under cultivation by using advance techniques e.g. agro forestry, pasture land, fiber crop, furniture wood, agri - horticultural land use, etc. This can improve economical status of farmer.

7.6.5 The steps in watershed management?

Watershed management involves determination of alternative land treatment measures for which information about problems of land, soil, water and vegetation in the watershed is essential.

(1) Recognition phase

It involves following steps



- (a) Recognition of the problem
- (b) Analysis of the cause of the problem and its effect
- (c) Development of alternative solution of problem

(2) Restoration phase

It includes two main steps

- (a) Selection of best solution to identified problem.
- (b) Application of the solution to the problem of the land.



Can you tell?

- (1) What do you do when low rainfall is received in your area?
- (2) Do you store water received from rainfall?
- (3) What kinds of containers are used to store rain water?

(3) Protection phase

This phase takes care of the general health of the watershed and ensures normal functioning.

(4) Improvement phase

This phase deals with overall improvement in the watershed and all land is covered.

7.6.6 Water harvesting

Concept : It is based on the concept of depriving part of the land of its share of precipitation, giving it to another part to increase the amount of water available to the gutter part and bring this amount closer to crop water requirement so that an economical agricultural production can be achieved. Such concentration of precipitation in a smaller area is called water harvesting (WH).

Definition

- The process of collecting natural precipitation from prepared watershed for beneficial use.
- Collecting and concentrating various forms of runoff from precipitation for various purposes.

- Simply water harvesting is defined as collection of runoff for its productive use.

Types of water harvesting

- (1) Rainwater harvesting : It is one of the most effective method of water management and water conservation.

It is the term used to indicate the collection and storage of rainwater used for human, animals and plant needs. It involves collection and storage of rainwater on surface or in subsurface before it is lost as surface runoff.

- (2) Ground water harvesting : Artificial recharge to groundwater is a process by which the groundwater reservoir is



Fig 7.14 : Water harvesting

augmented at a rate exceeding that under natural conditions of replenishment. Ground water is recharged and eventually flows to the surface naturally.

- (3) Roof water harvesting: It is the technique through which rainwater is captured from the roof catchment and stored in reservoir. It can be stored in sub-surface ground water by adopting artificial recharge techniques. It helps in self sufficiency of water supply and reduces cost of pumping, provides high quality water. i.e. soft and low in minerals, less expensive.

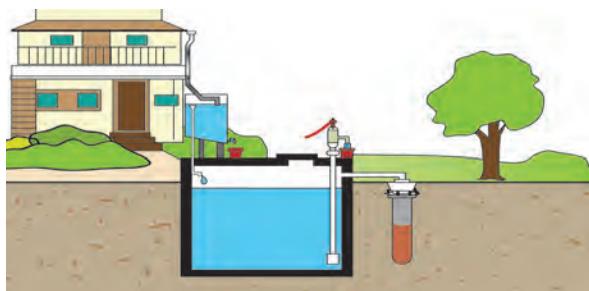


Fig 7.15 : Roof water harvesting

Exercise

Q1. A. Fill in the blanks

1. Ring method of irrigation is suitable for ----- crops.
2. Tensiometer instrument is used to measure soil -----.
3. Water harvesting is a component of -----.
4. Sprinkler irrigation method saves ----- % water.
5. Emitters are the main components of ----- irrigation system.

B. Make the pairs

- | A | B |
|--------------------|-------------------------|
| 1. Riser pipe | a. Drainage |
| 2. Perforated pipe | b. Rain gun |
| 3. Tensiometer | c. Sprinkler irrigation |
| | d. Surface drainage |
| | e. Soil moisture |

C. State true or false

1. Water supplies only oxygen to the plant.
2. Drip irrigation method saves more than 50 % water.
3. Furrow method of irrigation is suitable for crops like jowar, wheat and paddy.
4. Removal of excess water from the field is known as irrigation.
5. Micro watershed covers the area from 1 to 100 hectares.

Q. 2 Answer in brief

1. Write note on a ridge and furrow method.
2. Give components of watershed.

3. Write difference between surface and sub surface irrigation methods.

4. Complete the chart.

Surface Method	Check basin	
Irrigation scheduling criteria	Soil water regime	Plant indices
Surface drainage	Random field ditches	Bedding

Q. 3 Answer the following questions.

1. Describe drip irrigation method.
2. Explain the adverse effects of irrigation.
3. Give the advantages of irrigation.
4. Suggest remedies for poor drainage.
5. Read the following paragraph and answer the questions given below.

Farm pond is a dug out structure with definite shape and size having proper inlet and outlet structures for collecting the surface runoff flowing from the farm area. It is one of the most important rain water harvesting structures constructed at lowest portion of the farm area. The stored water must be used for irrigation only.

There are three types of excavated farm ponds – Square, Rectangular and Circular. Circular ponds have high water storage capacity. The problem associated with farm pond in red soils is high seepage losses. This can be reduced by lining walls. Some of the traditional methods for seepage control are the use of bentonite, soil dispersants and soil-cement mixture. Bentonite has excellent sealing properties if kept continuously wet,

but crack develops when dried. Soil cement mixture can be used. A soil – cement lining of 100 mm thickness reduces seepage losses up to 100 per cent. The other alternative sealant. Alfisols is a mixture of red soil and black soil in the ratio of 1:2.

- (a) What is farm pond?
- (b) What are the types of farm pond?
- (c) ----- type farm pond have high water storage capacity.
- (d) How seepage water losses are controlled in farm pond?
- (e) What is the thickness of soil – cement lining in farm pond?

Q. 4 Answer in detail.

- (1) Write in detail about sprinkler method with its advantages and disadvantages.
- (2) Write in detail about objectives of watershed management.
- (3) Write importance of water harvesting.
- (4) Write importance of drainage.
- (5) Describe controlled flooding method.

Activity :

- 1. Practice different surface irrigation methods in the field.
- 2. Collect information about WALMI and write the work details in table given below.

Photograph and information	Information (work details)

8.

Cropping System



Do you know ?

Management practices are developed for individual crops and recommendations are made accordingly. The residual effects of individual crops are not considered in crop based recommendations. In this approach, resources are not utilized efficiently. System approach is applied to agriculture for efficient utilization of all resources, maintaining stability in production and obtaining higher net returns.

A system consists of several components which depend on each other. A system is defined as a set of elements or components that are inter related and interacting among themselves. Farming system consists of several enterprises with appropriate combination like cropping system, dairying, piggery, poultry, fishery, bee keeping etc. These enterprises are interrelated. The end products and wastes of one enterprise are used as inputs in others. The wastes of dairy farm like dung, urine, refuse, etc. are used for the preparation of farmyard manure which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle. Cattle are used for different field operations for growing crops. Thus different enterprises of farming systems are highly interrelated.



Think and answer

- Why is it necessary to select cropping system in agriculture business?

Let us do it

Farming system represents an appropriate combination of farm enterprises viz. cropping system, livestock, poultry, fisheries, forestry and the means available to the farmer to raise them for increasing profitability. They interact adequately with environment without dislocating the ecological and socio-economic balance on one hand and attempt to meet the national goals on the other.

Enlist the different crops cultivated in the near by fields.

List the ways adopted by farmers to manage the needs of their soil, crop, animal, poultry, etc.

8.1 Meaning

Cropping system may be defined as the order in which the crops are cultivated on a piece of land over fixed period. The cropping system is the crop production activity of the farm or holding. It comprises all cropping patterns adopted on the farm or holding and their interactions with farm resources, other household enterprises and the physical, biological, technological and socio-economic factors on environment.



Remember this

Cropping system should at least satisfy the food requirements of the farmer for his family and fodder for his cattle.



Remember this

Cropping system is a land use unit comprising soils, crop, weed, pathogen and insect subsystems that transform solar energy, water, nutrients, labour and other inputs into food, feed, fuel and fibre.

Cropping system is an important component of a farming system. It represents cropping patterns used on a farm and their interaction with farm resources.



Can you recall?

The way in which the cropping system in a particular field or farm or operational holding or locality is practiced in an agricultural crop year (July-June) is said to be the cropping pattern at that site. Cropping pattern means the proportion of area under various crops at the yearly sequence and spatial arrangement of crops on a given land area. The system of utilizing the land resources by the cropping pattern is said to be the system cropping.



Do you think

Efficient cropping system for a particular farm depends on farm resources, farm enterprises and farm technology. The farm resources include land, labour, water, capital and infrastructure. When land is limited, intensive cropping is adopted so as to fully utilize available water and labour. When sufficient and cheap labour is available, vegetable crops are also included. Crops like sugarcane, banana, etc. should be included in the cropping system when capital is not a constraint.



Do you observe

In low rainfall regions monocropping is followed and when rainfall is more than 750 mm, intercropping is practiced. Farm enterprises like dairying, poultry, etc. also influence the type of cropping system. If the enterprise is dairying then fodder crops should be included in cropping system. Change in cropping system takes place with the development of technology. The cropping system should provide enough food for the family, fodder for cattle and generate sufficient cash income, for domestic and cultivation expenses.



Internet my friend

Collect the pictures and information on various cropping system.

8.2 Study of different cropping systems

Depending on the resources and technology available, different types of cropping systems are adopted on farms.

1. Monoculture
2. Multiple cropping
3. Intercropping
4. Mixed cropping
5. Strip cropping
6. Sequence cropping
7. Relay cropping
8. Multistoried cropping
9. Catch cropping

- Why some fields have single crops while other have mixture of crops.

8.2.1 Monoculture

Monoculture or mono cropping refers to growing of only one crop on the same piece of land year after year.

It may be due to climatological and socioeconomic conditions or due to specialization of a farmer. Under rainfed conditions, crops like paddy, groundnut or cotton or sorghum are grown year after year due to limitations of rainfall. Monoculture of bajra is practiced in certain district of Rajasthan because the rainfall is uncertain and no irrigation water is available.

In southern states and Konkan region of Maharashtra, rice is widely cultivated under the monoculture system because

1. Rice forms the main commodity of their daily diet.
2. Most of the area is low lying and high rainfall with some amount of waterlogging, which makes the land unfit for other crops.
3. The land holdings are smaller and scattered which do not allow to grow more crops.



It is noticed that under rice monoculture system, there is a rapid deterioration of organic matter and soil structure. Flooding and draining increases the decomposition process in the soil.

8.2.2 Multiple cropping

It is the practice of growing two or more crops on the same piece of land one after another in one calendar year.

e.g. *Udid* (K)-Wheat (R), Rice-Potato-Green Gram, Jute-Rice-Potato, Rice-Mustard-Maize.

Requirements for multiple cropping

- Fields should be levelled with high productive soil with suitable climate.
- Adequate and assured irrigation facilities should be available.
- Availability of inputs such as seed, implement, fertilizer, etc.
- Facility to remove crop residue from the field immediately after harvest.

Advantages

- More assurance of food and feed supply throughout the year.
- Increase in productivity per unit area, time, input, etc.
- Better distribution of income throughout the year.
- Increase in total employment and distribution of labour and capital use throughout the year.
- Minimum scope for soil erosion and degradation.
- Maximum utilization of land, residual effects, manures, fertilizers, moisture and management practices.

Disadvantages

- Little time is available for land preparation.
- It requires more intercultivation to compensate inadequate preparatory tillage.
- Cleaning of field from stubbles and stumps is a great problem.
- Previous crops with residual toxicity (Alleopathic effect) may affect next crops in quick succession.
- It increases weeds, pest and disease hazard if not managed properly.
- Long durational crops can not be taken.
- Weather and physical conditions may hinder quick succession.

Assessment of land use

The main object of cropping system is to use available resources efficiently. There are several indices to compare the efficiency of different cropping systems in terms of land use.

Multiple Cropping Index (MCI) or Cropping Intensity Index (CII): MCI is the sum of area planted under different crops and harvested in a single year divided by the total cultivated area expressed as percentage.

$$MCI = \frac{\text{gross cropped area}}{\text{Net area}} \times 100$$

Where n is 1th total number of crops, a.i. area under 1th crop planted and harvested within one year, and

A is total land area available for cultivation. It is also referred as cropping intensity.

Example - A cultivar has 10 ha of land. He has grown okra over 6 ha of land and bottle gourd over 3 ha of land during kharif, chilli over 5 ha of land and cauliflower over 5 ha of land during rabi and cucumber over 4 ha of land and muskmelon over 5 ha of land in summer. Calculate CII for the given farm.

Cropping intensity index calculated based on the gross cropped area and the net area of the farm. In this context, gross cropped area is :

During kharif = 6 ha + 3 ha	= 9 ha
Rabi = 5 ha + 5 ha	= 10 ha
Summer = 4 ha + 5 ha	= 9 ha
	Total = 28
	$= \frac{28}{10} \times 100$
	= 280 %

Here, cropping intensity index 280% , implies that land is put in use, almost three times (100% = 1 time) to its original extent.

8.2.3 Intercropping

Intercropping is growing two or more crops simultaneously on the same piece of land with a definite row pattern. For example, growing soybean + redgram in 5:1 or 6:2 proportion or cotton + tur. Intercropping was originally practiced as an insurance against total crop failure under rainfed conditions. At present, the main objective of intercropping is higher productivity per unit area in addition to stability in production. Intercropping system utilizes resources efficiently thereby productivity is increased. Either of the individual crop in intercropping is known as component crop.



Fig 8.1 Intercropping system

What do you think about successful intercropping ?

- The time of peak nutrient demands of component crops should not overlap.
- Competition for light should be minimum among the component crops.

- Component crops should be complimentary to each other.
- The differences in maturity of component crops should be at least one month.
- Cereals should be selected as main crop e.g. Jowar, wheat maize, etc. and among cash crops sugarcane, cotton, tobacco etc.
- The pulses and oil seeds should be selected as intercrops. The pulse crop fixes atmospheric 'N' and makes it available to main crop, improves fertility of soil, utilizes available soil moisture properly even under adverse conditions because of different root system.
- Time required for growth of main crop and intercrop should be different and sufficient.
- The water requirement of component crops should be different.
- Component crops should have different root systems i.e. shallow and deep root systems.

Objectives of intercropping

- Insurance against total crop failure under aberrant weather conditions or pest epidemics.
- Increase in total productivity per unit land area.
- Utilization of resources such as land, labour and inputs.

Practices of intercropping

Paired row system : In this system the distance between two crop lines of main crop is reduced and space for intercrop is created e.g. *Jowar+Mung/Udid/Tur* or *Bajra + Tur*

Skipped row system : In this system the distance between two crop lines is kept as it is but after two rows, one row is kept for intercrop. The plant population of main crop can be kept constant as in normal sowing by reducing plant to plant distance in the row. e.g. in jowar, plant to plant distance is kept 10 cm instead of 15 cm.

Advantages

- It provides yield advantages as compared to sole cropping.
- It gives profitable use of space and time by cultivating two or more crops.
- Greater assurance and stability of higher yield.
- It reduces the cost of cultivation of main crop.
- Improves soil fertility by use of legumes as intercrop.
- Efficient use of soil, nutrients, moisture, air, etc.
- It helps to control weeds upto some extent.
- It covers the more ground area continuously and helps to control soil erosion.
- It provides more employment and better distribution of labour.
- It provides income in installments and reduces marketing risks.

Disadvantages

- Difficulties may arise in the practical management of intercrops under high degree of mechanization and different requirements of component crops.
- Harvesting is difficult as each intercrop has its own harvesting time.
- It may reduces qualitative and quantitative yield of crops
- It requires sowing skills.

Assessing yield advantages

Since several crops are involved in intercropping system, it is not logical to compare total yield of different crops in one system with the other. Several indices are developed to evaluate cropping systems.

Crop equivalent yields

The yield of different intercrops are converted into equivalent yield of any one crop based on price of the produce. The crop equivalent yield (CEY) is calculated as follows.

$$CEY = \sum_{i=1}^n (Y_i e_i)$$

Where Y_i is yield of i^{th} component and e_i equivalent factor of i^{th} component or price of i^{th} crop.

Example : Let the yields of groundnut and redgram in a hectare of intercropping be 1000 and 600 kg, respectively. The total yield of intercropping system can be expressed as groundnut equivalent yields by knowing the price of each produce. If the prices of groundnut and redgram are Rs. 20 and Rs. 25 per Kg, respectively.

Equivalent yield (EY) of groundnut

$$= \frac{1000 \times 20}{20} = 1000 \text{ Kg}$$

$$\text{EY of redgram} = \frac{600 \times 25}{20} = 750 \text{ Kg}$$

EY of system = $1000 + 750 = 1750 \text{ Kg}$ of groundnut

Land equivalent ratio

Land Equivalent Ratio (LER) is the relative land area under sole crops that is required to produce the yields achieved in intercropping. LER can be mathematically represented as follows

$$LER = \sum Y_i Y_{ij}$$

Where Y_i is the yield of i^{th} component from a unit area grown as intercrop and Y_{ij} is the yield of i^{th} component grown as sole crop over the same area. In brief, LER is the summation of ratio of yields of intercrop to the yield of sole crop.

Example : Let the yields of groundnut and redgram grown as pure crops be 1200 and 1000 Kg /ha, respectively. Let the yields of these crops when grown as intercrops be 1000 and 600 kg / ha, respectively.

The land equivalent ratio of groundnut + redgram intercropping system is as follows:

$$\text{LER of groundnut} = \frac{\text{yield of intercrop}}{\text{yield of sole crop}}$$

$$= \frac{1000}{1200}$$

$$\text{LER of system} = \frac{1000}{1200} + \frac{600}{1000} = 1.43$$

LER of 1.43 indicates that 43% yield advantage is obtained when grown as intercrops compared to growing as sole crops. In other words, the sole crops have to be grown in 1.43 ha to get the same yield level that obtained from 1.00 ha of intercropping.

8.2.4 Mixed cropping

It is cultivation of two or more crops simultaneously in the same field without keeping their identity with respect to field area. e.g. Maize + Cowpea, *Jowar* + *Tur*, Wheat + Mustard.

Mixed cropping is grown for two or more crops simultaneously intermingled without any row pattern.

When two or more crops are sown together on the same land, it is known as mixed cropping. In mixed cropping, there is always one main crop and one or two subsidiary crops. It is a common practice in most of dryland tracts of India. Seeds of different crops are mixed in certain proportion and are sown. The proportion of the mixtures of different crops depend upon the local soil and climatic conditions. The object of mixed cropping is to meet the family requirement of cereals, pulses and vegetables. It is subsistence farming.



Fig 8.2 Mixed cropping system

Principles of mixed cropping

- Cereals should be sown mixed with legumes e.g. *Jowar* + *Tur*, Wheat+Gram.
- Tall growing crops should be sown with dwarf growing crops. e.g. Maize + *Mung*/ *Udid*.
- Tap rooted crops should be sown mixed with adventitious rooted crops. e.g. Kidney bean + Bajra
- Bushy crops should be sown with erect growing crops.
- The crops should not be grown together having similar insect pest and diseases.
- Long and short durational crops should be grown mixed together.

Advantages of mixed cropping

- Less risk of failure of crops and total loss in income due to insect pest, diseases and adverse climatic conditions. e.g. Wheat + Gram cropping. If there is epidemic rust disease, wheat crop may fail but farmer will get returns from gram crop.
- Mixed cropping helps for maintaining the fertility of soil by including legumes as a mixture.
- The farmer gets assured food from his land, by taking cereals, pulses and oilseeds.
- Problem of cattle feed is solved and the nutritious feed is obtained.
- Gets quick and periodic cash returns especially in irrigated crops.
- Achieves better utilization of land and labour throughout the year.
- Utilizes available space and nutrients to the maximum extent.
- Better use of soil moisture by the crops due to difference in root system.
- Helps to reduce the soil erosion and to control the weeds to some extent.

Disadvantages

- Usually it spreads pest and diseases e.g. Groundnut + Castor mixed cropping, castor spreads the pest castor semilooper.
- Difficulties in management, if the crops have different requirements.
- Labour saving implements and machinery can not be used e.g. Harvesting.
- Field can not be ploughed immediately after harvest of crop.
- Yield of main crop is always less compared to grown as sole crop.
- Reduces the acreage of main crop and also may reduces the quality of produce.

Characteristics of good subsidiary crop in mixed cropping

- It should preferably be a legume crop.
- It should mature earlier or later than the main crop.
- It should have different growth habit and nutrient requirement.
- It should not be very similar in climatic requirement.
- It should have different rooting depths.

8.2.5 Strip Cropping

Strip cropping consists of growing erosion permitting crops and erosion resisting crops in alternate strips across the slope of land. In this system, the crops like Jowar, Bajra etc. are grown as erosion permitting crops which allow the runoff water to flow freely within the rows. The erosion resisting crops are mostly legumes like groundnut, kidney bean, soyabean, horsegram, etc. spread and cover the soil and do not allow runoff water to carry much soil. The soil which flows from the strips of erosion permitting crops is caught by the alternating strips of legume crops reduces transporting and eroding power of water by obstructing runoff, filter the soil and retain in the field.

Strip cropping of bajra and groundnut, if followed will save erosion and also give more gross return than bajra grown alone.

8.2.6 Sequence cropping

Sequence cropping is growing two or more crops in sequence on the same piece of land. In general the sequence of crops is maintained season after season for one or more years.

Sequential cropping depends on several factors. The most important are the availability of water, the agro-climatic situation of the locality, the farmer's preference and requirements for the family and the price of the produce as well as the suitability of raising crops one after another even in turn around periods. Economic return per unit area, utilization of land and other resources, should also be considered.

Interactions in sequence cropping

Competition for light, water and nutrients as in mixed crop communities does not occur when sole crops are grown in sequence. It occurs only in relay cropping. The important purpose in sequential cropping is to increase the use of solar radiation. It is achieved by longer field duration and rapid ground coverage. Crops are raised in sequence one another, to keep the land occupied by the crop for longer period. If the crop development is slow, much of the solar radiation reaches the ground, favouring weed growth and increasing evaporation losses from the soil surface, which is checked in this cropping.

In sequential cropping, the preceding crop has considerable influence on the succeeding crop mainly due to changes in soil conditions, presence of allelopathic effect, shift in weeds and carry over effects of fertilizers, pest and diseases. Field preparation is difficult after rice crop since soil structure is destroyed due to puddling. Phosphorus applied to the previous crop is available for the succeeding crop.

Weed number and species differ in the succeeding crop due to the effect of the previous crop. The pest and diseases in stubbles and



other residues of the previous crop may infect the subsequent crop.

8.2.7 Relay Cropping

Relay cropping refers to planting of the succeeding crop before harvesting the preceding crop. Here the crop in succession is sown or planted either in the field of the standing crop which is going to be harvested soon or in nursery so that immediately after the harvest of the standing crop the subsequent crop can be transplanted in the same field without any allowance for keeping the field uncropped or fallow even for the turn around period. e.g. Jute-Rice, Mustard-Onion.

The farm resources such as land, labour, water, capital and infrastructure are efficiently utilized. When land is limited, intensive cropping is adopted to utilize the available water and labour. When sufficient and cheap labour is available, vegetable crops are also included in the cropping system, as they require more labour.

8.2.8 Multistoried cropping

When two or more crops are grown on the same piece of land according to their height is termed as multistoried cropping. It is mostly followed in Konkan region in high value plantation crops, where land holding is

very small and value of land is very high e.g. Arecanut + black pepper + banana+ pineapple. It is also termed as multitier or multilevel cropping.

In this arecanut with high sunlight demands makes first tier followed by black pepper growing with the support of trunk making second tier. In between two arecanut trees, papaya or banana is planted making third tier and pineapple or ginger makes the fourth tier with high demand of shade and humidity, just like a multistoried building.

8.2.9 Catch cropping

When a subsidiary crop is sown in between the gap of a widely spaced crop or when a subsidiary crop is sown in the gap between two major crops of different seasons or when contingent crop is sown to catch a season under the circumstances of total failure can be termed as catch cropping e.g. Cotton + green gram, Sugarcane + potato, Green gram, bajra, sesamum, sunflower as midseason correction crops when main season crop fails.



Try this

With the help of information collected from internet, prepare the slides of various cropping system for PPT presentation.



Fig 8.3 Multistoried cropping system

Exercise

Q.1 A) Fill in the blanks.

1. Growing two or more crops simultaneously on the same piece of land with a definite row pattern is known as _____.
2. The number of crops to be grown increases within a definite period of time, this cropping method is termed as _____.
3. Growing two or more crops simultaneously on the same piece of land with a definite row arrangement is called as _____.
4. Planting of succeeding crop before harvesting the previous crop is called as _____.
5. Planting one crop year after year on the same piece of land is called _____.

B. Make the pairs.

'A' group	'B' Group
1. Mixed Cropping	a. Growing of single same crop year after year
2. Multiple Cropping	b. Growing of two or more crops together
3. Intercropping	c. Growing of more number of crops within a year
4. Monocropping	d. Growing of two or more crops with definite row arrangement
	e. Use of two to three floors in same area and same time
	f. Crops at different time

C. State true or false.

1. When a subsidiary crop is sown in between the gap of widely spaced crop is called catch cropping.
2. Cropping system will not achieve better utilization of land and labour through out the year.
3. Cropping systems should be framed as per farm budgeting and management.
4. In mixed cropping system labour saving implements and machinery can be used for harvesting.
5. Cropping intensity index is the sum of area planted to different crops and harvested in single year divided by the total cultivated area expressed as percentage.

Q. 2 Answer in brief.

1. Define intensive cropping.
2. What do you mean by multiple cropping?
3. Define the term of sequence cropping.
4. Write examples of intercropping.
5. Define catch crop.

Q. 3 Answer the following questions.

1. Write short note on strip cropping.
2. Explain the difference between relay and intercropping system.
3. Complete following chart.

Sr. No.	Multistoried tier	Name of crop for planting
1	First tier crop	
2	Second tier crop	
3	Third tier crop	
4	Fourth tier crop	

- Calculate cropping intensity index for the given conditions. A cultivator has seven hectares of land. He has grown cotton over four hectare of land and soybean over 2 ha of land during kharif, Jowar over 2 ha of land and sunflower over 2 ha during rabi and ground nut over 1 ha of land and green gram over 1 ha of land in summer.
- Calculate the equivalent yield of soybean. Let's the yield of soybean and red gram in a hectare of intercropping be 2000 kg and 800 kg respectively. The total yield of intercropping system can be expressed as soybean equivalent yield by knowing the price of each produce if the price of soybean and red gram are Rs. 30 and Rs. 25 per kg respectively.

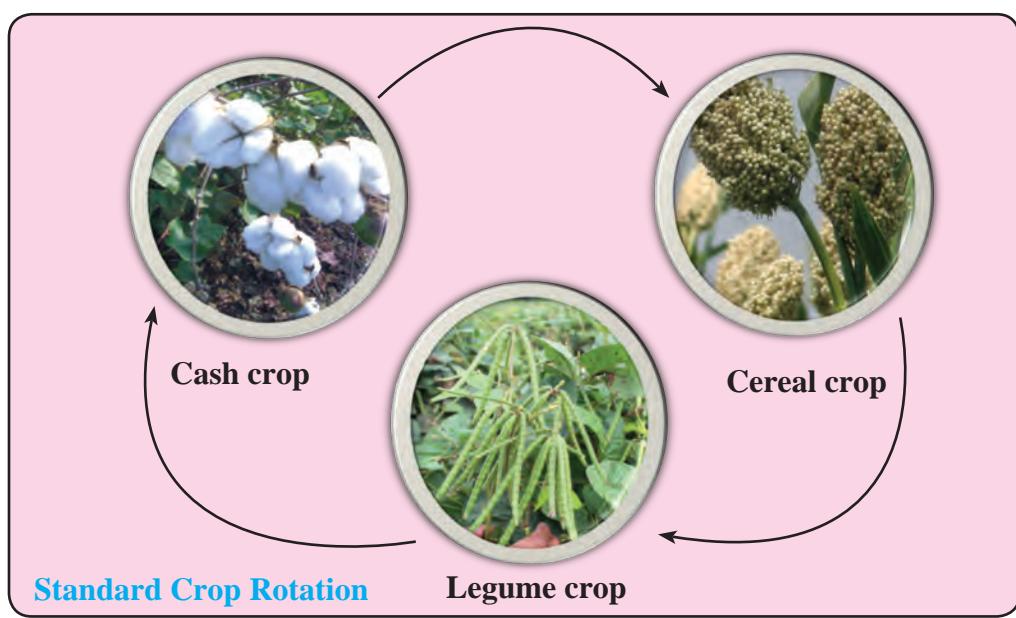
Q. 4 Answer in detail

- What is intercropping and give its advantages and disadvantages.
- Read the following information and answer the questions.

Cropping system is an important component of farming system. From the farm organization point of view, a system consists of several components'. They are depending on each other, defined as a set of components' which are

interrelated and interacted among themselves. The available technology determines their makeup. Farming system consists of several enterprises with appropriate combination like cropping system, dairying, poultry, fishery, bee keeping, etc. These enterprises are interrelated. The end products and wastes of one enterprise are used as inputs in others. The wastes of dairying like dung, urine, refuse, etc. are used in preparation of farm yard manure which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle. Cattle are used in different field operations for growing crops. Thus, different enterprises in farming system are highly interrelated.

- Which are the important components of farming system?
- What are the enterprises of farming system?
- List out the various wastes products dairy used as input for farming.
- What are the interrelations of straw obtained from crop and cattle in farming system.
- What is mixed cropping and give its advantages and disadvantages.
- Describe the land equivalent ratio (LER) with suitable examples.





Can you recall?

- Why the cultivable soil is banned for grazing animals?
- How does the soil look during sowing time and after harvesting?
- What is the difference between loose porous soil and compact hard soil?
- Why the tractor is mostly used now a days instead of bullocks in farm operations?
- Which operations farmer does before sowing?



Keep in mind

Soil serves as a natural medium for the growth of plants; but in its natural state, it is not in an ideal condition for growing the crops satisfactorily. The beating action of rain drops, irrigation and subsequent drying, weeds, stubbles, harvesting of crop, labour and subsequent activities cause soil compaction. Soil condition must be made favourable for crop growth and development from sowing to harvesting. The seeds require loose, friable soil with sufficient moisture and air for better germination and easy penetration of younger roots into the soil for absorption of nutrients, minerals, air and water. These ideal conditions of soil are achieved by proper manipulation of soil and bring it into good tilth condition.

9.1 Definition

9.1.1 Definition of Tillage :

Tillage may be defined as follows.

- The physical manipulation of soil with different tools and implements to bring the soil in a good physical condition for better

germination and subsequent growth of plants.

- Tillage of the soil consists of breaking the hard and compact surface to a certain depth and other operations that are followed for bringing the soil in a good physical condition i.e. fine tilth for plant growth.
- It is manipulation of soil with different tools and implements with an object to make the soil surface loose and bring it to favourable conditions for seed germination, seedling establishment and growth of crops.

9.1.2 Definition of tilth

- The term soil tilth means the physical condition of soil resulting from tillage operations.
- Soil tilth is the physical condition of soil in which soil becomes loose, friable, crum, soft, properly aerated but not very powdery.



Know the Scientist



Jethro Tull (1664-1741) was a British agronomist. He invented seed drill, hoe and plough, which were driven by horse.

He studied law and graduated from Oxford University in 1699. He began farming in 1700 and took greater interest in agricultural operations.

Tillage practices are as old as agriculture, Jethro Tull proposed that plants absorb minute soil particles hence suggested thorough ploughing and other operations were necessary for bringing soil in an ideal condition. He is known as father of tillage.

Advantages of tilth ?

Good soil tilth provides adequate aeration, maintain soil temperature, soil moisture, soil aggregates, moisture content also ensure good infiltration, easy and smooth movement of sowing implements. The good tilth condition maintains spaces, i.e. the macro and micro pores in equal proportion for retention of soil moisture and soil air.

9.2 Objectives of tillage

The various objectives of tillage are as follows.

(1) To make the soil loose and porous

This will enable rain or irrigation water to enter the soil easily and less losses of rain water and soil due to run-off and erosion. Due to adequate proportion of micro pores the sufficient amount of water will be retained in soil for crop growth and less losses of water due to percolation.

(2) To aerate the soil

Tillage enables the metabolic processes of living plants and micro-organisms to continue smoothly. Due to adequate air and moisture, desirable chemical and biological activities would go on at greater speed. This would result in rapid decomposition of organic matter and making plant nutrients available to crops.

(3) To increase the soil temperature

This can be achieved by maintaining proper amount of air and water in the soil and also by exposing the soil to the sun. The optimum soil temperature in active root zone of the crop is necessary for proper growth and functioning of plant roots and useful organisms in the soil.

(4) To control weeds

Weeds are enemies of crops as they compete with crops for plant nutrients, moisture, space and sunlight, that will result in poor crop yields. Therefore, management of weeds with suitable tools and implements is the definite advantage of tillage.



Observe and Discuss

1. How will you feel while walking on ploughed field and sown field?
2. Why the water lodging conditions after heavy rains do not appear in ploughed land ?
3. Why the bullocks do walk easily during sowing?

(5) To remove stubbles of previous crop

Deep tillage helps in removing stubbles of previous crop and other sprouting materials like bulbs, stolons, etc. and helps in making a clean seed bed.

(6) To destroy insects

Many of the insect pest remain hidden in the top soil layer during off-season and reappear on the crop in the next season. Insects are either exposed to the Sun heat or to birds, who would pick them up. Some harmful grubs or cutworms can be destroyed by proper tillage operations. Collection and destruction of the crop residues and weeds are helpful to control pest like jowar stem borer, cotton bollworm, etc.

(7) To break hard pan

Tillage with specially designed implements such as sub-soiler or plough is often useful to break hard pan if any, formed just below the ploughing depth. This is helpful for better penetration of roots in deeper layers and also for maintaining proper drainage in the soil. It also increases soil depth for water absorption.

(8) To incorporate organic manures and fertilizers into the soil

Organic manures such as F.Y.M. or compost and fertilizers should not only be spread on surface of the soil but properly incorporated (mix thoroughly) into the soil for minimizing the loss of plant nutrients.

Sometimes, bacterial cultures or pesticides are also required to be drilled into the soil for control of pest like white ants, termites, white grubs, cutworms, etc. and this purpose can be served by using proper tillage implements.

(9) To invert the soil to improve fertility

By occasional deep tillage the lower layer of the soil which is less fertile comes to the top, while the upper layer rich in organic matter and plant nutrients goes down, thus plant roots can get benefit of the rich layer.

(10) To prepare proper seedbed for germination of seeds and growth of the crop

Finally, it is necessary to prepare the suitable seedbed as per requirement of the crop and soil for good germination and emergence of seedling and also for proper growth and development of the crop for achieving higher yields.



Use your brain power

1. What will happen, if crop is grown without any tillage practice?
2. Why ploughed soils are not water logged easily?
3. Why the birds generally seen on the land where tillage practice is going on?

9.3.1 Preparatory tillage

It means the tillage operations which are carried out before the sowing of any crop. These operations done after the harvesting of the previous crop and upto seed bed preparation for next crop. It consists of a number of costly and time consuming operations, which are carried out by using suitable implements at proper moisture content of the soil. These operations are necessary for proper germination, emergence and growth of the crop. The various tillage operations which come under preparatory tillage are:

- (1) Ploughing
- (2) Clod crushing
- (3) Levelling of land
- (4) Harrowing
- (5) Manure mixing

(1) Ploughing

Ploughing means breaking of hard soil with different ploughs. This is considered to be the most essential operation for making the soil loose and porous to a desired depth as per requirement of the crop. Depth depends upon the effective root zone of the crop.



Fig 9.1(a) : Bullock ploughing



Fig 9.1 (b) : Tractor ploughing

9.3 Types of tillage

Tillage operations are grouped into three types on the basis of their time at which they are carried out.

These are

- Preparatory tillage
- Seed bed preparation
- Intertillage or intercultivation

(2) Clod crushing

This operation is necessary for working soil to fine tilth. This operation is not always necessary, if ploughing is done at right time i.e. when soil moisture is optimum then very few clods are formed. However, when the ploughing is done at less moisture content or after drying the soil, then big clods may form and therefore it is necessary to crush the clods with the help of implements known as clod crushers.



Fig 9.2 : Clod crushing

(3) Levelling the land

This is done occasionally and it is not an operation, which requires to be done every year. This operation is necessary for sloppy lands in order to ensure even distribution of rain and irrigation water. This will avoid yellowing of plants due to stagnation of water in low-lying areas.



Fig 9.3 : Levelling of land

(4) Harrowing

This is one of the most common operation which is done invariably for preparing good seedbed. The objects of harrowing are breaking clods, levelling the land, collecting stubbles, destroying newly germinating weeds, compacting the soil, mixing bulky organic manures and fertilizers with the soil.



Fig 9.4 : Harrowing

(5) Manure mixing

The bulky organic manures such as F.Y.M. or compost and fertilizers (Basal dose of fertilizer) should be mixed thoroughly with the soil before sowing of the crop. The bulky organic manures and fertilizers should be spread evenly on surface of the soil.



(a)



(b)

Fig 9.5 : Manure mixing in soil

9.3.2 Seed bed preparation

These operations are carried out after last preparatory tillage operation and upto sowing. The land is to be laid out properly for sowing seeds, irrigating crops if necessary and for transplanting seedlings. These operations are known as seed bed preparation and comprise of following operations.

- (1) Harrowing
- (2) Layout of the field
- (3) Compacting the soil

(1) Harrowing

If irrigation layouts are prepared immediately after completion of preparatory tillage then this operation is not required. Some times there may be

long gap or period between the preparatory tillage and preparation of irrigation layouts and for destroying newly germinated or young weeds existing in the field this operation is essential.

(2) Layout of the field

Irrigated crops like sugarcane, turmeric, ginger, cotton, potato and vegetables require preparation of irrigation layouts for sowing seeds, planting or transplanting seedling and also for giving irrigation water to the crop.

Opening ridges and furrows in the field for crops like sugarcane, irrigated cotton, potato and vegetables. border strips or saras for cereals like jowar, wheat, etc. flat beds for leafy vegetables and forage crops . broad bed furrows (BBF) or raised beds for turmeric and ginger are generally prepared as per requirement of the crop by using suitable implement.

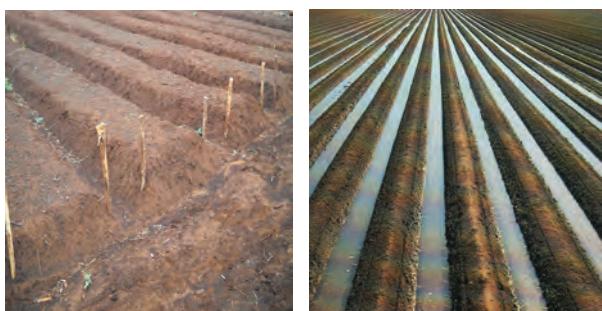


Fig 9.6 : Layout of the field

(3) Compacting the soil

Sometimes soil may be loosened more than the requirement, which is not desirable for small seeded crops like sesamum and mustard or adventitious rooted crops such as jowar or bajara, which are liable to lodge at maturity stage. Therefore, the soil may need compacting .

9.3.3 Intertillage or interculture

Tillage operations which are carried out in standing crop or in between the crop rows are called intertillage. It includes the following operations.

Gap filling, Thinning, Weeding, Hoeing, Top dressing of fertilizers, Earthing up, Mulching, Detrashing.



Do you know ?

Maharashtra government followed some policies to pick-up the sedimentary (mud) soil from medium and small lake, nala, dam and use it for farm, which improves soil fertility of the field. The water storage capacity of such lake, nala, dam, etc. is improved.

1. Gap Filling

Some times, there may not be emergence of crop seedlings at some of the places in crops lines and these gaps (spots without crop) are filled either by dibbling seeds or transplanting seedlings. This operation is necessary for maintaining the optimum plant population of the crop. Gap filling is done about 8 to 10 days after sowing of the crop.

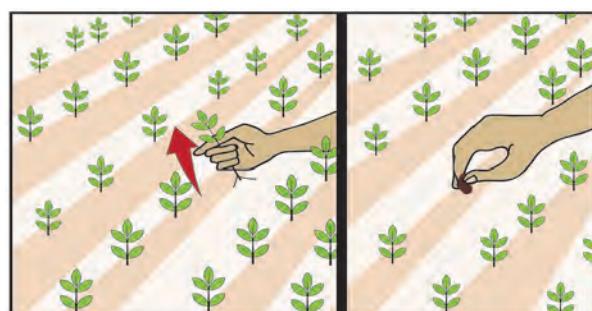


Fig 9.7 : Gap filling

(2) Thinning

It is process of removing excess plants from the field for maintaining optimum



Fig 9.8 : Thinning

plant population of the crop and for providing uniform space for normal growth and development of the crop. This operation is carried out about 2 to 3 weeks after sowing of the crop.

(3) Hoeing

This operation is necessary for removing weeds, conservation of soil moisture, mixing fertilizers with the soil and improving aeration of the soil. 2 to 3 hoeings are carried out from 2 weeks upto 5 or 6 weeks after sowing of the crop.



Fig 9.9 : Hoeing

(4) Weeding

Removal of weeds in the crops with the help of weeding hook (*khurapi*) by



Fig 9.10 : Weeding

manual labours is called weeding. One to three weedings are required in crop season depending upon the weed intensity and type of crop.

(5) Top dressing of fertilizers

The application of fertilizers in standing crop is known as top dressing. It is necessary for supplying plant nutrients essential for normal growth, development and yield of the crop.

(6) Earthing up

Supporting basal portion of the crop plants with soil for proper development of underground commercial plant parts is known as earthing up. This operation is done in case of crops like turmeric, ginger, potato and erect type of groundnut.



(a) Earthing up using bullock drawn implement



(b) Manual Earthing up

Fig 9.11 : Earthing up

(7) Mulching

Covering surface of the soil in between the crop rows with the help of organic mulch such as plant residues or inorganic mulch like polythene sheet for conservation of soil moisture, management of weeds, maintaining soil temperature, etc. is known as mulching.



Fig 9.12 : Mulching

(8) Detrashing

Detrashing refers to removal of unwanted bottom dry and green leaves at regular interval. Crop like sugarcane bears large number of leaves (30 to 35) equal to the number of internodes. Detrashing helps in maintaining clean field, enhances air movement and enriches CO_2 with the crop canopy. It also reduces the infestation problem by pest and diseases, reduces bud sprouting, facilitates easy entry and movement in the field, etc.

9.3.4 List of tillage implements

(A) Implements for preparatory tillage

(1) **Ploughing:** Various types of wooden and iron ploughs are used.

(a) **Deep ploughing** (20 to 30 cm deep):

Bullock drawn iron plough, Bullock drawn mould board plough, Tractor drawn mould board plough, two furrow bar point plough, Disc plough, etc.

(b) **Shallow ploughing** (12 to 15 cm deep): Small mould board plough, Deshi or wooden plough

(c) **Sub-soil ploughing:** Sub-soil plough or sub-soiler

(2) Clod crushing

(i) **Norwegian harrow**

(ii) **Disc harrow**

(iii) **Deccan blade harrow (blade harrow)**

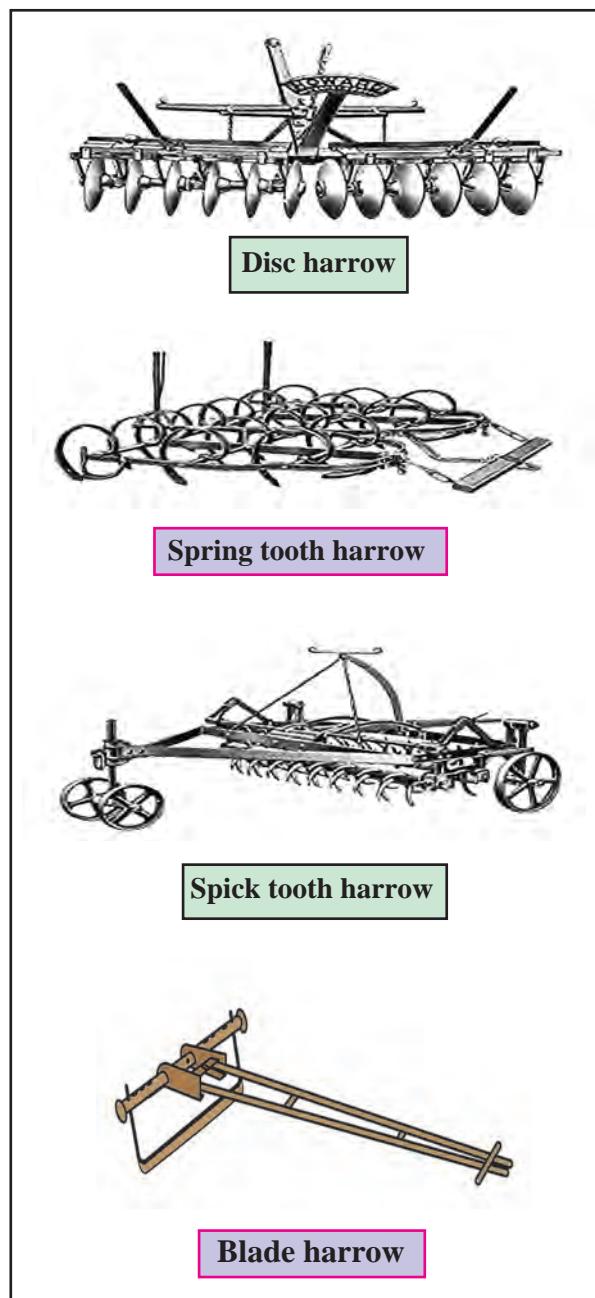


Fig 9.13 : Harrow

(3) Cultivators

This implement can be used for seedbed preparation and also for inter cultivation operation. The implement having tines which are having provision of vertical adjustments also. These are- (1) Disc cultivator, (2) Rotary cultivator, (3) Tine cultivator

(4) Levelling of land

Iron keni, wooden levelling boar, American Petari, blade harrow (when soil is loose and slope is less than 3 %)

Bulldozer: It is used when the soil is hard and slope of the field is more than 3%

(5) Harrowing

Deccan blade harrow or different type of harrows according to the type of soil.

This is the implement which cuts the soil to a shallow depth for smoothening and pulverizing the soil as well as to cut the weeds and to mix material with soil. Also used to break the clods after ploughing to collect trash from the ploughed land and to level the seed bed.

Types of harrow

- (1) Disc harrow
 - (2) Spring tooth harrow
 - (3) Spike tooth harrow
 - (4) Blade harrow (Bakkar)
 - (5) Guntaka
 - (6) Triangular harrow
- (6) **Manure mixing:** Disc harrow, blade harrow, Disc plough, and deshi wooden plough.
- (7) **Compacting of soil:** Maind, wooden log, and inverted harrow and rollers like iron roller, stone or wooden roller.
- (8) **Puddling:** Rice puddler. (bullock or tractor drawn) , Deshi wooden plough.

(B) Seed bed preparation

(1) **Ridges and furrows:** Different type of ridgers are used. e.g. Jeevan, Jagat and Jamboo ridger.

(2) **Preparation of border strips and saras:**

Sara former is used for preparation of saras in the field. Bund former is used for preparing bunds at required distance. For making irrigation layouts hand tool like spade is used.



Fig 9.14 : Ridger

(3) **Sowing seeds:** Indigenous seed drill – *dufan, tifan or chaofan* (two, three or four tined seed drill)

Two bowl seed drill (ferti- seed drill) for sowing seeds and fertilizer application, Mechanical seed drill.

(4) **Planting sugarcane:** Sugarcane planter.

(5) **Covering seeds:** Blade harrow and wooden plank.

(C) **Implements for interculture or Intertillage:**

(1) **Weeding:** Hand tool like weeding hook (*Khurapi*) is used.

(2) **Hoeing:** Different type of hoes used are as follows :

- (i) Entire blade hoe
- (ii) Slit blade hoe
- (iii) Akola hoe
- (iv) Japanese hand hoe and Karjat hoe
- (v) Peg tooth cultivator and shovel tooth cultivator
- (vi) Paddy weeder

- (vii) Hand hoes
 - (viii) Tyne tooth hoe
- (3) Earthing up**
- Sugarcane-** Sabul plough and ridger is used.
- Erect type groundnut-** Entire blade hoe is used.
- Hand tool like hand kudali, trenching hoe is also used for carrying out earthing up.
- (D) Harvesting implements**
- (1) Groundnut:** Groundnut digger or groundnut harvester and blade harrow, hand digger.
 - (2) Potato:** Potato digger or deshi wooden plough is used.
 - (3) Cereals, oil seeds and pulses:** Combine harvesters are used in developed countries for carrying out harvesting, threshing and winnowing as well as bagging at a time.
 - (4) Wheat and rice:** Wheat and rice harvester and improved *vaibhav* sickle is used.
 - (5) Safflower:** Safflower harvester or safflower combine harvester.
 - (6) Hand tools -** like sickle is used for harvesting cereals, pulses, some of the oil seeds and fodder crops. Chopper is used for harvesting of sugarcane crop, *tikav*, *hand kudali* for harvesting turmeric, ginger and potato, *Vaibhav* sickle is used for harvesting rice crop.
- (E) Threshing implements**
- (1) Jowar, Bajra, Wheat and Rice:** Vicon thresher or different type of power operated threshers are used.
 - (2) Wheat:** Olpad wheat thresher
 - (3) Paddy:** Paddy foot thresher
 - (4) Shelling of maize cobs:** Maize sheller-hand driven or power operated.
 - (5) Shelling groundnut pods:** Groundnut Sheller
 - (6) Sunflower:** Sunflower thresher or sheller

is used.

Hand tools like wooden thresher is used for threshing cereals, pulses and some of the oil seeds.

- (F) Winnowing:** Winnowing fan, box winnower.

9.4 Modern concepts of tillage

Modern tillage method such as minimum tillage, zero tillage and stubble mulch tillage are practiced in U.S.A. and Europe. Most of these practices are not suitable for Indian conditions due to several reasons. In developed countries straw and stubbles are left in the field as such further decomposition. In India, use of heavy machinery is limited and therefore, problem of soil compaction is rare. Minimum tillage can be practiced under Indian conditions by reducing number of ploughings to the minimum necessary requirement. The modern concepts of tillage can be followed in fruit crops after proper establishment.

9.4.1 Minimum tillage

Minimum tillage means reducing tillage operation to the minimum necessary requirement for ensuring a good seed bed, rapid germination, satisfactory and favourable growing conditions for the crop.

Tillage operations can be reduced by omitting the operations which do not give much benefit when compared to the cost and by combining operations like sowing and fertilizer applications by using two bowl seed drill i.e. seed cum ferti-drill or mechanical seed drill and by using herbicides for weed management.

Advantages of minimum tillage

- (1) It improves the soil conditions due to decomposition of plant residues *in situ*.
- (2) Higher infiltration as the soil is covered with vegetation.
- (3) Less resistance to root growth due to improved soil structure
- (4) Less soil compaction

For getting the above mentioned



advantages about 2 to 3 years are required after practicing the minimum tillage.



Think about it

- (i) What will happen if number of ploughings are increased in low rainfall region?
- (ii) When the cost of cultivation will lower down?

Disadvantages of minimum tillage

- (1) Some times it may affect seed germination and emergence of seedlings.
- (2) More nitrogen application is required as the rate of decomposition of organic matter is slow.
- (3) Nodulation is affected in some of the legume crops like peas and broad beans.
- (4) Sowing operation is difficult with ordinary implements.
- (5) Continuous use of herbicides causes environmental pollution problems.

9.4.2 Zero tillage

It is the extreme form of minimum tillage in which preparatory tillage or ploughing is completely avoided and tillage operations for seed bed preparation are restricted in adopted areas where soils are subjected to wind and water erosion and cost of tillage and labour is too high. In this method the machinery used performs four functions in one operation viz. clean narrow strip over crop row, open the soil for seed insertion, place the seed and cover the seed properly.

In case of fruit crops only trenches are opened at required distance for planting trees and other operations are not carried out. In zero tillage herbicides are used before sowing for destroying weeds or vegetation. Generally, non-selective herbicides (parquat or Glyphosate) with short residual effect are used before sowing of the crop and during sub-

sequent stages of crop growth the selective herbicides are used for management of weeds. The plant residues are also used as mulch for conservation of soil moisture and management of weeds in the crop.

Advantages of Zero tillage

- (1) Zero tillage soils are homogenous in structure with more number of earthworms.
- (2) It increases organic matter content of the soil.
- (3) Surface run-off is reduced and infiltration of water is increased due to mulching.
- (4) It saves cost on preparatory tillage and intertillage.

Disadvantages of Zero tillage

- (1) Some times the germination and condition of the crop is affected.
- (2) Sowing operation is difficult with ordinary implements.
- (3) More nitrogen application is required as the rate of mineralization is slow.
- (4) Continuous use of herbicides may cause environmental pollution and residual effects.
- (5) Some times perennial deep-rooted weeds become serious problem.

9.4.3 Mulching

Covering surface of the soil in between the crop rows with the help of organic mulch such as plant residues or inorganic mulch like polythene sheet for conservation of soil moisture, management of weeds, maintaining soil temperature, etc. is known as mulching.

The organic mulch such as plant residues i.e. wheat straw, sugarcane trash, stubbles of the crop, grass clippings, crop stump, straw, bark, chipads, compost saw dust, cotton burs, rice husk, bran, wooden pieces leaf litter, etc. are spread in between crop rows @ 5 tonnes per hectare. The black polythene sheet spread on surface of the soil in between crop rows

is more effective than white polythene sheet. Mulching with polythene sheet is more costly than plant residues and used in case of high value crops only.

9.4.4 Stubble mulch tillage

Covering the soil surface with crop residues or stubbles during the fallow periods for protecting the soil from unfavourable weather conditions (heavy rains and winds) is known as stubble mulch tillage or stubble mulch farming. Generally, disc plough or disc harrow is used to incorporate some of the



Do you know ?

In winter shedding of leaves occurs naturally. It is useful for summer, as it covers the soil and prevent evaporation losses. It's called natural mulch.

plant residues into the soil after harvest of the crop. This hastens the decomposition but still keep enough residues on surface of the soil as mulch. Similar to zero tillage, heavy power machinery performing different functions such as cleaning strip, sowing seeds and fertilizer application is used for sowing the crop in stubble mulch farming.

Purpose of Mulching

- (1) Conservation of soil moisture.
- (2) Regulation of soil temperature.
- (3) Suppression of weed growth.
- (4) Prevention of soil erosion.
- (5) Control of pest and disease.

9.5 Post Harvest Farm operations

9.5.1 Harvesting

Cutting or removal of plants after maturity from the field is called harvesting. Crop should be harvested at proper stage to get higher yields (production) with good quality produce. Hence, it is necessary to know signs of maturity in case of various field crops.

- (i) Moisture content of grains up to 12 to 14 percent
- (ii) Yellowing of leaves and plants
- (iii) Change in colour of produce
- (iv) Life cycle of annual crop ends

There are various methods of harvesting such as cutting close to the ground level, cutting ear heads picking pods, pulling plants, digging produce from soil with the implements like sickle, plough, kudali, etc.

9.5.2 Threshing

Process of separating grains from earheads or cobs is known as threshing. This is done by various methods such as beating with sticks, trampling under bullocks feet, using hand driven machinery, threshing machine (thresher), stone roller, etc.

9.5.3 Winnowing

Winnowing means separation of grains from *bhusa* or dirt material. For this purpose the threshed material is held against wind. This is done naturally or artificially for cleaning of grains or produce.

9.5.4 Storage

Farm produce is stored either in bulk when it is in large quantity or in containers such as bins, pots, gunny bags, *kangi*, etc. Before storing farm produce should be dried well in sunlight for removing excess moisture from grains.

Exercise

Q.1 A. Fill in blanks.

1. A British scientist ----- is known as father of tillage.
2. The term ----- means the physical condition of soil resulting from tillage operations.
3. Some harmful insect pest like ----- can be destroyed by proper tillage operations.
4. The tillage operations, that are performed before sowing are referred as -----
5. The practice of covering the soil, to conserve more moisture in soil is called as -----

B. Make the pairs.

Group 'A'

1. Clod crushing
 2. Sowing
 3. Weeding
- (OR)
- (i) Seed drill
 - (ii) *Khurapi*
 - (iii) Plough
 - (iv) Disc harrow
 - (v) Ridger

Group 'B'

C State true or false.

1. Reducing the number of tillage operations is called as zero tillage.
2. Mulch is a material that is added at too deep in the soil.
3. Harvester is the machine that used for sowing.
4. Tillage helps the irrigation water to infiltrate into soil easily.
5. The ploughing operation turns over the upper layer of soil.

Q. 2

Answer in brief.

1. Write short note on preparatory tillage.
2. Complete the flow chart of farm operations.
Ploughing → ----- → levelling →----- → preparation of irrigation system → ----- → covering seeds → ----- → fertilizer applications.
(Clod crushing, harrowing, sowing, irrigation)
3. Give reasons.
 - (a) Deep ploughing should be performed for tap rooted crops.
 - (b) Thinning and gap filling operation should be carried out within 10-15 days of sowing.
 - (c) Mulching practice should be followed in drought prone zone.
 - (d) The crop should be harvested at proper maturity stage.
4. Write purpose of mulching.
5. Enlist the names of operations that are carried out in inter tillage.

Q. 3 Answer the following questions.

1. Explain tillage operation with implements, used for it
(a) Ploughing, (b)Harrowing,
(c) Sowing, (d) Weeding.
2. Describe farm operations.
3. Give advantages of minimum tillage.
4. Give advantages and disadvantages of zero tillage.

Q. 4 Answer in detail

1. Define tilth. Give characteristics of good tilth.
2. Explain objectives of tillage in detail.
3. Explain in detail the types of tillage.
4. Complete the following table on tillage operations.

SR. NO.	-----	SEED BED PREPARATION	INTER CULTURE
1.	Ploughing	Harrowing	-----
2.	-----	-----	-----
3.	Levelling	-----	Weeding / hoeing
4.	-----	Compacting soil	-----
5.	-----	-----	Mulching

Activity :

Practice tieing and handling of bullock and tractor drawn implements.



Can you recall?

- Tell the weed plants observed in your area.
- Why are the weeds considered as enemies of crop plants ?
- List out the harmful plants to the crop ?
- Can you differentiate weed from crop plant ?

Farmers sow the seed in field and take care to obtain produce from that. The plant grown in the field (cultivated plants) by farmer are called as crop. Some plants grow without putting any seed and competing to the main crops for nutrient, water and space that makes heavy loss of crop yield, such plants are considered enemy of crop which causes huge loss of yield and favour other enemies as pest, diseases, wild animals, etc. These plant enemies are called weeds.



Fig. 10.1 : Weed free plot



Fig. 10.2 : Weed infested plot

Weeds are unwanted, useless, prolific, competitive and often harmful to the human beings. Weeds are undesirable as they not only compete with crop for nutrients, moisture, space and sunlight but also interfere with agricultural operations (labour, tillage). It also affects the yield and quality of farm produce. Weed seed may get mixed with main crop seed. These weed plants are required to be uprooted before flowering stage. Therefore, management of weeds at right time is necessary.



Use your brain power

Complete following table with the information from your surroundings.

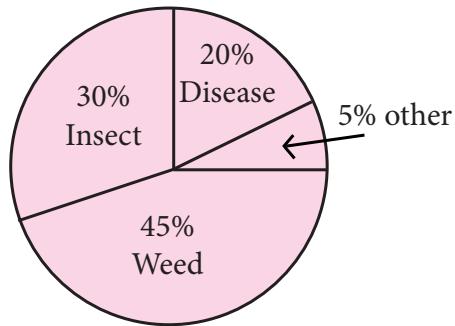
Sr. No.	Crop Plants	Weeds
1.		
2.		
3.		
4.		
5.		

10.1 Definition of weed

The most common definitions of weeds are :

- Weed is a plant growing where it is not desired.
- Any plant not sown in the field by the farmer and which is out of place is known as weed.
- Weed is a noxious, unwanted, undesirable plant in the field.

Annual loss in agriculture produce (%).



Always remember

- Jethro Tull was the first person to use word Weed.
- In India 45% of agricultural loss is due to weeds.
- Clean field always pays higher.



Understand and remember

- Weeds are considered as enemy of Crops.
- Weeds are very difficult to eradicate completely.
- Weeding is carried out in every crop.

10.2 Characteristics of weeds

1. They are unwanted and undesirable.
2. Weeds are harmful to crop, cattle and human beings.
3. The weed seed germinate early and grow very fast.
4. They flower earlier, produce more quantity of seed and mature earlier or late than crop and their separation become difficult.
5. They being hardy, compete with crop plants for nutrients, moisture, space, sunlight and reduce the crop yield.

6. They can thrive even under adverse conditions of soil, climate and biotic stress.

7. Viability of weed seed remain intact, even they are buried deep into the soil and passes through digestive track of the animals.

8. Weeds are prolific with abundant seed production capacity.

e.g. *Striga*, *Hazardana*, *Piwla Dhotra*

9. Weed seed have special structure like wings, spines, sticky, hairy, light weight, free flowing and hooks, etc. on account of which they can be easily spread.

10. Some weeds are propagated vegetatively e.g. : Doob, Kans, Laval, etc.

11. Some weed seed are very similar to crop seed and therefore their separation become very difficult. e.g. : Mustard seed with seed of Piwla Dhotra

12. They are persistent and resistant to control and eradication.

13. Some weeds have deep roots they store food in their rhizomes and reappear every year.

14. Some weeds have similar morphological characters like crops therefore escaped from weed control. e.g. wild rice, wild oat.

15. Some weed seed have long dormancy period and have a hard seed coat and hence not loose viability.

Beware that the weeds have varied characters and structures.



Try this

Activity - Survey residential area, waste land, cropped land and collect weeds, prepare an album and label.



Use your brain power

- Classify the plants or crops on various aspect.
- Classify the weeds on different aspects.
- Give special identifying characters of weed.



Do you know ?

- Weeds are specific for a particular location.
- Weeds are seasonal as well as periodic.

10.3 Classification of weeds

10.3.1 According to life cycle

(a) Annual weeds : These weeds grow and mature within a season.

- Kharif season weeds :** They appear with the onset of monsoon (June / July) and complete their life cycle when rainy season is over (Oct. / Nov.) e.g. Cocks comb, math, dudhi, hazardana, parthenium, chimanchara, etc.
- Rabi season weeds :** Weeds grow during winter season and finish their seed production before summer starts. e.g. bathua, ghol, vasantvel, etc.
- Summer season weeds :** Summer season weeds complete their life cycle during summer season (Feb / May) e.g. *Solanum nigrum* (*kamuni*), *Argemone mexicana*.
- Multiseason weeds :** They occur almost at any time of the year. e.g. *Eleusine indica* (Goose grass) *Phylanthus niruri* (*Bhuiawala*).

(b) Biennial weeds : These weeds live for two seasons. They complete vegetative growth in first season and produce flowers and seeds in the next season. These are mostly found in temperate climate. e.g. *Jangli gobhi*, wild carrot, wild onion, wild brinjal.

(c) Perennial weeds : They require more than two years to complete their life cycle. e.g. nutgrass, *hariyali*, johnson grass, wild ber, *ghaneri*, *kans*, *motha* or *lavala*.

10.3.2 According to place of occurrence

- Weeds of cropped lands : e.g. *dudhi*, *chandvel*, *vasantvel*, cocks comb, *bathua*, etc.
- Weeds of pastures and grazing lands : e.g. *parthenium*, *hulhul*, *hariyali*, etc.
- Weeds along water channel : e.g. *jalkumbhi*, *pandhari phuli*, *maka*, *ekdandi* (*Jakhamjodi*), etc.
- Weeds along rail and roadside : e.g. : *tarota*, *gokhru*, *parthenium*, *chubh kata*, etc.
- Weeds of waste land : e.g. wild ber, *rui*, *babhu*, *parthenium*, etc.
- Weeds of lawns and orchards : e.g. : *Cannabis sativa*, *ambooshi*, *ghol*, etc.
- Weeds of forest lands : e.g. *Lantana camara* (*ghaneri*) *tantani*, *chillari*.

10.3.3 According to plant family

- Gramineae : e.g. *hariyali*, *kans* or *kunda*, *chiman chara*, etc.
- Leguminosae : e.g. *lajalu*, *shewara*, *senji*, *tarota*, *takala*, etc.
- Solanaceae : e.g. wild brinjal, *kateli* or *kateringani*, etc.
- Euphorbiaceae : e.g. All types of *dudhi* (*Euphorbia spp.*)
- Liliaceae : e.g. wild onion
- Convolvulaceae : e.g. *chandvel*, *hirankuri*, *undirkani*, etc.
- Compositae or asteraceae : eg : *parthenium*, *maka*, *osadi*, *pandhari phuli*, *pohli*.

10.3.4 According to dependence on other host

1. Stem Parasites : e.g. *amarvel*, *loranthus* on mango.
2. Root Parasites : e.g. *gudiya*, *stringa*, *bambakhu* on tobacco, etc.
3. Independent : e.g. *chandvel*, *vasantvel*, *hirankuri*, etc.

10.3.5 According to soil type

1. Weeds found in black soil : e.g. *hariyali* or *doob*, *kans*, *kunda*, etc.
2. Weeds found in sandy loam or light soils : e.g. *aghada*, *chhoti dudhi*, *cockscombs*, *chirchiri*, etc.
3. Weeds found in ill drained soils : e.g. *maka*, nutgrass or *laval*a.
4. Weeds in tanks, ponds, rivers or aquatic weeds : e.g. *jalkumbhi*, *typha*, *hydrilla*, *salvinia spp*, lotus, algae, etc.

10.3.6 According to mode of cultivation

1. Weeds of dry land : e.g. *chimanchara*, *kombada*, etc.
2. Weeds of irrigated land : e.g. *laval*a, *hariyali*, *ghol*, etc.

10.3.7 According to morphology

- [i] Broad leaf weeds : These are mostly dicots having broad leaves with netted venation alternately arranged on stem e. g. *bathua*, common purslane, spiny, amaranth, etc.
- [ii] Grasses : Cylindrical and hollow stem having node and internodes, leaf emerges from node that are long, narrow upright with parallel veins, fibrous roots, gramineae family e.g. bermuda grass, barnyard grass, etc.
- [iii] Sedges : These are monocots like grasses but leaves occurring two rows. Triangular stem, no nodes, very large internode and leaf at top, no branch usually three leaves at top. e.g. *motha*, purple nut, etc.

[iv] Algae : This is a large and diverse group of simple photosynthetic plants. e.g. *chlorella*, *spirogyra*, *cladophora*, etc.

[v] Ferns : These are seedless vascular plants which produce spores. e.g. *Ceratopteris Siliquosa*, *Marsilea crenata*, *Salvinia molesta* etc.

10.3.8 According to association

Association of weeds with crops and seasons they are classified as :

- [i] Season - bound weeds : They grow in specific season of the year irrespective of the crop species cultivated. e.g. Johnson grass and Canada thistle.
- [ii] Crop - bound weeds : These are usually parasite on the host crop. e.g. *cuscuta*, *orobanche*, etc.
- [iii] Crop - associate weeds : Weeds associate with certain crops. They grow with crop due to their requirement, habitat and survive along with the crop in the form of mimicry. e.g. Wild oat, canara grass, barnyard grass, etc.

10.3.9 According to origin of weeds

- [i] Foreign origin (Alien Weeds) : *piwala*, *dhotara*, wild carrot, water hyacinth, etc.
- [ii] Indigenous origin (Apophytes) : bermuda grass, purple nut, jungle rice, *kans*, etc
- [iii] Introduced by Man (Anthrophytes) : *Avenahido viciana* (wild oats), *phalaris minor* (canara grass), *corchorus acutangulus*, etc.

10.3.10 According to nature of stem

- [a] Aerial Stem :
 - [i] Herbs : lambs quarter, *bhringraj*, etc.
 - [ii] Shrubs : *pethari*, jelly leaf, etc.
 - [iii] Bushes : wild ber, wild jujube (*Toran*)
 - [iv] Trees : *pimpal*, banyan
 - [v] Filamentous : *chiman chara*, water horse tail



- [b] Sub aerial stem :
- [i] With storage organs :
 - eg. 1. Nuts - purple nut
 - 2. Rhizomes - *sonkadi*
- [ii] Without storage organs :
 - eg. 1. Runners - *oxalis*
 - 2. Stolons - *aaloo*
 - 3. Offsets - *pankobi*



Use your brain power

- Why some weed seed float on water ?
- Whether the structure of weed seed that helps in dispersal ?



Try this

Collect different samples of Weed and Weed seeds from surrounding area.

10.4 Dispersal of weeds

Weeds are hardy and vigorous than crop plants, grow faster and spread so rapidly, therefore difficult to eradicate completely. Weed seed and fruits are dispersed very fast in various ways. Wind, water, animal, man and farm machinery are the principal agencies of weed seed dissemination.

1. Wind : Many weed seeds are light in weight with special structural modifications like parachute, wings, chaffy, silky hairs, balloons, etc. due to which they disperse to a long distance e.g. rui, Jakham jodi, *argemone mexicana*, milk weed, ground cherry, etc.



Fig. 10.3 : Dispersal of weeds by wind

2. Water : Some weed seed have special structures to float on water. Surface run off from the fields carry weed seeds during rainy season. Irrigation and drainage channels are also important in spread of weeds. Streams and flood water carry weed seeds to long distance. e.g. lavala, mothra, gajar gawat, chubkata, etc.

3. Animals and birds : Many weed seed are eaten by animals, birds and spread from one place to another through excreta. Many weed seed do not lose their viability even after passing through digestive track of birds and animals.

Weed seed having spines, awns, hooks or sticky hairs may get attached to the body of animals and spread from one place to another. e.g. gokhru, hooks, lantha, aghada, kusal, etc.

4. Man : Man himself is also responsible for the spread of weeds. Farmer use partially decomposed F.Y.M., compost or silage containing weed seed, feeding cattle with fodder having weed plants. Movement of uncleaned farm machinery, import food grains, vegetables, seedlings, etc. contaminated with weed seed.

5. Farm machinery : Farm implements carry weed seed from field to field and from one area to another.

6. Crop seed : Many times weeds are also harvested and threshed along with the main crop. If seed from such source is used for sowing in the next year. It gets dispersed.

7. Others : Weeds are also commonly spread through transport vehicles, manures, compost pits, soil mass and weeds used for mulching, etc.

Collect Information : Collect information about weeds from your parents, books and internet.



Let's discuss

- Discuss between two groups in your class about advantages and disadvantages of weeds.
- What will be the overall effect of weeds on field crops ?
- What will be the effect of weeds on animals and human beings ?



Try this

Prepare a list of beneficial and harmful weeds.



Always remember

- Along with Insect-Pest, Plant diseases, animals and weeds also cause considerable damage to agriculture crops.
- The estimated losses in crop yields alone range from 5 % in clean field to over 70 % in neglected fields.
- The losses of nitrogen through weeds as high as 150 kg / ha.
- There are over 30,000 species of the weeds around the world, out of these about 18,000 species are known to cause serious losses.

10.4.1 Effects of Weed

[A] Harmful effects of weed

- [1] Yield losses :** Weeds germinate earlier, seedlings grow very fast, produce large amount of seeds, weeds are hardy and vigorous in growth habit. It competes with crops for plant nutrients, moisture, space and sunlight. It consumes large amount of water, nutrients and causes heavy losses in crop yields. Sometimes complete loss

may occur. The annual agriculture loss in India due to weeds is estimated to 45 %.

[2] Increase in the cost of cultivation :

When the land is infested with weeds, the cost of tillage increases, i. e. repeated tillage operation and more labour is also required for weeding. Finally results in increasing the overall cost of cultivation and reducing the margin of the net profit.

Tillage operations are done to control weeds and generally 30 % of the total expenditure for crop production is incurred on tillage operations.

[3] Incidence of the pest and diseases :

Weeds act as alternate hosts to pest and pathogens during off season, which infect the crop later and cause severe damage.
e.g. Wheat - (Black Rust) → *Agropyron repens* (Quak grass).

Tomato - (Wilt) → *Amaranthus spp.*

[4] The quality of produce is reduced :

weed seeds get mixed with the main crop seeds, when crop is harvested and reduce the quality.

[5] The quality of livestock produce is reduced :

Certain weeds e.g. wild onion, wild garlic, *parthenium*, *piwali tilwan* when eaten by cattle, it imparts an undesirable flavor and bitter taste to milk. Weeds like *gokharu* get attached to the body of sheep and affect the quality of wool.

[6] Problems of human health :

Some of the weeds cause health problems, allergic reactions. e.g. *parthenium* causes irritation of skin and allergy. Mixture of Mexicana in mustard seeds cause dropsy, string needle causes severe itching and inflammation, fever and asthma may caused by *franseria spp.*

[7] Problems of animal health :

Many weeds are poisonous to animals when ingested. *Lantana camara* induces

hypersensitivity Johnson grass at tillering stage is poisonous. Sweet clover act as antiblood coagulant. Kala dhotra may cause death of cattle. Weeds with thorns or spines may cause injury to animals while grazing.



Fig. 10.4 : Dhatura spp.

[8] Problems of water contamination : Weeds block drainage and check the flow of water in irrigation channels and field channels. It increases seepage losses as well as losses through over flooding. Aquatic weeds render water unfit for drinking. After its decomposition, it emits offensive odor and pollutes the atmosphere. Aquatic weeds create difficulty in fishing and navigation.

[9] Weed secretions are harmful : Heavy growth of certain weeds like nut grass, johnson grass vasantvel, amaranthus lower the germination and reduce the growth and yield of many crop plants. This is due to certain allopathic compounds or phytotoxins released by the weeds in the soil.



Fig. 10.5 : Chaulai

[10] Weeds cause quicker wear and tear of farm implements : Weeds are hardy and having deep root system, the tillage implement get worn out early and cannot work efficiently unless they are properly sharpened or repaired.

[11] Weeds reduce the value of land : Agricultural lands which are heavily infested with perennial weeds like kans always fetch less price, because such lands cannot be brought under cultivation without incurring heavy expenditure on labour and machinery.

[12] Many weeds lower the beauty of Public Places

Do you know the weeds : *Pathri, ghol, jakham jodi, gumma, maka, bramhi, rui, argemone spp.* etc.

How these weeds are beneficial ?

[B] Beneficial effects of weeds

[1] Add nutrients to the soil

Several species of weeds having vigorous and leafy growth are used for green manuring. Some wild leguminous weeds fix atmospheric nitrogen. Aquatic weeds are used for making compost. It adds considerable amount of organic matter and plant nutrients into the soil.

[2] Fodder value of weeds

Several weeds of grasslands used as fodder for animals. Some weeds have succulent leafy growth good for milch animals. e.g. *Hariyali, chimanchara, shewari*, etc.

[3] Vegetable value of Weeds

Some weeds like *math, kanjru, tandulja, amaranthus, pathri, ghol*, etc. are used as green leafy vegetables at many places.



Fig. 10.6 : Pathri

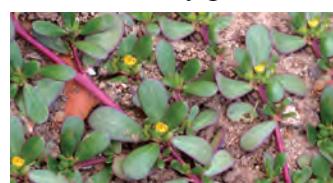


Fig. 10.7 : Ghol

[4] Medicinal value of Weeds

Some weeds are used in the preparation of certain drugs or medicines.

e.g. *Gumma* - used in the snake bite. *Maka* - cough disorders and as hair oil.

Argemone spp. - oil is used against skin diseases. *rui* - Good medicine for gastric troubles.

Striga, *Orobanche* - for treatment of diabetes. *Bramhi* used for preparation of brain tonic and ayurvedic oil, etc.



Fig. 10.8 : *Maka*



Fig. 10.9 : *Rui*

Fig. 10.10 : *Bramhi*

[5] Religious value of weeds

e.g *hariyali*, *aghada*, *maka*, *lavala* etc. are used in religious ceremonies.

[6] Economic importance of weeds

Kans, are used for thatching of huts, *lavala* for making essence sticks (*Udbattis*) and lemon grass for aromatic oils. Some weeds protect different types of farm bunds, especially in soil and water conservation.

[7] Reduce Erosion

Weeds growing on desert lands, waste lands and sloppy lands in the heavy rainfall



Fig. 10.11 : *Kans*

areas, sloppy fields, lowers wind and water erosion and helps in protection of environment.

[8] Reclamation of alkali soils

The application of powder of *piwala dhotra* @ 2.5 tonnes / ha is useful for reclamation of alkali soils and thereby increasing the yield.

[9] Source of resistance to pests and diseases

Weeds have been a constant source of new genes for resistance to pests and diseases. e.g. wild grass has conferred cold tolerance to bread wheat, resistance of potato to nematode. Some weeds useful for controlling nematodes when mixed into soil. e.g. *Rui*, *parthenium*, etc.

[10] Weeds can be used for preparation of paper pulp, biogas and the manufacture of edible proteins.

[11] Weeds serve as ornamental and hedge plants

e.g. *ghaneri*, *ghol*, *cactus*, *jalkumbhi*, etc. produces beautiful attractive flowers and are used as ornamental plants or hedges.



Fig. 10.12 : *Ghaneri*

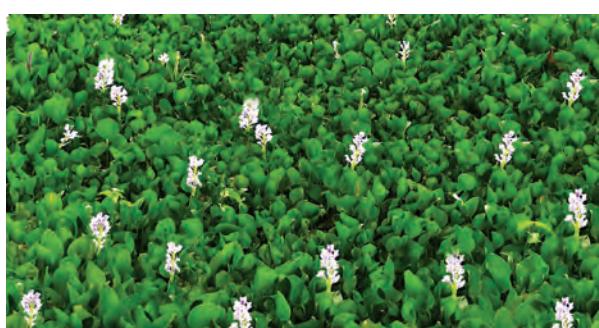


Fig. 10.13 : *Jalkumbhi*



Think about it

- What are your suggestions for minimizing weed growth?
- Which chemicals are used to control weeds?
- Which method is safe and effective?
- How do you kill weeds naturally?



Internet my friend

1. Collect information about different methods of weeds control.
2. Collect information about different trade names of weedicides.

10.5 Weed control

The process of minimizing weed infestation in cropped field for remunerative crop production is called weed control.

Different methods of weed control are as follows

- I. Preventive measures
- II. Curative Measures
 - a. Mechanical methods
 - b. Cropping or cultural methods
 - c. Biological methods
 - d. Chemical methods
- III. Integrated weed management



Always remember

1. The golden rule in agriculture is “Prevention is better than cure”.
2. Weed prevention is cheaper than weed control.

10.5.1 Preventive measures

The aim of this method is to prevent introduction and spread of specific weed species in areas that are not currently infested.

No weed program can be successful if proper preventive measures are not taken to minimize the weed infestation. Different measures adopted to prevent spread of weeds to minimize weed population are as follows.



Use your brain power

Why it is necessary to

- a. Use clean seed for sowing.
- b. Use well decomposed F.Y.M. / Compost.

1. Use weed free crop seeds and seedlings.
2. Do not use fresh or partly decomposed F.Y.M. or compost.
3. Remove weeds before flowering and seeding.
4. Remove weeds before raising crops.
5. Restrict livestock to move from weed infested area to clean area.
6. Use clean farm implements and tools before handlings.
7. Avoid shifting of soil from infested area to clean area.
8. Keep the threshing yard, compost pits free from weeds.
9. Follow legal and quarantine measures while importing crop seed, grains, seedlings, etc.
10. Use vigilance - Inspect your farm frequently for any strange looking weeds and destroy it immediately.
11. Keep the nursery stock free from weeds.
12. Keep river banks, hill slopes, field bunds and fence lines free from weeds.
13. Keep the irrigation and drainage channels free from weeds.

10.5.2 Curative measures or remedial measures

They are employed after the occurrence of weed. They are classified into four groups :

[A] Mechanical method or physical method

This is the common method of weed control, it started when man began to grow crops. Choice of each method depends on the location, extent and habitat of weeds. It includes -

[1] Hand weeding or hand pulling

It is a physical removal or pulling out weeds by hand. Weeds do not regenerate from pieces of root left in the ground. Weeds can be easily uprooted after good soaking irrigation or rain. Weeding should be done before flowering of weeds. This is costly and time consuming method.

[2] Hand Hoeing

Hand hoeing is a simplest weeding tool. It is effective on annuals and biennials so that weeds can be completely destroyed. It is effective on shallow root system weeds.

[3] Tillage

Tillage operation such as ploughing, disking, harrowing and levelling for seed bed preparation.

[4] Digging

This method weed control is useful where other methods are not effective. It is very useful to remove underground propagating parts of perennial weeds from deeper layers of soil. It is costly and time consuming method.

[5] Sickling

It is used to remove top weed growth to prevent weed seed production.

[6] Burning

It is not a good method, since useful vegetation and organic matter is also destroyed along weeds. Fire is used to burn crop residues and weeds after the harvest of crops like sugarcane, cotton, maize, potato etc.

[7] Flooding

Weed infested field is ploughed deep and flooded with 20 - 30 cm standing water. Flooding is an efficient method of weed

control for perennial weeds. The weeds are submerged under water and are smothered.

[8] Mulching

It has smothering effect on weeds by restricting the photosynthesis. It is effective against annual weeds. Generally organic mulches or polythene expensive sheet are used.

[9] Dragging

With the help of mechanical force, weeds are removed along with their roots and rhizome.

[10] Soil solarisation

During solarisation soil temperature is increased around 50° C. High soil temperature can suppress weed seed germination and kill weed seedlings.

[B] Cropping and Cultural method

This method is relatively less expensive. It may not control weed completely.

However weed intensity can be reduced to some extent to improve crop yield. The main objective of cultural practices is to provide a short term relief to crop during initial growth period. So that the crop may take lead in its growth and development.



Fig. 10.14 Cropping and cultural method

Cropping and Cultural methods includes

1. Proper crop rotation
2. Clean cultivation
3. Suitable time and methods of planting crops
4. Use clean seeds and higher seed rate
5. Inclusion smoother crops such as legume in intercropping

6. Summer ploughing
7. Water and nutrient management
8. Mulching and crop residue management
9. Reduction in area under bunds and water channels
10. Line sowing for using inter cultivation implements

[C] Biological Weed control



Let's recall

1. What is meant by parasites and predators?
2. Are predators can be used for controlling weeds ?

Biological weed control involves the use of living organism (Bioagents) such as Insect, pathogens, herbivorous fish, other animal and competitive plants to limit the weed infestation. In this method natural enemies of weeds (Parasites, predators and pathogens) are employed to control weeds.

The objectives of biological control are not to eradicate but to reduce and regulate the weed population. A bio agent may be either specific or non specific.



Fig. 10.15 : Bio weed control



Fig. 10.16 : Bio weed control



Try to understand

Characteristics of bio agents

1. The bio agents must feed or affect or kill only host plant. (weed)
2. They do not feed or harm the crop.
3. It should be free from predators and parasites.
4. It must be able to kill the host or atleast prevent seed production or reproduction of host plant.

The example of biological weed control are given below

- [1] Insects : Cactus or Prickly pear weed (*opuntie* spp) by- Cochineal insects. *Ghaneri* (*Lantana camara*) by lantana bug.
aquatic weeds like water hyacinth by snails or sea cow.
parthenium by *Zyogramma bicolorata*
- [2] Fish : aquatic weeds - common carp and chinese carp.
- [3] Fungi : water hyacinth - *Eichhornia crissipes* fungus. (Rhizoctina blight)
- [4] Mites : prickly pear - spider mite.

[D] Chemical Method

Chemical method is very effective in certain cases and have great scope in weed control. The chemicals are cheap, efficient and easily available. The chemicals which is used to kill or control weeds and their growth are called herbicides.

Advantages of chemical control method :

1. Most effective as compared to other methods.
2. It controls the weeds before crop emergence.
3. Highly suitable for close spaced crops.
4. Suitable for adverse soil and climatic conditions.

5. Control many perennial weeds which cannot be controlled by other methods.

Collect Information about different weedicides / Herbicides available in the market from nearest 'Krishi Seva Kendra'.



Think about it

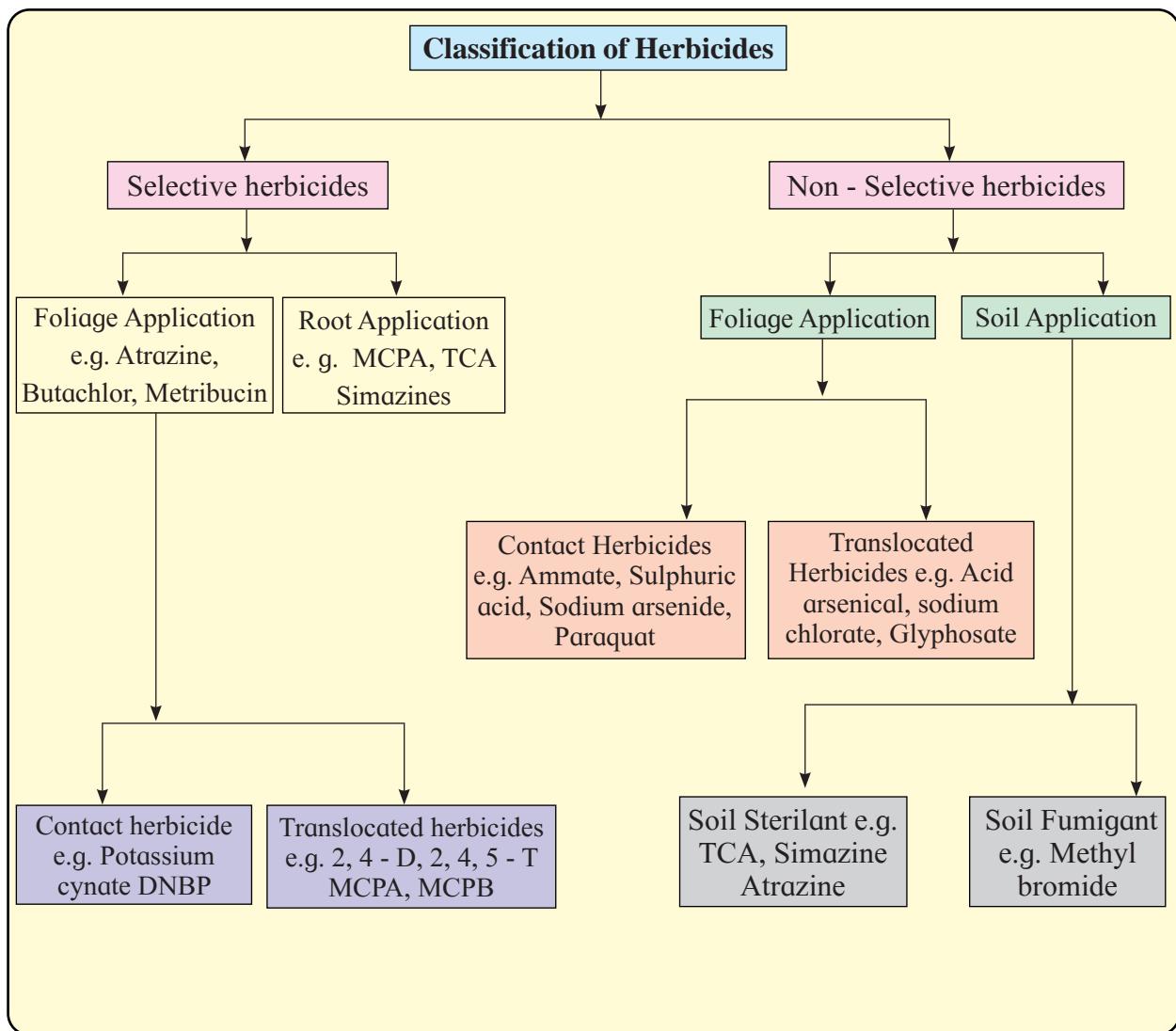
Select the best method of weed control from your point of view, which is good to the farmer by considering its costs, time, technique, skill, soil properties etc

10.5.3 Integrated Weed Management (IWM)

Integrated weed management is the suitable combination of all methods including preventive measures, mechanical, biological, cultural and chemical methods of weed control.

Importance of Integrated Weed Management

Weeds can be controlled by adopting different methods. However, each method has advantages and disadvantages or limitations. The continuous use of same method leads to built up of tolerant species. Therefore, the suitable combination of different methods of weed control or integrated use of weed management should be practiced for minimizing the losses caused by weeds.



Exercise

Q.1 A. Fill in the blanks.

1. Weeds can be controlled by preventive and ----- measures.
2. Any plant not sown by the farmer and is out of place called as -----
3. The chemical which is used to kill or control weeds is called as -----
4. The bio agent must feed or affect or kill only ----- plant.
5. The weeds which require more than two years to complete its life cycle is called as -----

B. Make the pairs.

Group A

1. Mango
2. Jowar
3. Tobacco

Group B

- a. *Dudhi*
- b. *Loranthus*
- c. *Gokharu*
- d. *Bambakhu*
- e. *Striga*

C. State true or false.

1. Biological method is most effective method than other methods of weed control.
2. Jethro Tull was the first person to use word weed.
3. *Lavala* is a weeds of ill drained soil.
4. Summer season weed appear with the onset of monsoon.
5. Weed also act as alternative hosts during the off season.

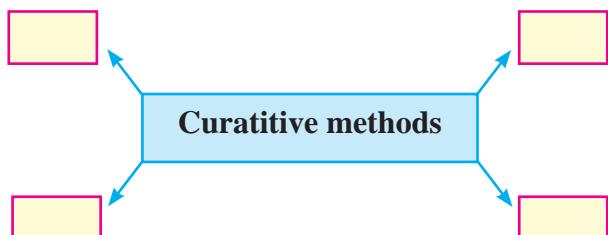
Q.2 Answer in brief.

1. Write short note on Integrated weed management
2. How weeds are controlled by biological method ?
3. Classify the weeds according to dependence on other host.

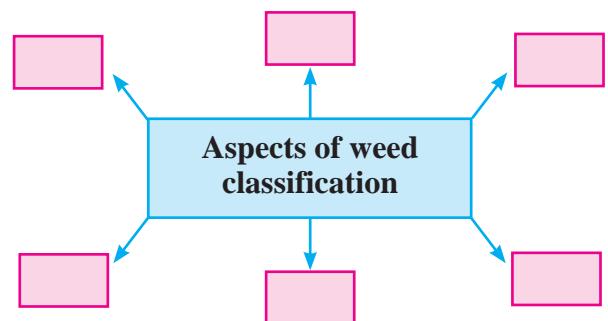
4. Write beneficial effects of weed.

5. Complete the following chart.

[a]



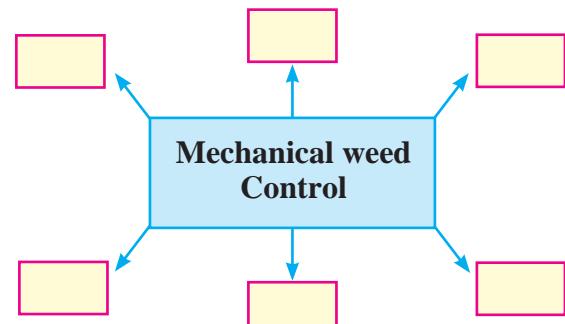
[b]



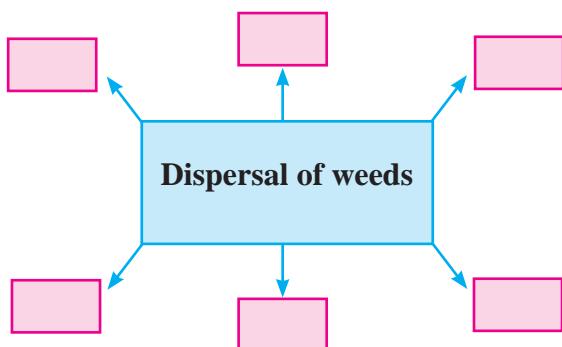
Q.3 Answer the following questions.

1. Classify the weeds according to life cycle.
2. Describe in short-dispersal of weeds.
3. Write in short preventive method of weed control.
4. Write about harmful effect of weeds.
5. Complete the following chart.

[a]



[b]



Q. 4 Answer in detail.

1. Define weed and give its characteristics.
2. Give detail classification of weed with suitable examples.
3. Describe curative methods of weed control.
4. List out methods of weed control and describe any two of them.
5. Explain harmful and useful effects of weed .

Activity :

Practice different methods of weed control and prepare a concept map of weed control methods.

Concept Map

**Can you tell?**

- Names of some insects familiar to you.
- The body parts of insects.
- The examples of harmful and useful insects.

11.1 Meaning and types of pest and diseases**11.1.1 Meaning of pest**

Pest means any living organism that multiplies in large number and cause damage or disease to human, animals, plants or property. Pest indicates the harmful insect or this includes insects, mites, fungi, bacteria, viruses, rats, birds, animals, nematodes, weeds, etc. The term pest is derived from Latin word *pestis* which means damage.

The insects are dominant in ecosystem as insects have external skeleton, small size, prolific reproduction, efficient body system, adoptability to new environment, remain dormant in adverse condition.

**Can you recall?**

- Names of human diseases
- Name the organisms responsible for diseases.

**Do you know ?****When plant is said healthy?**

Plant growth and development is good and it is capable of reproduction.

When plant physiological processes [Cell division and growth, absorption of water and minerals from soil, photosynthesis, respiration, food storage, etc.] are performing smoothly.

**Try this**

Take some disease affected seed and observe.

**Always remember**

The economic threshold level is the pest density at which control measures should be determined to prevent an increasing pest population from reaching economic damage level.

11.1.2 Meaning of diseases

Disease is defined as physiological or structural deformity that is harmful to plant or any of its parts or produce that reduces their economic value. Diseases of plant are responsible for damage to plant and their produce. Damage due to diseases in India is estimated approximately 500 crores per year. Disease may be caused by living organism which are affected by factors as temperature, moisture, aeration, deficiency or excess of plant nutrients, soil pH (acidity or alkalinity), etc.

**Always remember**

Plant diseases make changes in plant. Destroy plant cells or tissue due to toxic or growth retarding substances secreted by causal organism.

Due to continuous feeding of organism on plant food material, plants become weaker as well as absorption of minerals and water is disturbed.

Reduction in the yield of plant.

11.1.3 Types of pest and disease

[A] Types of pest on basis of incidence

1. **Regular pest:** The regular pest occur most frequently on the crop and such pest have close association with a particular crop. These pest are expected to occur on the crop sometime before harvest e.g. Thrips on chilli, Jassids on paddy, Aphids on mustard, Fruit borers on brinjal.
2. **Sporadic pest:** The sporadic pest occur in a few isolated localities occasionally in certain years e.g. stink bug on rice, slug caterpillar on castor.
3. **Occasional pest:** Many pest occur rather infrequently and close association with particular crop is absent e.g. case worm of rice, the mango stem borer.
4. **Seasonal pest:** Those pest which occur mostly during a particular part of the year. The incidence of these pests are governed by environmental factors in a locality. e.g. red hairy caterpillar on groundnut during April-May in certain localities of the south India, rice grass hopper during August – September in U.P.
5. **Persistent pest:** Pest that occur on a crop throughout the year are known as persistent pest e.g. mealy bugs on sugarcane.
6. **Potential pest:** These pest normally cause little loss but may become highly destructive resulting from some disturbance in the environment and the consequent increase in their number e.g. brown plant hopper on paddy.

[B] Types of pest on the basis of damaging organism

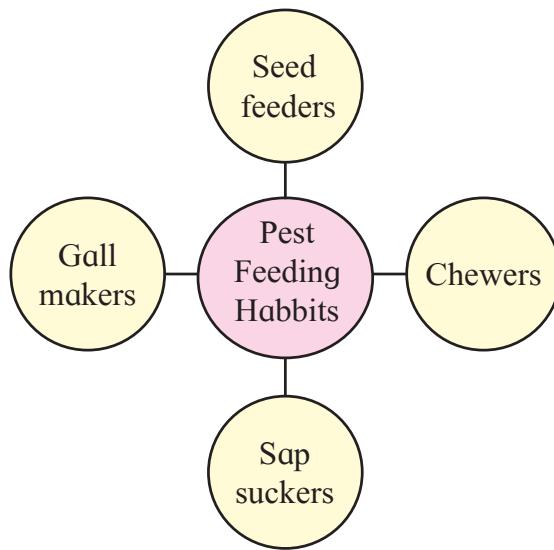
1. **Insect:** These are important and major pests. Insect have three pairs of legs, two pairs of wings, segmented body and characteristic compound eyes and antennae. The damaging stages of different

insects pests are larvae, nymphs and adults.

2. **Mites:** These are creatures similar to insect having four pairs of legs. They suck the sap from the plant and attack the crops in huge number.
3. **Rodents:** The rats eat away large amount of human food and also damage the crops on large scale. They are also responsible for heavy loss to stored grains on farms, in warehouses and houses.
4. **Animals:** Large animals like boar, deer, elephants, wild buffalo, monkeys, squirrels cause direct damage to crop plants. They eat away the plants and waste huge amount of crops.
5. **Birds:** Birds attack the crop plants and eat grains. Crow, parrots and sparrows are major birds that attack the crops.

[C] On the basis of feeding habits the insect pest

1. **Chewers:** Chewing is the most common way by which insects feed plant materials (leaves, stems, flowers, pollens, seeds, roots) larvae and adult have chewing mouth parts e.g. beetles
2. **Sap suckers:** Some insects with the help of their highly modified mouth parts pierce the plant epidermis and suck the cell sap. They do not physically damage the plant e.g. aphids, thrips.



3. **Miners and borers:** Leaf miners are chewing insect feed within plant tissues layers between the intact upper and lower epidermis of leaves. Due to feeding a tunnel is made that is often characteristics of the species. Boring insects live in the woody tissue of plants or fruits. Larvae of sugarcane top borer and stem borer feed the content of the stem. Most of the fruit borers (brinjal, okra) and stem borers (jowar, paddy) are injurious to crop.
4. **Gall makers:** Some insects induce the galls (the production of abnormal growth) in the tissues of their host plants, flowers or roots. The gall is entirely product of plant developed in response to a chemical stimulus from the secretions of the insect e.g. Paddy gall
5. **Seed feeders:** Seed feeders and seedling feeders are the only true predators among insects because they kill plants by consuming them e.g. seed beetles
6. **Soil insects:** Insects that are found in the soil live by feeding on the roots of plants by chewing or boring or sucking the sap or forming galls. Many soil insect are host specific as in cutworms, flea beetles.
7. **Store grain pest:** The stored products are attacked by insects in three ways,
 - (i) It may be a continuation of field attack as in potato tuber moth.
 - (ii) The eggs may be laid in the field itself and damage occur in storage as in red gram infested by bruchid beetle.
 - (iii) The attack may come from the material stored earlier and be carried over to fresh material stored in the same storage house as in the grain weevil.

[D] Classification on the basis of economic damage

1. **Major pest:** The pest causing 10% or more damage to crop is called as major pest e.g. sucking insect of cotton.

2. **Minor pest:** The pest causing only 5-10% damage (loss) to crop is called as minor pest. e.g. mealy bug of sugarcane.
3. **Negligible pest:** The pest causing loss of crop production less than 5% is called as negligible pest e.g. gray cotton bug.

[E] Classes of pest on the basis of feeding on crop.

1. **Monophagous pest:** Pest in this class gets food from specific single crop hence called monophagous pest, e.g. hoppers of mango.
2. **Polyphagous pest:** Pest feed on many crops is known as polyphagous pest. e.g. gram pod borer.
3. **Oligophagous pest:** Pest feeds only on special crops is called oligophagous e.g. spotted bollworm of cotton.

[F] On the basis of outbreak of the pest

1. **Epidemic pest:** Irregular large scale infestation of insect at specific time in a particular area e.g. grass hoppers on jowar.
2. **Endemic pest:** When insect infestation is regular in large scale but at particular place then that pest is called endemic pest. e.g. white grub on sugarcane at riverside of kumbhi.
3. **Economically important pest:** The insect population is always above economic threshold level and require repeated control management for that pest. In spite of regular control measures insect population crosses economic threshold level. e.g. gram pod borer.

Types of diseases: On the basis of various criteria disease are classified as below.

(A) On the basis of symptoms of disease.

1. **Mosaic:** Due to uneven development of chlorophyll when colour variation and alternate light green patches develop on plant that disease is called as mosaic.



- Blast :** When the entire leaf blade, bud or other plant parts are involved resulting in quick death of the parts or whole plant that disease is called blast. e.g. blast in rice.
- Rot:** In such disease affected tissues get disintegrate. e.g. root rot, stem rot, collar rot, etc.
- Smut:** In this disease there is development of sori which are filled with masses of spore that gives them deep brown or black colour. The malformation affects floral structures, buds and leaves. e.g. jowar smut.
- Cankers:** Corky growth often develop in affected parts. It causes localized death of the tissue but in several infection they may girdle the stem and kill the plant. e.g. citrus canker.
- Rust:** Infection begin when a spore lands on plant surface. Infection is limited to plant parts as leaves, petioles and tender shoots. It may display signs of infection such as rust fruiting bodies e.g. Wheat rust.

(B) On the basis of affected plant parts.

- Root disease : e.g. Root rot
- Stem disease: e.g. Tumours
- Flower disease : e.g. Smuts
- Fruits disease : e.g. Scab
- Leaf disease : e.g. Leaf spot

(C) On the basis of spread and intensity

- Endemic:** When a disease occur more or less constantly prevalent from year to year in moderate to severe form in a particular area. e.g. Wart disease of potato is endemic to Darjeeling.
- Epidemic or epiphytotic:** A disease occurring periodically but in a sever or involving major area of the crop. It may be constantly present in locality but occur severe occasionally. e.g. Rust.
- Sporadic:** Disease that occur at very irregular interval and location in a moderate to severe form e.g. Wilt.

- Pandemic:** Disease occurring throughout the continent or sub -continent resulting in mass mortality. e.g. late blight of potato.

(D) On the basis of cause (pathogen).

- Infectious :** Causal organisms may be fungi, bacteria, viruses, nematodes, higher parasitic plants.
- Non infectious :** Disease caused by nutritional deficiencies e.g. Khaira disease of rice due to Zn deficiency.

(E) On the basis of host plants

- Disease of Cereals
- Disease of Vegetables
- Disease of Legume crops
- Disease of Flower crops



Use your brain power

Infectious microbes

1. Fungal
2. Bacteria
3. Viral
4. Nematode
5. Parasitic



Try this

- Prepare a glass slide from disease plant part and observe under microscope.
- Visit the field and record following observations
 - (a) Difference between healthy and infected plant
 - (b) Symptoms of disease
 - (c) Changes in next few days

11.2 Principles and methods of pest and disease control

Principles of pest control may have two approaches viz. control planning against a pest or disease and control planning for crop.

Control planning against a pest and disease is directed against a specific pest without taking in to account of other pest of the same crop.

Control planning for crop involves a plan in which all insect pest, diseases are taken in consideration. The second approach is of more practical value for farmers because they are interested in increasing productivity of the crop hence prefer a plan that can provide safeguard against all possible pest occurring on the crop. This control planning is based on the following principles.

1. Prevention of pest and pathogen.
2. Avoid entry of pest and pathogen.
3. Removal and destruction of pest or diseases.
4. Chemical control of pest and diseases.
5. Development or production of pest or disease resistant plants.

In accordance with the above stated approaches to the pest and disease control the methods of the pest control are as follows.

11.2.1 Methods pest control

1. Cultural control methods
2. Mechanical methods
3. Physical methods
4. Legal methods
5. Biological methods
6. Chemical methods

1. Cultural control methods :

These tactics may include

- (a) Selection of seeds
- (b) Clean cultivation
- (c) Provision of alternate hosts
- (d) Crop rotation
- (e) Tillage operation
- (f) Timing of planting and harvesting
- (g) Cultivation of trap crops
- (h) Nutrient management
- (i) Plant density

Selection of seeds and cultivars: Seed damaged by insects or other pest, if sown may cause poor germination or poor health of seedling. Seed of resistant crop varieties should be used for crop production.

Clean cultivation: Disposal or destruction of crop residues removes residual pest population e.g. pink bollworm larvae.

2. Mechanical control

- (i) Hand picking of infested plants and destruction
- (ii) Netting, Bagging and dislodging of insect pest
- (iii) Trenching
- (iv) Burnings
- (v) Hitting and crushing
- (vi) Insect barriers or mechanical excluders
- (vii) Insect traps
- (viii) Provisions of bird perching objects

Handpicking of infested plant parts along with pests is effective in controlling the pests e.g. the easily detectable egg masses of rice stem borer can be handpicked and killed. Trenching is very good method for controlling locusts at nymphal stages.

3. Physical method :

Use of certain physical forces for eradication of insects e.g. kaolinite clay mixed with stored grains. It also includes use of heat, moisture, light, etc.

4. Legal methods :

Legislation to prevent introduction of new pest, prevention of already established pest, regulate the activities of men engaged in pest control operation.

5. Biological methods :

Control of a pest by means of another living organism that is encouraged and spread by man is called as biological control. The natural enemies of insects, parasites and predators, diseases causing viruses, bacteria, fungi, parasitic nematodes, etc. are used to control pest.

6. Chemical methods :

Various common pesticides are used for controlling the insects. The natural or synthetic chemicals that directly cause the death, repulsion or attraction of the insects are used in this method.

The pesticide is chemical or a mixture of chemicals employed to kill pest. The term pesticide encompasses insecticide, herbicide, rodenticide, fungicide and other substance.



Always remember

Protection: Preventing infection by creating a chemi-toxic barriers between the plant surface and pathogen

- Chemical treatment
- Chemical control of insect vector
- Modification of environment

Resistant varieties :

Preventing infection or reducing effect of infection by managing the host through improvement of resistance in it by genetic manipulation or by chemotherapy

- Selection and hybridization
- Mutation

The following formula is used for preparation of spray solution to find out the quantity of insecticide required for treating an area at a required.

$$N_1 V_1 = N_2 V_2$$

Or

Quantity of insecticide required =

$$\frac{\text{Total quantity of spray solution} \times \text{Strength in percentage of spray solution desired}}{\text{Strength of the chemical available}}$$

Example : Find out the quantity of Chlorpyrifos 20 % EC required for treating an area which required 1000 liters of spray fluid at 0.02 % strength.

Solution : Formula

$$N_1 V_1 = N_2 V_2$$

Where

N_1 – Strength of the chemical

V_1 – Quantity of insecticide

N_2 – Strength of spray solution desired in percentage

V_2 – Total quantity of spray solution required

Quantity of Chlorpyrifos required

$$V_1 = \frac{N_2 \times V_2}{N_1}$$

$$V_1 = \frac{0.02 \times 1000}{20}$$
$$= 1 \text{ litre}$$

Precautions and care to be taken during application of pesticides

- (1) Select only proper insecticide/ fungicide.
- (2) Keep pesticides in their original containers with label.
- (3) Read carefully information about precautions and first aid.
- (4) Store the pesticides beyond the reach of children, away from food and food materials.
- (5) Wear protective appliances while application.
- (6) Do not drink, eat or smoke while handling pesticides.
- (7) Do not use defective equipment.
- (8) Spray along with wind direction.
- (9) Wash all equipments after handling pesticide.
- (10) Take care for avoiding contamination of tanks, ponds, wells and other sources of water
- (11) Use pesticide in appropriate concentration against particular pest.

Storage and handling of pesticides

Pesticides are toxic to human being and animals. They should be handled with utmost

care. The following precautions should be taken while storing and handling of pesticides.

- (1) The pesticides should always be stored in their original containers.
- (2) They should be stored away from food, fodder and medicines. They should be kept out of reach of children and domestic animals.
- (3) Containers of pesticides should be cut open with separate knife and the empty containers should be destroyed properly.
- (4) The instructions found on the labels should be strictly followed.
- (5) Avoid contact of pesticides with skin or clothing.
- (6) Avoid smoking , chewing, eating or drinking while mixing or applying the chemicals.
- (7) Make the spraying or dusting in cool and calm weather and in the wind directions.
- (8) Sprayer nozzles should not be blown by mouth if gets blocked while spraying.
- (9) Washing of equipments in or near wells or street should be avoided.
- (10) Contaminated parts should be buried.

11.2.2 Disease control / management



Can you tell?

Approaches regarding plant disease control.

Measures taken to prevent incidence of a disease, spread of diseases and minimize the loss caused by the disease is called as control measure. The aim of disease control is to check the loss of economic gain from the crop. If the control measure fails to increase economic gain even if disease incidence is reduced, farmer will not accept the recommendations for plant disease management.

The principle of plant disease management have two approaches viz. management of a single disease of crop and planning for overall health of crop. Management planning for

disease is against a specific disease that causes heavy loss without taking into consideration other diseases of the same crop. Management of crop health involves plan in which all diseases of crop are taken into consideration, although major stress may be against the severe disease. The second approach is difficult for farmer but have more practical value.

General principles

1. Avoidance : It involves avoiding disease by planting at time when, or in areas where inoculums are absent or ineffective due to environmental conditions.
Main practice:
 - (1) Selection of planting material
 - (2) Modification of cultural practices.
 - (3) Escaping varieties
 - (4) Choice of geographical area
 - (5) Selection of the field
 - (6) Sowings / planting time
2. Exclusion: It restricts the movement of diseased plant materials to the area free from the disease concerned.
3. Eradication: It involves eliminating the pathogen from infested areas.
4. Protection: These are measures used to prevent the onset of a disease on a crop to protect the host from attack by the pathogen.
5. Host resistance: It utilizes in build mechanism to resist various activities of pathogen. The infection or subsequent damage by pathogen can be rendered ineffective through genetic manipulation or by chemotherapy.
6. Therapy : It is the treatment of infected host plant

The first five principles are mainly preventive (prophylactic) and these are applied to the population of plants before infection takes place. Therapy is curative procedure and is applied to individual after infection has taken place.

Method of disease control

1. Exclusion of the pathogen

- (i) Quarantine (Legal method)
- (ii) Inspection and certification
- (iii) Seed treatment
- (iv) Eradication of insect vectors.

2. Avoidance of the pathogen

- (i) Choice of geographical area
- (ii) Selection of field
- (iii) Choice of time of planting
- (iv) Disease escaping varieties
- (v) Selection of seed and planting material

3. Eradication of pathogen

- (i) Heat treatment :** Seed/stock
Tools and implement
Soil

- 4. Biological :** Antagonists
Hyper parasite
Mycorrhizae
Cross protection
Control of weeds and pests

5. Cultural practices :

- Crop rotation
- Fertilizer application
- Storage disinfection
- Sanitation
- Removal and destruction of diseased plant.

6. Chemical control :

Information on Important methods

Cultural methods

In this methods pest or pathogen population is either eliminated or reduced by farm practices

- (i) Crop rotation: Growing of crops which are hosts of pest in a successive manner results in increase of population of that pest. When crop rotation with non-host crop is done, population of pest is reduced because the insect is excluded from its food supply. Lady's finger followed by cotton crop suffers from increased pest infection.

Most of diseases are caused by soil born pathogens and can be significantly reduced by crop rotation. The success of crop rotation for disease control depends on proper selection of crops in the sequence.

- (ii) Mixed cropping: Mixed cropping is intended for getting some return from an area if one crop is attacked the other escapes. Mixed cropping of pigeon pea and sorghum give significant reduction in the incidence of wilt of the pigeon pea.
- (iii) Sanitation – Destruction of crop debris by burning the field decreases parasites. Sanitation is very important when diseased crop residue is left on the field.



Always remember

- Basic requirement for plant disease control
- 1. Clean and healthy seeds
- 2. Clean field, pathogen free soil.
- 3. Prevent entry of pathogen in standing crop.
- 4. Precautions during harvesting and storage.

Chemical control

In this method protective toxic layer on host surface is formed so that when pathogen comes in contact it is killed or prevented from growth.

Spraying and dusting with fungicides protect plant from infection of disease. The chemical act externally to destroy the organism on the plant surface or act from within a systemic manner to eliminate a pathogen already established in the host.

Fungicide is a chemical which is capable of killing fungi.

Fungicide based on their mode of action can be grouped as follows.

- 1. Protectant : Fungicides which is effective only if applied prior to fungal infection is called Protectant e.g. Sulphur
- 2. Therapeutic: Fungicides having capacity

- to eradicate fungi after it has caused infection e.g. carboxin.
3. Eradicant: Eradicant are those chemicals which remove pathogenic fungi from infection court e.g. organic mercurial.
 4. Systemic fungicides: Any compound capable of being freely translocated after penetrating plant is called systemic. This type of fungicides could eradicate established infection and protect the new parts of the plant. e.g. Carboxin, Benlate.
 5. Antibiotics: Antibiotic is defined as a chemical substance produced by microorganism which in low concentration can inhibit or kill other microorganism.

Biological control

Biological control is nothing but control of plant disease using living micro organism

The bio control agent parasitizes the pathogen by coiling around the hype e.g. *Trichoderma viride*. Various bacteria and fungi secret enzymes which degrade the cell wall of pathogen e.g. *Bacillus sp.*

11.2.3 Integrated Pest Management (IPM)

Integrated pest management is a system that utilizes all suitable techniques in compatible manner to reduced and maintain pest populations at levels below those causing economic damage.

Principles of integrated pest management

1. Identify pests, their hosts and beneficial organisms before taking action.
2. Establish monitoring guidelines for each pest species.
3. Establish an action threshold for the pest.
4. Evaluate and implement control tactics.

IPM comprises strategies aimed at minimizing pest damage through the careful integration of available pest control technologies.

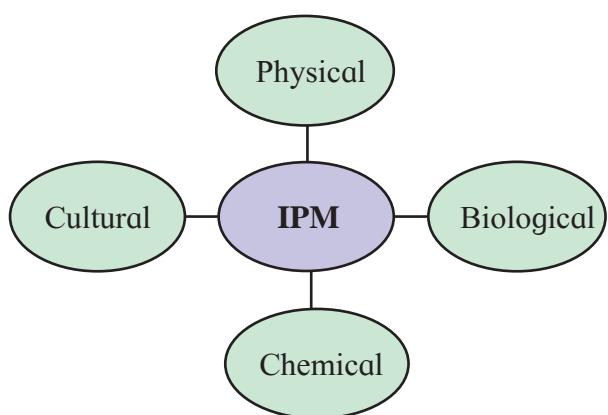
Objective of IPM

1. To reduce pest status below economic damage level.
2. To manage insects by not only killing them but by preventing feeding, multiplication and spread.
3. To use ecofriendly methods.
4. To make maximum use of natural mortality factors and apply control measures only when needed.
5. To use components in suitable crop production

Requirements for successful pest management

1. Correct identification of insect pest
2. Life history and behavior of the pest
3. Natural enemies and weather parameters affecting pest population
4. Pest forecasting and predicting pest outbreak
5. Need and timing of control measure
6. Selection of suitable method of control.

Integrated pest management



11.2.4 Integrated Disease Management (IDM)

Definition

Integrated plant disease management can be defined as a process involving co-ordinated use of multiple methods of optimizing the control of pathogen or it is a disease control methods that uses all types of management techniques to keep disease pressure below the economic threshold level.



Use your brain power

1. Can single control methods be effective for pest or disease control?
2. Is it possible to use control methods simultaneously?
3. What is your opinion regarding biological control methods?

Technique use in IDM

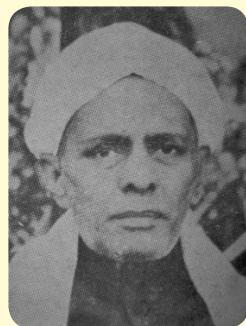
1. Maintaining plant population
2. Balanced fertilizers application
3. Avoid alternative host during off season
4. Avoid coincidence of susceptible stages with disease favorable conditions,

Advantages

1. It does not allow the development of disease resistance in the plant.
2. It is ecofriendly and does not harm the nature.
3. It is economical and efficient method for disease control.
4. Plant disease of crop are managed by minimum number of operations and repetition for each separate disease.

Introduction to scientist

Tarakad Vaidyanatha Ramakishana Ayyar was an Indian entomologist who was born at Tarakad in Palghat. In 1908, he took charge of entomology education at college of Agriculture, Coimbatore. He was a founder of the entomological society of India. Hand book of economic entomology for south India was written by him.



11.3 Important pests

Sr. no	Name of pests	Nature of Damages	Control Measures
Sugarcane			
1	Top shoot borer	Larva feeds on the leaves and later bore in to the shoot	Remove and destroy infected shoots, spray the crop with Quinalphos.
2	Sugarcane stem borer	Larva bores hole into the stem and feeds on inner matter. The affected plant dries up.	Remove dry plant parts, spray the crop with Monochrotophos
3	Mealy bugs	Nymph suck the cell sap. In severe infestation canes shrivelled and remain stunted.	Sets treatment with 1% fish oil, rasin soap solution before planting
4	Wooly aphids	Infestation starts beneath the leaves along the midrib and later on spread to entire lower surface. Huge insect population suck cell sap.	Clip and destroy affected leaves of initial stage, spray the crop with mixture of Malathion and Dimethoate.
5	White grub	The fleshy grubs are highly destructive to the roots and underground stalks of cane . The damage to sugarcane by grubs is noticeable during July to September	Collection and destruction of adults and grubs. Application of Phorate granules @ 25 kg / ha
Cotton Pest affecting before flowering			
1	Aphids, Jassids, Thrips Whiteflies	Pest of this group suck the sap from leaves and tender parts causing their yellowing and curling.	Spray insecticide belonging to Organo Phosphorus group (e.g. Chlorphyriphos)
Pest affecting after flowering			
2	Spotted boll worm, Pink boll worm, American boll worm	Larva bores hole on bolls and feeds on it, boll rotting takes place that result in shedding of bolls	All boll worms can be controlled by spraying of insecticides like Acephate, Chlorpyriphos
Paddy			
1	Stem borer	Larva enters the leaf sheath feeds on it and bore in to stem near to the nodal region.	Collection and destruction of egg masses, spray Phosphomidon
2	Gall fly	Maggot infestation is seen on growing points of the plants and produces long tubular structure which is covered by silvery shoots.	Remove and destroy affected plant parts

Soybean			
1	Stem borer	Larva causes damage by tunneling the stem and side branches plants dry and affect yield.	Spraying of Chloropyriphos on crop controls the pest.
2	Pod borer	Larva bores hole in pod and feed on developing seeds.	Pod borer can be controlled by spraying Monocrotophos
3	Hairy caterpillar	Pest cause damage by feeding on young leaves.	Spray Monocrotophos insecticide, plough land immediately after harvesting
Onion			
1	Thrips	Nymph and adult suck the sap from the leaves. Bulb yield is affected	Spray Dimethoate at 15 days interval.
2	Jassids	Jassids also suck the sap from leaves and make spot on it	Spray Monocrotophos.
Potato			
1	Tuber moth	The caterpillar feed on the leaves and attack the exposed tubers. It makes a tunnel in the tubers and feed on inner matter.	Earthing up to plants and spraying of Carbaryl
2	Cut worm	The larva remains hidden in soil, larva cut the young potato plant at the ground level and feed on tender leaves.	Collect and destroy the larva. Application of Carbaryl
Mango			
1	Mango – hopper	Adult and nymphs suck sap from tender shoots and flower panicles, secretion of honey dew like substance on leaves results in the sooty mold growth on affected portion .	Spraying of Malathion or Monocrotophos at panicle emergence and peak fruit setting stage.
2	Fruit fly	The maggots feed on flesh and affected fruits become unfit for consumption. The fruit fly lays eggs in the clusters under the skin of fruit just before ripening. The affected fruits begin to rot and drop.	Collection and destruction of damaged fruits Spraying of Malathion. Use fruit fly trap
Pomegranate			
1	Fruit borer	The caterpillar bores into the fruit and feeds on the internal contents. The affected fruits fall and rot.	The fruit screened with polythene paper bags may escape infestation, spray the crop with Carbaryl

2	Bark eating caterpillar	The caterpillar bores into the bark and feeds inside. Tree becomes weak and collapse in severe cases.	Clean the hole and put the cotton dipped in petrol in it.
3	Fruit sucking moth	Adult moth suck the juice from ripened fruits with the help of spines by making puncture after sunset during the rainy season. Pin hole spot appears on fruits	Keep poison bait Malathion + molasses+ water) spray tree with Carbaryl
Citrus			
1	Citrus butterfly	The adult feed on the leaves from the margin towards the mid-rib and defoliate branches	Hand picking of larva spraying of malathion is effective against pest.
2	White fly	Adult and maggots suck the cell sap from tender shoot and leaves, yellow patches are formed on surface of leaf	Spray tree with Monocrotophos
Coconut			
1	Rhinoceros beetle	Caterpillar burrows and cut across the leaf in its folded conditions. Death of growing points.	Hook out beetles from affected palms. Fill the leaf axils with Chlordane dust.
2	Red palm weevil	Adult feeds on soft tissue inside trunk	Inject Carbaryl in the trunk of infested tree.
3	Mites	Mites feeding on young and developing nuts causes superficial bands with necrotic tissue about the circumference of the nuts	Root feeding with Carbosulfan, spray Fenpyroximate.

11.4 Major diseases of crop

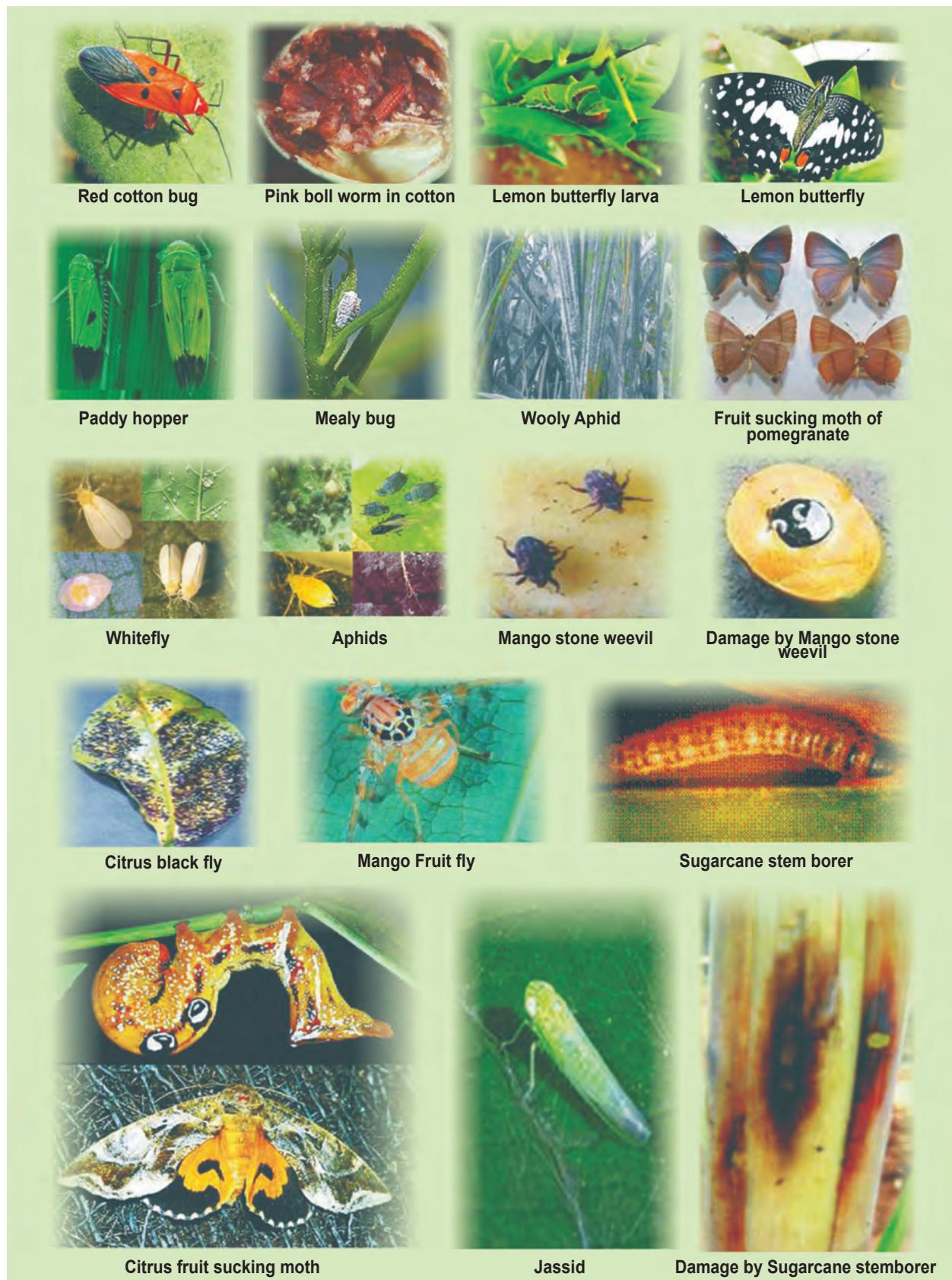
Sr. no	Name of Disease	Symptoms	Control Measure
Sugarcane			
1	Whip tail (smut)	This is fungal disease, long whip like structure comes out from the growing point. This is covered with black powder.	Use healthy sets for planting, treat sets with fungicide like Ceresan.
2	Red rot	In this fungal disease on splitting red strips are observed. In severe cases rotting and alcoholic smell come out.	Treat the sets with fungicide like Agalol.
3	Grassy shoot	In affected plots to many lateral tillers arises with light green to dark green in colour.	Treat the sets with hot water at 50° C for two hours.

4	Rust	Numerous small but long yellow coloured spots appear on both the surfaces of leaves. These spot later on turn dark brown to black.	Grow resistant variety.
Paddy			
1	Blast	The fungus attack all aerial parts at all stages of growth. Spindle shaped spots whitish gray with brown margin are originated on leaf, neck of panicle, nodes, glumes, etc.	Use of disease free seeds, spray Copper fungicides, systemic fungicides are very effective in controlling blast.
2	Bacterial blight	Initially dull greenish water soaked or yellowish spots on leaf margins are observed, these spots extend into lesions to form blighted portions. On drying these form minute crusts.	Hot water treatment for 10 minutes at 52-54°C. Soak seed in Agrimycin for eight hours. Spraying of Streptocycline.
3	Stem rot	Affected plants remain stunted, they produce tillers, root become reddish stem, root rot, grain get shriveled	Avoid extra standing water in the field. Apply fungicides like Ceresan at the ease of plants.
Cotton			
1	Wilt	It is fungal disease. Gradual drying and dropping of the plant is observed. The wiltings and dropping starts from top to bottom.	Grow resistant varieties, seed treatment with fungicides like Ceresan.
2	Anthracnose	Fungal infection starts in seedling stage. In seedling stage red circular spots are found on leaves. Affected bolls show brown circular spots. These do not open properly to form <i>kawadi</i> . Shedding of bolls takes place.	Seed treatment with fungicides, spray 1% Bordeaux mixture.
3	Dahiya (powdery mildew)	The affected leaves show whitish growth on underside of older leaves, defoliation of leaves takes place.	Grow American cotton varieties, spraying of Sulphur
4	Root rot	Rotting of roots and sudden wilting of plants.	Seed treatment with Carbandazim
5	Black arm	This is a bacterial disease. Bacteria attack on aerial plant parts. Angular water soaked spots appear on leaves. It also causes rotting of bolls.	Seed treatment with Streptomycin.

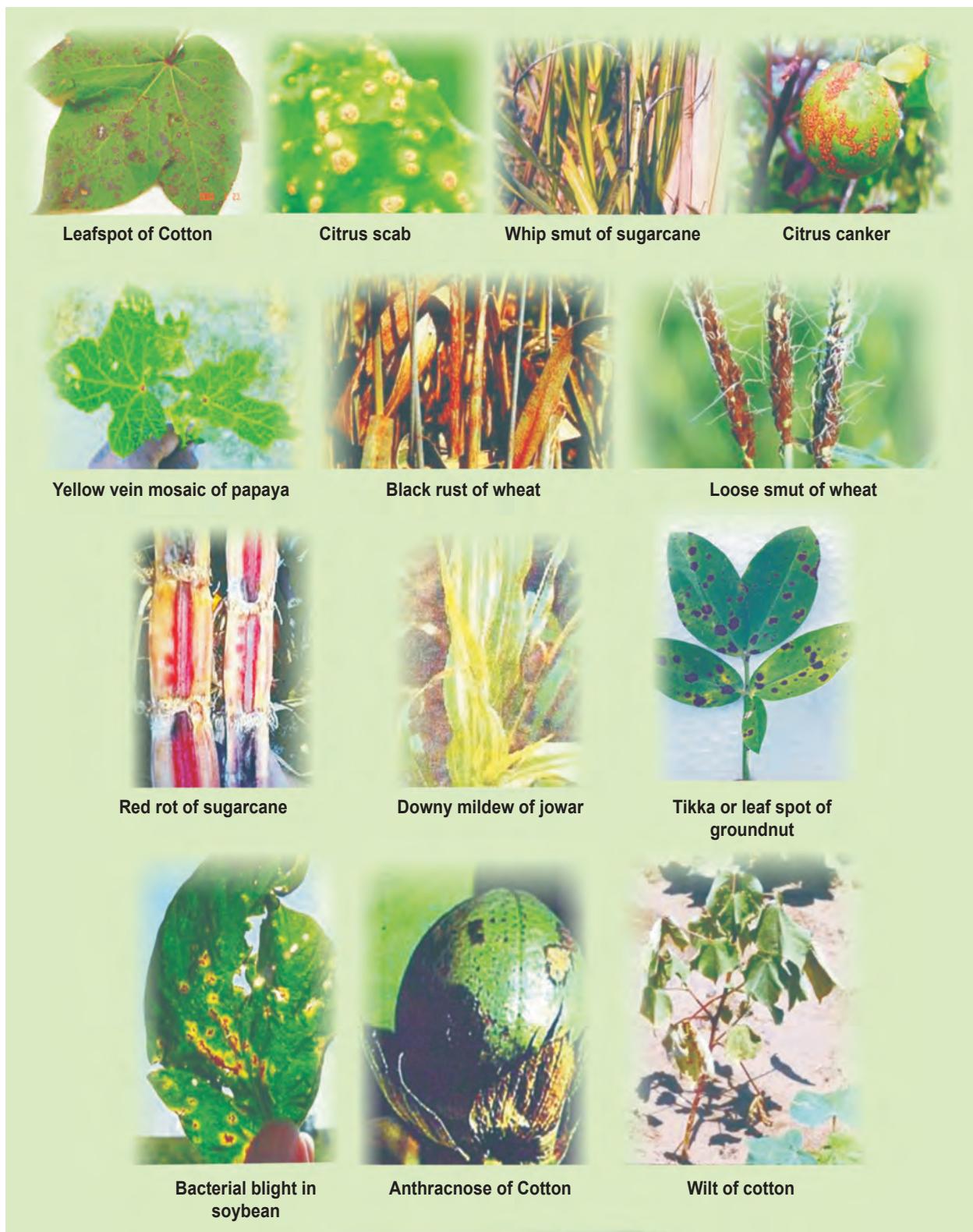
Soybean			
1	Bacterial blight	Reddish – brown spots having yellow margin appear on the leaves and pod .	Grow resistant varieties, seed treatment with fungicides like Ceresan
2	leaf spot	Brown spots appear on upper surface of the leaves and other plant parts.	Seed treatment with Thirum spray the crop with Thirum or with Dithane M-45
3	Downy mildew	On leaves upper surface small yellow spots appear which turn to brown in later stages, under side of leaves show whitish downy growth.	Seed treatment with Thirum. Grow resistant varieties.
Onion			
1	Seedling blight	Disease infection starts in early stage on leaves, yellowish or brownish patches are developed.	Spraying of 1% Bordeaux mixture.
2	Smut	It is a fungal disease. The fungus attack on young seedling, dark thickened areas on small leaves occur, leaves are swollen and dry to bent.	Treat the seed with Thirum, grow disease resistant variety, apply fungicides in furrow.
Potato			
1	Early blight	Disease infection starts in early stage, with brown spots on leaves. In severe cases leaves shrivelled and fall down	Spraying of Bordeaux mixture
2	Late blight	In later stage of crop growth it is serious disease, brown spots develop on leaves and rapidly spread on stem and tubers.	Use of disease free sets for planting. Spray Dithane Z-78
3	Ring rot (bacterial wilt)	It is bacterial disease, leaves turn yellow plants get dry, brown spot are observed when tubers are cut.	Use disease free tubers. Follow proper crop rotation.
Mango			
1.	Powdery mildew	It is fungal disease, grey white powdery patches appears on the blossom and fruit, affected panicles gets dry and turn back.	Application of Wettable Sulphur Spray Benlate 0.1 %
Pomegranate			
1	Bacterial leaf Spot (<i>Telya</i>)	Disease is characterized by the appearance of many dark coloured, irregular spots on the leaves, they drop off prematurely. The bacterial infection on fruits causes dark brown spots with an oily appearance.	Spray Dithane M 45

2	Fruit rot	The small irregular spots surrounded by greyish yellow border are observed on the fruit rind. Arils become brownish in colour.	Spray tree with Dithane M-45 at the time of fruit development at interval of 15 days.
Citrus			
1	Citrus canker	It is a bacterial disease of citrus. The lesion appears first as minute water soaked roundish spot which turns brown. Due to severe infection of leaves there may be defoliation. The lesion on fruit reduces market value of fruits.	Periodically spray Streptomycin sulphate or Bordeaux
2	Gummosis	Fungal infection starts with forming water soaked large patches on stem. These patches soon turn brown and bark may spilt, through which a gum like liquid ooze exudes.	Scraping off the infected portion Apply Bordeaux paste on the stem up to 60 cm from bottom.
3	Citrus decline (die – back)	Drying and die back of small branches and twigs begins with infection of this disease. In severe cases chlorosis and mottling is observed. Reduction in leaf size and wilting is observed. Roots become dead, the bark of larger roots is distorted and brittle.	Good drainage is beneficial for checking of disease, periodical spray against insect vector.
Coconut			
1	Bud rot	Fungal infection starts with yellowing of young leaves surrounding the spindle. The tender leaf base and soft tissues of crown rot into slimy mass.	Application of Bordeaux paste.
2	Root wilt	Yellowing and marginal necrosis of the leaflets. Nuts are smaller, kernel is thin.	Application of fertilizer along with $MgSO_4$ Grow hybrid varieties

Pest of crop plants



Diseases of crop plants



Exercise

Q. 1 A. Fill in the blanks.

1. Physiological or structural deformity that is harmful to plant or reduce its economic value is called as
2. Pyrilla is serious pest of crop.
3. Use of insecticide to control pest is method of pest control.
4. Root rot disease infection normally observed in growth stage of plant growth.
5. Infestation of bollworm in cotton is difficult to identify.

B. Make the pairs.

- | 'A' Group | 'B' Group |
|---------------------|------------------|
| 1. Soil insect | a. Aphid |
| 2. Sap suckers | b. Grain weevil |
| 3. Store grain pest | c. White grub |
| 4. Chewing insect | d. Housefly |
| | e. Boll worms |
| | f. Cutworm |

C. State true or false.

1. Paddy gall fly is important disease of paddy crop.
2. Citrus dieback is serious disease of sweet orange crop.
3. Biological control method is hazardous due to residual effect on human health.
4. Sugarcane red rot disease can be control by hot water treatment.
5. Plants protection focus only on mineral management.

Q. 2 Answer in brief.

1. Write note on pest control
2. Give examples of regular pest.
3. Write down nature of damage by white grub to sugarcane crop.
4. Give types of pest on the basis of damage.

Q. 3 Answer the following questions

1. Describe the biological method for insect pest control.
2. Classify plant diseases on the basis of symptoms.
3. State advantage of integrated disease management.
4. Write the nature of damage and control measure for citrus pest.

Q. 4 Answer in detail.

1. Describe integrated disease management
2. List out the control methods for pest and diseases and explain cultural methods.
3. State principles of disease control.
4. Explain sugarcane pest management in detail.
5. Complete the following table

No.	Name of pest	Nature of damage/symptom	Control measure
1	Citrus butterfly	-	-
2	Mango hopper	-	-
3	-	Bore holes in to bolls and after entry block it	-
4	Red rot	Red strip and rotting observed	-
5	-	-	Hot water treatment of sets.

Activity :

Practice different methods of pest and disease control whichever possible at your locality



Do you know ?

1. Can you differentiate domestic and wild animals?
2. Which wild animals are harmful for agriculture crops?

In India, wildlife protection act 1972 is in enforcement. Now a days abundant population of wild animal is found on farms and near forests. Wild animals are special challenge for farmers throughout India. Many wild animals make heavy losses to farm and farm crops. They can damage the plant parts or crop simply by running in the field or trampling the crops. Farmers suffer heavy financial losses due to wild animals. These wild animals such as wild boars, monkeys, elephants, deers, nilgai, rabbits, moles, squirrels, parrots, peacock, etc. damage the crops.

Maharashtra is a home to a large number of animals including tiger, leopard, wild boars, monkey, rabbit, crocodile, bison, gawa, nilgai etc.



Use your brain power

- What type of damage to crops and crop fields done by wild animals?
- Up to which extent damage done by wild animals?
- Collect information about wild life protection act.

For security of agricultural crops and crop fields every farmer should be aware and take into consideration the fact that animals are living beings and need to be protected from any potential suffering.

12.1 Protection from wild animals

12.1.1 Wild boars

Wild boars are unpredictable and have violent nature. Most noticeable feature of wild boar is long curved tusks. Fully grown wild boar weighs about 50 to 90 kgs. The razor sharp tusks itself is a primary weapon of wild boar. When agitated, they charge with these tusks. Sharpness of tusks and heaviness of his body could result in injuries to crop and farmer.

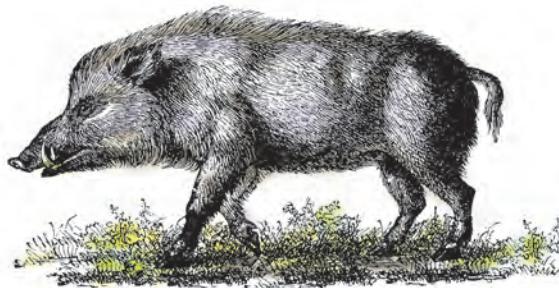


Fig. 12.1 : Wild boar



Always remember

1. Wild boars are highly adaptable to wide range of climate.
2. They are opportunistic, omnivorous. They eat mostly plant material and invertebrate animals such as worms, insects, insect larvae, etc.
3. They have high reproductive potential. They reach sexual maturity as early as six month of age and produce average about six piglets at each calving.
4. Female boar may undergo farrowing twice per year.
5. They have low natural mortality.

Nature of damage

Wild boars consume and trample crops. Uprooting of crops and wallowing in the field may creates holes (pits) that can damage farm equipments and disturb farm operation.

Control Measure

1. Trapping wild boars by box traps, cage traps, corral traps, using prebaits and baits.
2. More than 40 transferable diseases (Zonotic diseases) affects on wild boar and some extent population may suppresses.
3. Use of fences like wire fences, plastic fences, electric fences (Zatka Machine), etc.
4. Natural repellent, electronic repellent, etc are used to keep wild boars away from crops.
5. Fire crackers are also effective for keeping away to these animals.



Fig. 12.2 : Damage by boar

12.1.2 Monkeys

Near about 13 species of monkeys are found in India. They are often seen living in group of 20-30 feeding on the ground or sitting on trees.

Nature of Damage

Monkeys are the notorious wild animals causing serious damages to agricultural crops. The monkeys consume plants as food and also change their food habits with change in season. Attack of monkeys could result in severe crop damage.



Always remember

1. Most monkeys live on trees, but some live in mountain areas.
2. Monkey tribes always move to find food. They do not have stable home.
3. Monkeys are very social animals.
4. Group of monkey is called tribe or troop. A troop will work together to take care of young monkeys in the group.
5. They also like to play, cuddle and protect each other.
6. The strongest and largest male monkey is the leader of the troop.



Fig. 12.3 Damage by monkey

Control

1. Mix 1/3 cup of floor, 2 table spoon chilli powder and 2 table spoon mustard powder and sprinkle the mixture in the garden to keep away monkeys. The mixture of 4 cups of water and some vinegar can be sprinkled with pepper on vegetables will deter monkeys from eating them.
2. Small pockets of boneless dry fish pieces are made and kept around the field. After opening the pockets monkeys rub the fish with both hands. After smelling they get irritated and rub their hands on rocks and continue the operation till the blood come out from the hand. Leader of gang face the bad experience. Thus they never enter the same field.

3. The practice of driving them away by beating drums and using well trained dogs has been used since long time.
4. Catch one monkey and paint its whole body except eyes with red paint and leave that monkey in the field. Due to fear other monkeys will not enter in the field. Repeat the process when a new group enters in the field.
5. Use fire crackers (which make large sound) like rassi bomb / sutali bomb.

12.1.3 Elephant



Recall a memory

1. Which is the largest land animal on the earth?
2. Discuss type of food of an elephant.

Two types of elephants are found on earth / world i.e. African elephant and Asian elephant. Group of elephant is called a herd.

Nature of damage

Wild elephants feed on agriculture crops, seeds, barks, leaves, grasses and trees. They use their tusks to pullout the bark from trees and dig roots out of the ground. They trample crops and damage crop fields. Also elephant cause damage to crops both in pre harvest and post harvest condition.



Fig. 12.4 : Elephant



Always remember

1. They have characteristic long nose or trunk, large, floppy ears, and wide thick legs.
2. Asian elephant and African elephant live at separate continents and have many unique features.
3. The herd is led by a matriarch, which is the oldest female. The matriarch will often teach young elephants in her herd.
4. Male elephants are called bulls and females are called cows. A baby elephant is called as a calf.



Fig. 12.5: Damage by elephant

Control

1. Buzzing of the bees - Studies showed that elephants are repelled by the sound of honey bees. Therefore start bee keeping around the field, there by generate some source of extra income.
2. Noise – it is a common practice to use loud noise to scare away instructive elephants. Noise makers include fire crackers, pipe cannons, vehicle horns, and rifle shots.
3. Light – bright lights, oil lamps and fire are sometimes used along the perimeter of a farm area to scare elephant population nearby farm.
4. Smoke fire – in some areas people burn elephant dung that will smoulder and create heavy acrid smoke.
5. Hot chilli – Capsaicin spray can repel elephants. Simplest method consist of planting a row of chili around cultivated fields and gardens.

6. Elephant geo fencing – It is a means of detecting radio collared elephants that cross a virtual fence line. When an elephant with a collar passes through a virtual barrier, a message is sent to the wildlife management center along with GPS coordination. This will help them to take action against attack of elephant.

12.1.4 Deer



Recall a memory

1. What are different types of deer in Maharashtra?
2. What is the destructive role of deer in agriculture?



Fig. 12.6 : Deer



Always remember

1. Deers are included in antelope family.
2. Antlers are fast growing living tissue in the world.
3. There are over 60 different species of deer worldwide.
4. During the mating season, male deer will often use their antlers to fight and try to attract the attention of female deer.
5. Deers are present on all continents except Antarctica.

6. Length of pregnancy in deer varies according to size. Generally in large species the longer gestation period is observed.

7. Deer in tropical climate can breed all year round.
8. All species of deer have a four chamber stomach which allow them to chew the cud. This process of partial chewing food, regurgitating it, chewing it again to make easier to digest.
9. A male deer is called a buck but some larger males are called as stags. A female deer is called a doe or hind. A young deer is called a fawn.

Nature of damage

Deer frequently prefer agricultural crops rather than wild foods.

There has been surge of damage among farms and gardens. Just two deer can produce a herd of up to 35 deer in just seven years.

In addition to flower beds and vegetable gardens, corn, peas, cotton, watermelon, peanuts and gram crops experienced the most damage from deer.

Control

Wild deer can have impact on agricultural production and environment.

Main methods of wild deer control include.

1. Trapping
2. Ground and aerial shooting (it's ban now)
3. Fencing - (a) Wire fencing
(b) Plastic fencing
(c) Electric fencing (Zatka Machine)
4. Fire Crackers
5. Dogs

12.1.5 Blue bull / Nilgai

Blue bull is the largest Asian antelope and most commonly seen as wild animal in India.



Always remember

1. *Nilgai* / blue bull is indigenous deer and is currently protected under wildlife protection act 1972.
2. *Nilgai* is the largest Asian antelope.
3. Mature male appears like ox and also is known as blue bull.



Fig. 12.7: Blue bull

Nature of damage

Nilgai is highly adaptive antelope naturally diurnal. It goes for field crop grazing in the evening and night. It is also found to damage most agricultural crops. Whereas in high density *nilgai* areas, damage to wheat, gram, mung, mustard crop is caused not only by grazing but also through trampling, resting in the field and daily movements of the animals.

A major constraint on control is that the *nilgai* is an animal of considerable religious reverence as most people in affected area are religious.

Control

1. Fencing - (a) Wire fencing
(b) Plastic fencing
(c) Electric fencing (Zatka Machine)
2. Fire Crackers

3. Pet Dogs can control blue bull.

4. Beating drums

12.1.6 Wild rabbits

Wild rabbits cause severe damage to crops. The main predator of rabbits is fox, while young rabbits also fall to bird attack as prey.



Fig. 12.8 : Rabbit

Nature of Damage

Rabbits are herbivores who feed by eating weeds, grasses, clover, wild flower and vegetable plants and other crops in warmer season.



Always remember

The male is called a buck and the female a doe.

1. Rabbits are generally 40 to 45 cm in length and have ears that measures 8.5 cms long. They have compact body with long powerful hind legs.
2. The smallest pygmy rabbit have only 20 cms of body length and 0.4 kg in weight while the largest rabbits grow to 50 cms and more than 2 kgs.
3. Rabbits are abundant in grassland areas where the soil allows them to make extensive well drained burrows, where there are hedges or patches of woodland to give shelter and cover.

4. Rabbits are herbivorous who feed by grazing on grass, leafy weeds, however they also eat all vegetables.
5. Rabbit generally are able to breed at young age and many regularly produce upto 7 young ones, at about so 4 or 5 times in a year 28 to 31 days.
6. New born rabbits are naked blind and helpless at birth.
7. Mothers are remarkably inattentive to their young and are almost absentee parents commonly nursing their young only once per day and for just few minutes.
8. The milk of rabbit is highly nutritious and among the richest of all mammals. The young grow rapidly and most are grown up in about a month.

Rabbits damage is almost always the result of their appetite for plants. They eat flower and vegetable plant during spring and summer and the bark of fruit and ornamental trees and shrubs in fall of winter.

Control of wild rabbits

1. Traps and snares – use of cage traps, drop box traps or spring traps. Place them where they will be exposed to severe weather. Place them near a fox earth or badger sett. Use self locking snares. Use only approved traps.
2. Fencing – use of cotton wire nets, strained wire (similar to the kind user to manage cattle and sheep) permanent wire mesh netting.
3. Ferreting - a domesticated polecat used for catching rabbits.
4. There are three types of fencing for controlling.
 - (a) Electric netting
 - (b) Electric strained wire (similar to the kind used to manage cattle and sheep)
 - (c) Permanent wire mesh netting
5. Baiting is the most cost effective way to reduce rabbit populations. e.g. 1080 (Sodium fluoroacetate) rabbit bait is available.



Electric Fencing

Exercise

Q. 1 A) Fill in the blanks.

1. Wildlife protection Act is in force since _____.
2. _____ are unpredictable and has violent nature.
3. According to feeding habit rabbit is _____ animal.
4. Group of monkey is called _____.
5. The herd is led by a _____ which is the oldest female

(B) Make the pairs.

- | A | B |
|----------------------|-------------|
| a. Razor sharp tusks | 1. Monkey |
| b. Antlers | 2. Elephant |
| c. Big ears | 3. Deers |
| | 4. Boars |
| | 5. Rabbits |

(C) State true or false.

1. Male rabbit is called a buck and the female a doe
2. Boar has a long straight tusks.
3. Fire crackers are also effective for keeping away the wild animals.
4. Monkeys are not very social animals.
5. Monkeys consumed plants for food and change their food habits with change in season.

Q. 2 Answer in brief.

1. Write note on deer.
2. Why monkeys are lived in troops?
3. Give difference between deer and nilgai.
4. Write short note on elephant herd.
5. Write the nature of damage of nilgai?

Q. 3 Answer the following questions.

1. Which are the wild animals who causes serious problem to agri. crops?
2. Give control measures for wild boar.
3. What are the characteristic of the monkey ?
4. Explain nature of damage by elephant.
5. How will you control farm and crops from blue bulls ?

Q. 4 Answer in details.

1. Explain wild animals control strategies in detail.
2. Give nature of damage and control of elephants.
3. Give information about wild deer and their control.
4. Give information about rabbits in detail.
5. Give information about nilgai in detail.

Activity :

Collect the information about different wild animals causing damage to field crops.



Recall a little

- Already you know the food and also the waste that we generate
- The prime object is to understand the waste and the volume generated

13.1 Scenario

Waste management is the study of knowing waste generation, collection, transport, processing, recycling or disposal and monitoring waste material. Food supply and waste management are the emerging challenges for the policy makers and industries in the processing and food supply. The global population is expected to grow upto 9 billion and demand for food is about 77% by 2050. Over the same period, food production will be under threat from climate change, competing land uses, and erosion and diminishing supplies of clean water. The food which we consume has to undergo a series of food processing operations soon after harvesting at the farm industry level.

The agro-food industry generate huge amount of waste material annually around the globe from a variety of sources. Food is a basic need of human beings, while food waste has been identified a major crucial challenge faced by human community today.

Over 4.2 million tons of food waste is dispersed to landfill in Australia each year. 2.7 million tons of this is from households and around 1.5 million tons of this is from commercial and industrial sector, costing around \$ 10.5 billion in waste disposal charges and waste product. The largest single contributor in the commercial and industrial sector is food service activities.(e.g. - cafes, restaurants, fast food outlets), which generate 661,000 tons of food waste per year, followed by manufacturing (312,000 tons) and food retail (179,000 tons).

Most waste in food manufacturing is unavoidable, and almost 90% is already recovered as animal feed, compost or bio-energy. Presently, around 21,000 people die every day due to hunger related causes and globally one in nine people go to bed each night hungry. Nevertheless, approximately one third of all the food produced goes to landfill as waste. The vast amount of food ending up as waste is not only a humanitarian problem but also serious economic, nutritional and environmental pollution problem.

13.1.1 World situation

At global statistics, according to the British Institute of Mechanical Engineers (IME) half of the food produced is wasted worldwide at different stages. The global volume of the food wastage has been reported to around 1.3 billion tons. The total volume of water used each year to produce food that is lost or wasted i.e. equivalent to the annual flow of Russia's Volga river or three times the Lake Geneva. Similarly, 1.4 billion hectares of land 28% of the world's agriculture area is used annually to produce food that is lost or wasted . About \$ 165 billion worth of food waste enters landfills each year.

World environmental problems

Population growth contributes to GHG (Green House Gas) emission through its effect on deforestation as land is grabbed for enhancing food production. As the world's population grows and becomes more affluent, waste production rises and might double by 2025. According to the US Environmental Protection Agency (EPA), food wastage currently represents the single largest type of waste entering landfills. Wasted food leads to over utilization of water and fossil fuels and to increase greenhouse gas emission i.e. methane

and carbon dioxide arising from degradation of food in landfills.

Therefore, the environmental impact of food waste is two fold

1. It is associated with the depletion of natural resources used for its production (e.g. soil water).
2. It relates to the costs associated with waste disposal.

There is a growing awareness needed to minimize the amount of food waste at the end of the food supply chain- an issue particularly relevant in high-income countries where more than 40% of the food losses occur at retail and consumer level.

3. Globally per capita food waste by consumers amounts to 95-115 kg/ year in Europe and North America compared to 6-11 kg/year in South or South East Asia and Sub-Saharan Africa.
4. Food waste reduction at the consumption level represents indeed a large target for medium and high income countries, where evidence shows that the main source of the problem is the domestic setting.

13.1.2 Indian condition

In India, according to UN Development Program, 40% of the food produced is wasted at pre and post-harvest stages. According to Government of India's resources, about Rs. 58,000 crore worth of food is wasted every year. About 25% of fresh water used to produce the food is ultimately wasted. On the other hand millions of people still don't have access to drinking water. About 300 million barrels of oil are used to produce the food that is ultimately wasted. As a result, a large quantity of food is wasted and being thrown away around the world, on the other hand, a child dies every five seconds because of hunger. In terms of food waste, agricultural produce, meat, poultry and milk, India ranks seventh, with the Russian Federation at the top in the list. India's major land is under agriculture hence, there is highest wastage of cereals, pulses, fruits and vegetables.

Meat accounts for just four percent of the food wastage but contributes 20% of the economic loss of the wastage. Wastage of fruits and vegetables is 70% of the total produce, but translated into only 40% of the economic losses. Also, rice crop emits methane, a potent global warming gas, because of the decomposition of organic matter in submerged paddy fields. Food loss and waste costs the world about \$ 940 billion a year.



Can you recall?

- The volume, effect and consequences of waste.
- Which industry has the potential huge generation of waste.

However, the utilization or disposal of food waste is difficult due to its inadequate biological stability, potentially pathogenic nature, high water content, potential for rapid autoxidation, microbial decomposition through high level of enzymatic activity.



Can you tell?

- What are the consequences and health hazards of waste?
- What is the environmental impact of waste?

13.2 Types of waste

13.2.1 Solid waste (Organic and inorganic)

Sources- domestic waste, factory waste, waste from oil industry, e-waste, agricultural waste, food processing waste, variety of plastic based waste, packaging material (industry and domestic waste), etc. Out of the total solid waste generated, 44% is wet organic.

13.2.2 Wet waste

- (a) Kitchen waste (food waste, cooked and uncooked food, egg shells, meat and bones, fish, fruit and vegetable inedible portion, etc.

- (b) Flower, fruit and vegetable waste
- (c) Garden, tree, leaves, branches, straw, trash waste
- (d) Sanitary waste (drainage waste)
- (e) Food industry waste (raw materials and finished goods)
- (f) Food waste (left over, stale, spoiled food)
- (g) Wet garbage and industry (sewage) waste

13.2.3 Dry waste

- (a) Paper, plastic (all kinds), laminates, foils
- (b) Card boards, cartoons, packaging, glass bottles, metal tins and containers, strappings, foils, rags, rubber, houses, pipes, sweepings, ashes, wrappings, discarded clothes, etc.

13.2.4 Domestic Hazardous waste

- (a) Compact florescent lamps, tubes, glasses, batteries, etc.
- (b) Chemicals, detergents, etc.

Non-hazardous waste

Glass bottles, iron containers/ wares, plastic bottles/ wares and materials

13.2.5 E –waste

E- wastes are the electronic equipment / products that connect with power plug, batteries which have been become absolute due to

- advancement in technology.
- changes in fashion, style and status.
- nearing the end of their useful life.

Food waste from different food groups

- Cereals (grains), pulses, fruits and vegetables, meat, dairy products, marine, sugarcane, winery, plantation by-products, slaughter house, canning industry, etc.
- Wastes are untreated and underutilized; therefore its disposal is widely adopted through burning, dumping or land filling.
- Juice industry produces a large amount of waste as peels, pulp, seeds, fiber, etc.
- Fruit and vegetable processing industry waste.



Can you recall?

- Identify the reasons of food losses.
- What do you mean by lost / waste food.

13.3 Reasons for losses

Following are the main reasons for losses in different areas, thereby generating different kinds of waste.

Table 3.1 : Major processed food and types of waste generated

Sr. no	Food crop	Food product	Waste
1	Rice, wheat, corn	Grain, flour, bread, biscuits, roti, cake, starch, flakes, bakery products, etc.	Straw, stem, leaves, husk, comb, hulls, fibers, brans, germ, gluten, fodder , etc.
2	Fruits and vegetables	Juice, pulp, preserved products, vegetable oil, potato products, fruits, roots, tubers, bulbs, sugar dehydrated, pickles, fermented products , etc.	Rotten fruits, vegetables and their parts, pomace, skin, seed, stones, fibers, etc.
3	Fish and sea food	Canned, salted fish, smoked fish, processed form, dehydrated, frozen , etc.	Scales, fins, shells, bones, guts, fish oil, skeleton, etc.
4	Meat and poultry	Processed meat (beef, pork, poultry, eggs and their products)	Blood, hairs, head, skin, horn, bones, carcass, fat, feet, guts, large intestinal parts, etc.

5	Dairy products	Milk, butter, cheese, milk powder, cream, ghee, paneer, ice cream, etc.	Whey, processed water, solids, waste material, effluents, etc.
6	Beverages	Cocoa, coffee, tea, fruits, alcohol (wine), molasses, grain based alcohol, etc.	Shells, seed coat, molasses, sewage water, etc.
7	Oils	Oil, hydrogenated fat, fatty acids, etc.	Oil cakes, solid impurities, water effluents, rancid spoiled seeds oil, etc.
8	Sugar	Sugar, jaggery, confectionary, etc.	Solid wastage, sugar industry effluents, waste, etc.

- Agricultural production:** Destruction from insects, pests, diseases, inappropriate crop cultivation practices, changing agro climatic conditions, not meeting the quality specifications, low yielding varieties, lack of inputs, poor crop yield due to drought and natural calamities, etc.
 - Post-harvest handling and storage practices:** Not meeting the specifications for quality and/ or poor or lack of post-harvest handling, packaging, storage facilities may lead to damage due to insect, pest, spoilage, germination and degradation (lack of pack houses, packaging materials, pre-cooling facilities, storage and transport facilities (cold chain, cold storages, poor supply chain management, etc.)
 - Lack of primary processing and packaging facilities:** Inadequate infrastructure such as godowns, ware houses, cold storages for perishable commodities, referred vans for high value commodities like grapes, strawberry, broccoli, milk and milk products, poultry, meat, fish, etc. These operations create trimmings and other food preparation waste. Inedible portions, wet or dry material, their storage and transport or proper utilization at proper stage. Wet or dry garbage may create severe problems of their proper disposal, failure may create air pollution and health hazards.
 - Distribution and logistics (wholesale and retail):** Damage or loss of food in transit/ storage due to packaging failures, shelf life of processed / fresh food commodities, poor road facilities, transit storage (warehouse/ cold storage) at the port or metro cities hub. Packaging failures, product spoilage, fresh produce (perishable), etc. may get damaged during handling, storage and distribution, short shelf life hence low sales.
 - Food service sector:** Food wastage generated in the hotels, restaurants, institutional kitchens, poor management of such wet food wastages, their packaging, boxes, plastics, improper food handling, left over or stale food items.
 - At home:** Trimmings, cuttings, peels, stones, seeds, and other food preparation waste, damaged or spoiled food items, preparing too much food, leftover food, improper stored food and food items. The overall food loss and wastage costs the world about \$ 940 billion a year. The food losses are reported to be higher in developing countries than the developed nations. However to overcome and handle the food wastage problem is a huge challenge and task all over the globe.
- In USA alone, annually people throw away 30% of the food produced which corresponds to 40 billion liters of water.

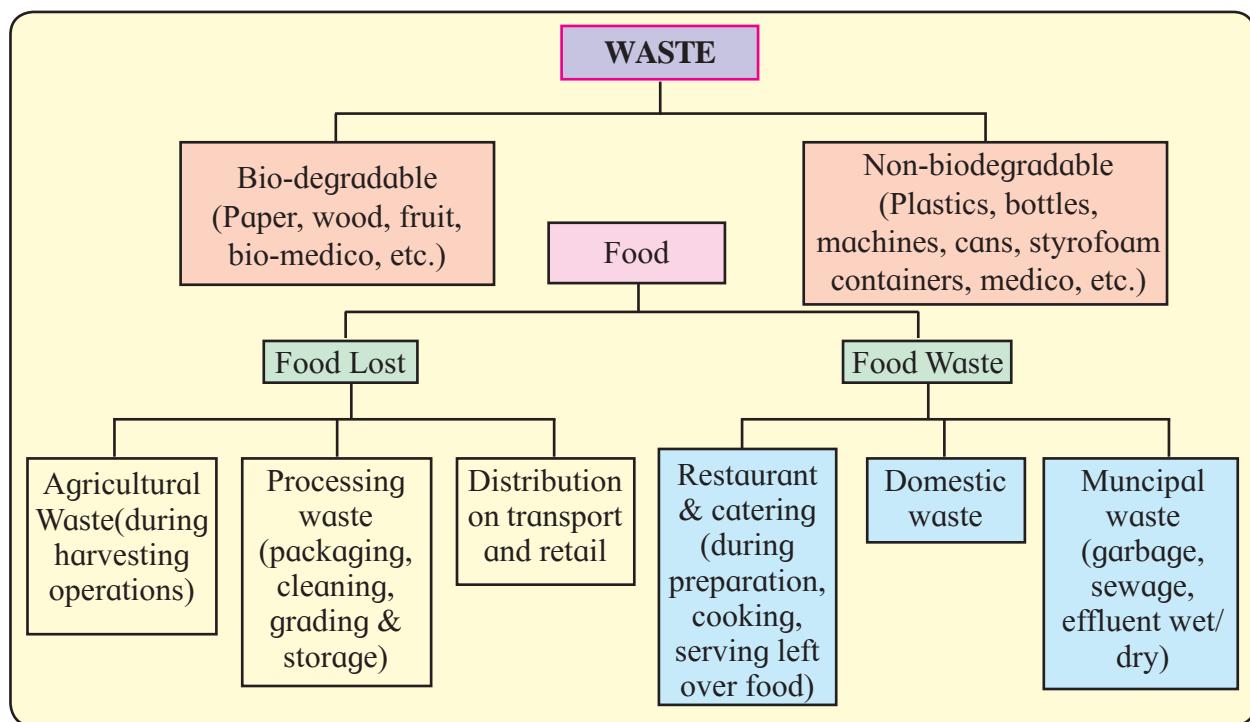
Whereas in UK, the household waste estimated to be 6.7 million MT from purchased goods. This means that approximately 32 % of all food purchased every year is not eaten. Most of this (5.9 million MT or 88%) is currently collected by local authorities. Most of the food waste (4.1 million MT or 61%) is avoidable and could have been eaten if had been better managed.

- The annual food losses and waste are estimated to be about 30% for cereals, 40-50% for root crops, 30% for fish and 20% for oilseeds and meat.

- On globe scale, just 43% of the fruits and vegetables produced are consumed and the remaining 57% are wasted.
- Food waste accounts for roughly US \$680 billion in industrialized countries and US \$ 310 billion in developing countries.
- Roughly one-third of the food is lost or wasted that translates into 1.30 billion MT each year worth nearly one trillion US dollars and equivalent of 6-10 % of human generated greenhouse gas emission.

13.4 Sources of waste

The following are main categories of waste generated.



13.5 Measures of Waste Management

- Effective supply chain management practices to fresh agro produce (fruits and vegetables, dairy products).
- Reduction in food wastage (at processing, storage, distribution)
- Improvement in post-harvest handling practices, transport, storage and distribution of food through appropriate technologies (cold chain, improved packaging, etc.)
- Value addition of the by-products generated in the food industry
- Quick and appropriate disposal of food industry wastage, garbage, effluents, sewage, etc.
- Food lost or wasted should be discarded to avoid environmental pollution (each year it accounts for 3.3 billion tons of Carbon dioxide emission globally)
- Government and Community must work collaboratively to achieve policy of zero waste or policy “No to food waste”.

- The agro-industrial residue have high nutritional potential, therefore it can be utilized for production of a variety of by-products, chemicals or any suitable disposal.
- Conversion of waste into valuable product through biodegradation/ decomposting.
- Fermentation of the solids/ semi-solid waste.
- Formation of ‘Food Banks’ and its timely distribution to the needy/ hungry population
- Bio gas (fuel gas) production
- Composting through earthworms/ microbes into manure.

13.5.1 Methods of waste management

The waste material generated at different sources is disposed by various methods; however some of the important methods are given below-

- 1. Landfills :** Throwing daily waste/ garbage in the landfills is the most popularly used method of waste disposal used today. The waste is buried in the land; It is most easy and economical method. Landfills are commonly found in developing countries, Landfills give rise to air and water pollution which severely affect the environment and can prove fatal to the lives of humans and animals.
- 2. Dumping :** The city garbage and waste in many countries is practiced to collect through garbage collecting vehicles and dumped in open baren space, lying there for many days. Some times it is covered or capped firmly by sheet, so as to avoid the air pollution. It will promote anaerobic fermentation by bacteria and thereby the decomposition and disposal is carried out. After a year or so the decomposed mass is used as manure in the field crops. It requires huge area and long time process, may lead to heavy environmental pollution during rainy season.

- 3. Incineration / combustion :** It is a type of waste disposal method in which municipal solid wastes are burned at high temperatures of as to convert them into residue and gaseous products. The biggest advantage of this method is that it can reduce the volume of solid waste to 20 - 30 % of the original volume, decreases the space to take up reduce the stress on land fills. The process also known as the thermal treatment. Where solid waste materials are converted by incineration into heat, gas, steam and ash. It is adopted in Japan as the landfill space is no longer available.

- 4. Recovery and recycling :** Recovery is the process of taking useful from the discarded items for a specific next use. The discarded items are then processed to extract or recover materials and resources or convert them to energy in the form of useful heat electricity or fuel (co-generating plant of sugarcane factory).

Recycling is the process of converting waste products into new products. Recycling is the third component of reduce, reuse and recycle waste hierarchy. The idea behind recycling is to reduce energy usage, reduce volume at land fills, reduce air and water pollution, reduce green house gas emission and preserve natural resources for future use.

- 5. Composting :** Composting is the process of reducing vegetable and animal refuse or farm waste. Composting is a easy and natural bio-degradation process that takes organic wastes i.e. parts of plants, garden, kitchen waste and turns into nutrient rich manure for plants, composting, normally used for organic farming, occurs by allowing organic materials to sit in place for months until microbes decompose it. Composting is one of the best methods of waste disposal as it can turn organic products into sage compost. On the other side, it is slow process and takes lot of space.



6. Vermicomposting : It is ideal for biodegradable waste from kitchens, hotels, municipal, waste, etc. A barrel or pit is provided in which the macerated moist waste mass is dumped and mixed with earthworm culture. Then it is moistened, covered, sprinkled with water intermittently and kept closed for about 30 days. The compost is taken out in dry form, sieved and then used as manure.

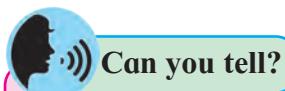
The same mixture is used as earthworm culture which can be used for next lot. Sometimes, microbes also added in the pit or drum to hasten the decomposition process.

7. Farm Yard Manure (FYM) : It is the method of composing farm waste. FYM is the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. A rectangular pit is dugged and filled with the above trash material plastered with cow dung earth slurry. The manure becomes ready for use in about 4-5 months after plastering. FYM is the most commonly used organic manure in India.

8. Sewage and sludge : The solid portion in the sewage is called sludge and liquid portion is sewage water.

9. Mechanical composting : The process of stabilization is expedited by mechanical devices of turning the compost which stabilizes in about 1 to 2 weeks. To enrich, night soil and cow dung are added to the refuge. Usually done in compost pit. which requires excess moisture. The process carried out by micro-organisms within 30 days.

10. Biogas : The farm waste, food industry waste municipal wet waste is disposed by decompositing the wet waste along with cow dung in a close chamber known as bio-gas plant. During the process the cellulose material is decomposed by the bacteria from cow dung slurry and anaerobically methane gas is released, which is used as



How the waste is disposed off efficiently.

fuel for lightening and cooking purposes. The slurry coming out of the plant is dried and used as farm manure. Big size plants are seen in many municipal areas and at rural areas at domestic level.

13.6 By - products of waste

By-products resulting from processing of papaya, pineapple and mango represent approx. 10 – 16% of fruit weight. In case of citrus fruits, amount residues accounts for about 50% of the original fruit weight. Seeds constitute considerable proportion of grape ranging from 38 -52 % on dry mater bases.

- **Pineapple pomace** has good nutritive value, rich in dietary fibers, contains Calcium, Phosphorus and Iron. About 25% of fresh fruit is lost as pomace. Pomace contains about 1.8% ash, 21.5mg / 100gm ascorbic acid and 0.41 % crude fiber .
- **Pomegranate peels** contain 249.4mg/gm. of phenolic compounds as compare to only 24.4 mg/gm of phenolic compounds found in the pulp of pomegranate.
- **Banana peels** constituting about 40% of total weight of fresh banana as a major waste. It is rich source of starch (3%), crude protein (6-9 %) total dietary fiber (43.2-49.7%) and crude fat (3.8-11.0%). Banana peels is a good source of micronutrients (K, P, Ca, Mg) PUFA (linolenic acid and alpha linolenic acid) and essential amino acids (leucin, valine, phenylalanine, threonine). Moreover significant amount of lignin (6-12%) pectin (10-11%), cellulose (7.6-9.6 %).
- During **tomato processing**, about 3-7% of the raw material is lost as waste. Tomato pomace generally consists of the crushed dried skin and seeds of the fruit. Appropriately, the seeds account for 10% of fruit and 60% of the total waste.

The seeds are reported to be good source of protein (35%) and fat (25%). Tomato seed oil is found to be rich in unsaturated fatty acids such as linolenic acid that has largely attracted the interest of researchers. As compared to seeds and pulp, the tomato peel contains higher levels of total flavonoids, total phenolic compounds, lycopene and ascorbic acid exhibiting higher antioxidant activity.

- **Carrot pomace**, generated during processing, contains 14.75% soluble fiber, 30% insoluble fiber, 6.50 proteins, 5.12% ash, 5456 µg total carotenes and 607 µg β-carotene.
- **Chemically, the agricultural wastes** contain 31-60% cellulose, 11-38% pentosane and 12-28% lignin. This product has been reported to be used in the alcohol production. Fruits are very rich in sugar content which can be a very good source of alcohol production.
- **Grape and wine making** industry generate a number of waste and by products. These material include wine pruning, grape stalks, grape pomace, grape seed, yeasts, tartrate, carbon dioxide and waste matter, every by- product will become fertilizers, animal feed or fuel. The grape seed extracts have gained ground as nutritional supplement in view of its antioxidant activity.

Enzyme production

Grape pomace, main polluting waste from the wine industry, is a good natural medium for solid state fermentation that is used for production of hydrolytic enzymes such as cellulases, xylanses, and pectinases using *Aspergillus awamori*. Proteolytic enzymes such as bromelain is recovered from pineapple pomace and papain from papaya latex. Moreover, orange peel and orange finished pulp, sugarbeet pulping and peas waste are good substrates for polygalacturonase production.

Apple pomace, a waste from the apple processing industry is also used as a substrate for pectinase production by *aspergillus spp.* in solid state fermentation.

Pectin production

Pectin a heteropolysaccharide having properties like capacity to make gels, emulsify and stabilize. The major waste during processing is peel (citrus) which is widely used for the producing pectin powder; other sources of pectin are mango peels, residue of sunflower and guava. Many researchers have given the detail information about utilizing waste of fruit and vegetables. Apple peel, pomace for pectin, guava peels for preparation of guava cheese, water melon rind for pickle making, jackfruit for pectin, pineapple for vinegar production, limes for citric acid, seeds for oil, orange, lime peel can be used for extraction of essential oil, Citrus oil/ orange oil. Banana pseudostem, leaves for preparation of paper pulp and banana fiber (for clothes), green papaya for latex and tutti frutti preparation, other waste and garbage can be used in feed or decomposition of compost manuring.

1. Salad dressing- orange peels and orange waste pulp.
2. Yoghurt- added with grape pomace extract for enrichment of bioactive compound.
3. Grape seed oil rich in polyphenols, antioxidants and vitamins used in cooking oil.
4. Mango stone kernel oil/ fat to be used as cocoa butter equivalent.
5. Pulpy waste in ethanol production by fermentation.
6. Tomato pomace can be used in extruded products.
7. Others for recovery of fiber, vitamins, β-carotene.
8. Natural colouring agents- beetroot (red), leaves (green), paprika (chilli powder),

- turmeric (yellow), carrot (orange red), kesar (pink-yellow), radish (anthocyanin).
9. Brewery and wine industry waste- the brewery industry waste are the spent grain, the trub, and the residual yeast. Brewer spent grain (BSG) is the main by-product of brewing industry representing approximately 85% of the total.

13.7 Consequences of waste

1. Wastage of valuable bulk.
2. Loss of bulk nutrients.
3. Loss of functional nutraceuticals nutrients (natural ingredients/ nutrients).
4. Severe problem of their disposal, transport, movement.
5. Being wet/ perishable likely to undergo fermentation quickly; need to provide additional attention.
6. Emission of toxic as well as green house gases (CO_2 , CO, methane), microbes, when wasted food is kept open as such or buried in landfills.
7. Air, water, atmosphere get severely polluted due to improper disposal.
8. Loss of energy, manpower, water, land, etc. for growing of the food being lost.
9. Heavy financial loss to the community/ government on disposal.
10. Loss of soil fertility (that soil remain as waste land).
11. Food industry causes health hazards and air pollution to human beings.



Garbage Collection Machine

Exercise



Q.1 A. Fill in the blanks.

1. Disposal of food waste is difficult due to its -----.
2. Wasted food is generated because of over utilization of -----.
3. Major reason for food losses is -----.
4. The example of solid waste is -----.
5. Cheapest method of waste management is -----.

B. Make the pairs.

'A' group	'B' group
1. Dry waste	a. CD
2. Wet waste	b. Food powders
3. E-waste	c. Plant Trash
4. Agri-waste	d. Fruit peels and pomace
5. Municipal waste	e. Machines
	f. Water
	g. Garbage

C. State true or false.

1. Wet garbage is useful for environmental pollution.
2. E-waste disposal is easy for landfill.
3. Fruit pomace are used for production of chemicals.
4. Burning of waste is the most beneficial method.
5. Domestic waste is disposed by land filling method.

Q. 2 Answer in brief.

1. Give various sources of food waste generated.
2. Give example of food waste generated.
3. Discuss any two methods of waste management
4. Give a brief account of pectins.
5. What do you mean by waste management?

Q. 3 Answer the following questions.

1. Explain composting method of waste management.
2. Write in brief about wet waste.
3. Complete the following chart.

Food	Food product
Rice	
Fruits	
Fish	

Q. 4 Answer in detail

1. Explain in detail production of various enzymes from food waste.
2. Give the various consequences of waste generation.
3. Complete the following chart

Food	Waste
Meat and poultry	
Dairy products	
Beverages	
Oils	





Can you recall?

1. Any garden plant that you have seen before.
2. Why the fruits are eaten by human being since ancient time?

14.1 Definition and branches of horticulture

14.1.1 Definition :

The word Horticulture is derived from the Latin words *hortus* and *colere* meaning garden and to cultivate, respectively.

Horticulture is a part of plant agriculture which is concerned with cultivation of garden crops.

Garden crops traditionally include fruits, vegetables, ornamentals, spices, plantation crops, flowering plants, medicinal plants and aromatic plants.

Horticulture can be defined as the branch of agriculture concerned with intensively cultured plants directly used by people for food, medicinal purpose or aesthetic gratification.

14.1.2 Branches of horticulture

Horticulture is a wide field which includes numerous crops (groups) having great diversity.

Following are the branches of Horticulture

- (1) **Pomology** - Study of fruits (*Pomam* means fruit and *logy* means science)
- (2) **Olericulture** - Study of vegetables (*Oleries* means pot herb)
- (3) **Floriculture** - Study of flowers, ornamental plants and landscaping.

In addition the following are the classes of horticulture -

- (1) **Plantation crops** - Study of crops grown on large area for commercial uses.

(2) **Spice crops** - Study of crops grown for their spicy taste and flavour. (used in food preparations)

(3) **Medicinal and aromatic Plants** - Study of plants having medicinal property.

(4) **Post harvest technology** - Deals with post harvest handling, grading, packaging, storage, processing, value addition, marketing, etc. of horticultural crops.

(5) **Plant propagation** - Deals with propagation of horticultural crops and their nursery.

Landscape gardening is an art of beautifying a piece of land with garden design, methods and plant material



Remember this

India is the second largest producer of fruits after Brazil.

India ranks second in vegetable production after China.

14.2 Importance of horticulture

- (1) **Economic** - Horticultural crops especially fruits, vegetables and plantation crops are more and prolific yielders. Spices, medicinal, aromatic and floricultural crops are high value crops. These crops fetch more price in the market. These crops yield more per unit area and are grown with different objectives on different fields. Horticultural crops are useful for improving economic, health and nutritional status of the farmer.
- (2) **Employment** - These crops are labour intensive. Horticultural crops are delicate and tender in nature hence they require utmost care at each stage of production which increases requirement of man days.

Area	Man days for cereals per year	Man days for fruit production per year
1 hectare	143	860 for fruits 1000 to 2520 for grape and banana



Always remember

Sr. no.	Nutritional item	Rich source
1	Vitamin A	Mango, Papaya, Carrot, Drumstick leaves
2	Vitamin B	Cashew nut, Walnut, Colocasia leaves
3	Vitamin C	Aonla, Lime, Guava, Coriander leaves
4	Carbohydrates	Banana, Dates, Sweet Potato, Potato,
5	Protein	Almond, Pea, Cowpea, Beans
6	Fat	Walnut, Avocado
7	Fibre	Amaranth, leafy vegetables
8	Calcium	Litchi, Curry leaves, Fenugreek, Cucumber
9	Phosphorus	Cashew nut, Walnut
10	Iron	Karonda, Dates, Spinach

(3) **Industrial** - Horticultural plants supply raw material to the industry directly or indirectly. A vast industrial development is observed in area growing horticultural crops. Manufacturing of processed fruit products, edibles, cosmetics, medicines has shown improvement in recent years in India.

(4) **Religious and sacred value** - Horticultural plants have religious value to their leaves, flowers, fruits, roots, plants, etc. and are used in many religious functions.

(5) **Food and nutrition** - As a source of carbohydrates, proteins, fats, fibre, vitamins and minerals, some horticultural crops have high food value. These act as alternative for the conventional food. Further processed product of these crops show high nutritional value. Consumption of adequate amount of fruits and vegetables helps in maintaining health, vigour and resistance of human body.

14.3 Scope for horticulture :

Areas in horticulture having scope for future prospects-

- Hi-tech Horticulture** : Technology for intensive production system, including ethnic and exotic crops.
- Microirrigation** : For saving water and giving enough water thereby bringing more area under cultivation.
- Use of plastic** : For cultivation practices (Poly house, mulching) and post harvest handling.
- Protected cultivation** : For production of high value crops under controlled conditions.
- Precision farming** : Emphasis on maximum precision in production, minimizing wastage of inputs and resources.
- High density planting** : High yield from same piece of land.
- Integrated nutrient management** : Use of organic and inorganic sources enabling better availability of nutrients in the soil.
- Integrated pest management** : Use of different methods in of pest control combination so as to minimize use of hazardous chemicals.

9. **Mechanization** : Reduce agriculture labour, fast field operations, easily handling huge area.
10. **Organic farming** : Increasing demand for safe and natural food providing natural inputs.
11. **Contract farming** : Economic liberalization process leads to efficient changes in marketing strategies of agriculture produce.
12. **Export - Import trade** : Showing continuous growth in export of horticultural produce and import of certain commodities better assured market for agri-horti produces.

Table : 14.1 Comparison of Area, Production and Productivity of horticultural crops

Crops	Particulars	1991-92	2016-17
Fruits	Area in 000 ha	2874	6480
	Production in 000 MT	28632	92846
	Productivity in MT/ ha	9.96	14.33
Vegetables	Area in 000 ha	5593	10290
	Production in 000 MT	58532	175008
	Productivity in MT/ ha	10.47	17.01
Flowers and Aromatic	Area in 000 ha	106	943
	Production in 000 MT	535	3277
	Productivity in MT/ ha	5.05	3.48
Plantation crops	Area in 000 ha	2298	3677
	Production in 000 MT	7498	16897
	Productivity in MT/ ha	3.26	4.59

Spices	Area in 000 ha	2005	3535
	Production in 000 MT	1900	7077
	Productivity in MT/ ha	0.95	2.002
Total	Area in 000 ha	12770	24925
	Production in 000 MT	96562	295164
	Productivity in MT/ ha	7.56	11.84

Information from NHB data, (2018)

14.4 Planning and layout of orchard :

14.4.1 Selection of site: Selection of site is of paramount importance in horticultural crops. Mistake committed at the initial stage is difficult to rectify at the latter stage.

Factors to be considered while selecting suitable site for growing horticultural crops are,

1. The site should be in a favorable fruit region.
2. The site should be free from stagnation of water during rainy season.
3. The climate should be suitable for the fruit crop chosen.
4. Sufficient supply of good quality irrigation water throughout the year.
5. Suitability of soil, its fertility, the nature of sub soil and depth.
6. Along with irrigation facilities proper drainage arrangement should be made.
7. Supply of electricity.
8. Nearness to the city or market so that other special problems can be solved. Otherwise site should be connected with good road.
9. Nearness to the horticultural industry already established so that grower can get technical guidance and co-operation
10. Availability of skilled labour at cheaper rate.
11. Nearness to the processing industries and cold storage facilities.



After selecting a site, taking into consideration, the above criteria, land is levelled, brought to fine tilth. Different plots are made as per the layout, sufficient space given for roads and path, irrigation channels are prepared, provision of adequate drainage and wind breaks are made around the orchard.



Keep in mind

- a. Careful plan of orchard is necessary for utmost economic and efficient management
- b. Attractiveness
- c. Economic use of labour
- d. Location of roads, drainage, irrigation channels, path, hedges, and wind breaks.

14.4.2 Layout of orchard

While preparing plan of a big orchard, following points are highly essential.

1. Optimum spacing to grow optimum number of trees per unit area.
2. Farm buildings should be at entrance of the orchard or centre or at high level for thorough supervision.
3. Do not plant large trees with small trees.
4. Planting fruit trees according to their soil requirements.
5. Irrigated trees should be near the source of water.
6. Evergreen trees should be at front and deciduous crops should be behind.
7. Trees having big canopy should be on the back side and trees with less canopy should be in front.
8. Fruits attacked by birds and animals should be close to the watchman shed.
9. Pollinator should be provided to self incompatible fruit trees e.g. ber, mango, etc.
10. Those crops require equal spacing should be grouped in one blocks.



Remember this

Orcharding refers to growing of fruit plants in an orderly manner and maintain them for successive economic returns.

Garden refers to fruit farm where sophisticated agro techniques are employed for commercial cultivation e.g. Grape garden.

14.4.3 Development of new orchard

Fencing

Fencing is essential to prevent destruction of the trees from stray cattle and also to protect the orchard from stress passing. It is necessary to provide some kind of fencing on all sides of the garden and this should be done preferably before planting the fruit trees. Fencing helps to mark the borders of the orchard. Fences may be live or can be made using thorny and dead bushes, but these are not satisfactory and require frequent repair and replacement (e.g. chilar, sagargota) Barbed wire fencing is very good but its initial cost is rather high.

Types of fencing

There are two types of fencing used for protection of orchard.

1. Live fencing 2. Non-living fencing

1. Live fencing - The cheap and best protection is planting of live fence. Some of the plants are very useful as live fence.

1. *Prosopis juliflora* (vilyati Babhul) and *Caesalpinia sepiaria* (Chillar):- These can be established in May - June. The seed should be sown in a trench 30 cm wide and 22.8 cm deep all around the orchard boundary.

2. *Carissa carandas* (Karonda): This makes an effective dense hedge. In addition it bears fruits if not pruned too closely.

Other plants used for live fence are *Lantana camera* (Ghaneri), cacti, Coenel, Dedonia, mendhi, casurina (Khadsarni, sher), Adulsa, Shendri, sagargota, etc.



2. Non living fencing
 - (a) Barbed wire
 - (b) Compound wall
 - (c) Grill.
 - (d) Electrical fencing
 - (e) Solar wire fencing

In solar wire minute current is developed from solar cells or battery rays. Due to this current minimum shock will be created when stray cattle and human touch it.

14.4.4 Planting Systems

The layout of an orchard is a very important operation. Laying out the orchard begins with the marking of a base line which is usually taken parallel to fix structure. First line should be at half the spacing to be given between the trees. At both ends of the base line right angles are created by following the simple carpenters meter system. After the formation of these three lines. It is easy to fix the boundary of the orchard.

Different methods of planting an orchard:

1. **Square system** - The field is divided into squares as per spacing. In this case a sapling is planted on each vertex of a square whatever may be the planting distance. This plan is commonly followed. It is easy to layout. Convenient for inter cropping and cultivation is possible in two directions e.g. mango (10×10 m), banana (1.25×1.25 m). Each plant gets equal area for growth and drip.

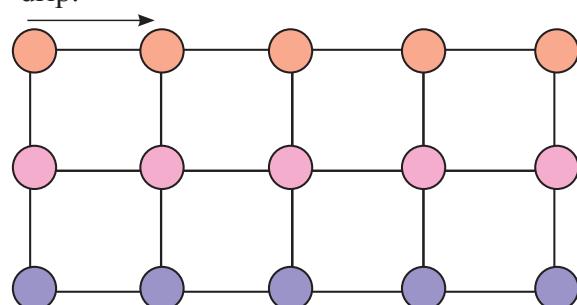


Fig. 14.1 : Square system

2. **Rectangular System** - In this system, the field is divided into rectangles as per spacing. Saplings are planted at each vertex of the rectangle. E.g. Grape (3×2 m) Increased spacing in rows is useful for mechanical cultivation between rows.

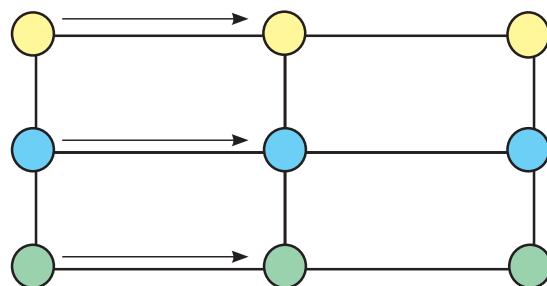


Fig. 14.2 : Rectangular system

3. **Hexagonal system** - In this method the saplings are planted at each vertex of equilateral triangle. In this way six trees form hexagon with the seventh tree in the centre. It is also called as septuple. This plan can be usually employed where land is expensive and very fertile with good available water supply. The trees are equally spaced from each other but difficult to layout. Intercultivation is difficult in this system. In this layout 15% more plants are accommodated than the square system.

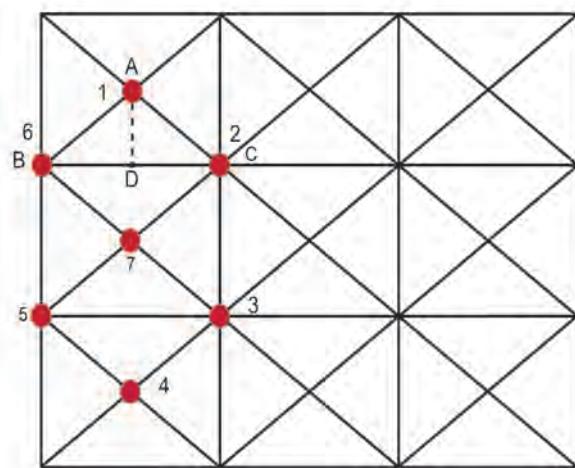


Fig. 14.3 : Hexagonal system

4. **Triangular System** - In this system the saplings are planted as in the square system but the plants in the 2nd, 4th, 6th and such other alternate rows are planted mid way between the 1st, 3rd, 5th and other alternate rows. This system has no special advantages over the square system except providing more open space for the trees and for inter crops. It is difficult for labour and cultivation. This system is useful for plantation on hill slopes.

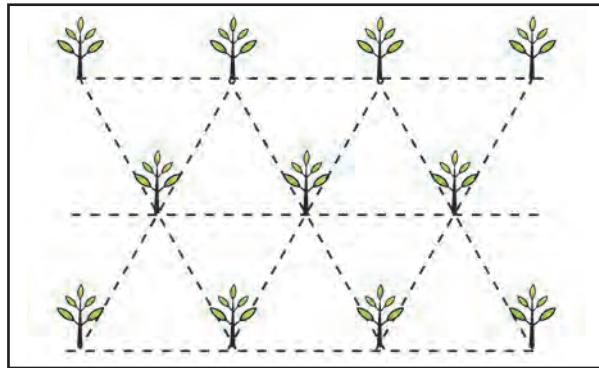


Fig. 14.4 : Triangular system

5. Quincunx system - It is differing from square system by planting an additional sapling in the centre of each square of permanent trees. The central tree is usually the filler tree which is kept only for a shorter period.

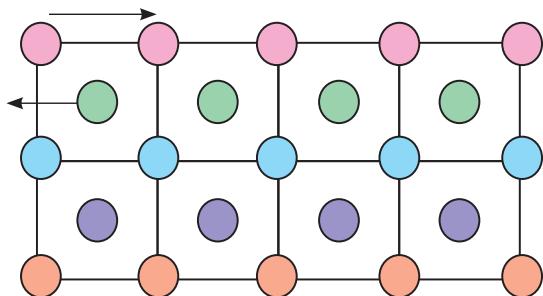


Fig. 14.5 : Quincunx system

6. Contour system - It is only followed on hills with high slopes. Contour line is an imaginary line drawn connecting points on same level on sloppy land. In this case the trees are planted along a uniform slope and usually at right angle to the slope with the idea of reducing loss of soil due to soil erosion. It is followed just as in case of square system. The marking should be done from the lowest level to the top.

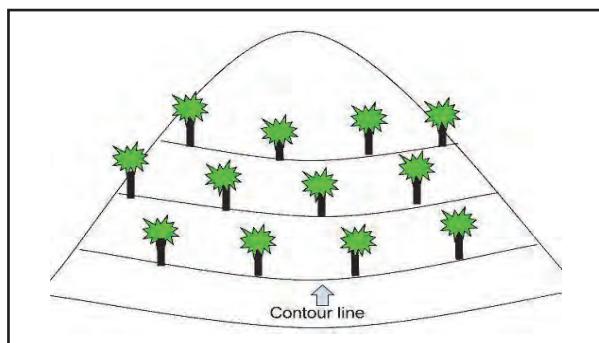


Fig. 14.6 : Contour system

Table : 14.2 No. of trees in various planting systems

Planting distance	No of trees / ha in system		
	Square	Hexagonal	Quincunx
3 × 3 mt	1085	1250	2170
5 × 5 mt	480	555	960
7 × 7 mt	225	255	450
12 × 12 mt	65	75	130

Formula for calculating number of plants

$$\text{No. of Plants} = \frac{\text{Total area in Sq. M.}}{\text{Plant to plant distance in m} \times \text{Row to row distance in m}}$$

Plant to plant distance in m × Row to row distance in m

Calculation of number of plants in hexagonal system (From fig. 14.3)

Plant to plant distance = 10m

Row to row distance to be calculated

ABC is an equilateral triangle

$$BC = AB = AC = 10\text{m}$$

Draw a perpendicular line AD to BC which divides it in to two halves.

It means $BD = DC = 5\text{ m}$

Now in triangle ABC

$$AC^2 = AD^2 + DC^2$$

$$\text{i.e. } AD^2 = AC^2 - DC^2$$

$$= 10^2 - 5^2$$

$$= 100 - 25$$

$$= 75$$

$$AD = \sqrt{75}$$

$$= 8.66$$

Thus row to row distance is 8.66

No. of Plants =

$$\frac{\text{Total area in Sq. M.}}{\text{Plant to plant distance in M.} \times \text{Row to row distance in M.}}$$

$$= \frac{10000}{10 \times 8.66}$$

$$= 115 \text{ approximately}$$

Wind breaks :

Definition :

The wind break means close planting of tall growing trees all around the orchard preferably at south west direction of plantations.

Importance

Fruit orchards usually cause heavy losses when exposed to strong wind. Heavy wind increases the losses of moisture both by increasing transpiration and surface evaporation. The high winds also cause the damage to fruit trees by breaking of branches, destruction of blooms, dropping of immature fruits and erosion of surface soil. The fruit yield is also reduced on the exposed orchards firstly due to drying of stigmatic fluid and secondly due to reduced activities of pollinating insects. The growth and yield in protected orchard is definitely better than the exposed orchard. Hence, establishment of a tall growing wind break is necessary to protect the orchard.

Selection of wind breaks

While selection of wind breaks more importance should be given to the height than the thickness. Wind break will give full protection to distance of 4-5 times the height of trees. The wind breaks should be erect and tall, quick growing, hardy and drought resistant, occupy less space as far as possible. They should be mechanically strong and dense to resist maximum wind velocity.

Planting distance

Proper spacing of fruit trees is one of the most important considerations in successful fruit cultivation. Spacing depends upon the fertility of the soil and nature of growing of the trees. Improper spacing of trees may result in the poor quality of fruits and incidence of pest and diseases. Too much close spacing will result in poor growth of fruit trees and inferior quality of fruits because of lack of sunlight. Very wide spacing will result in waste of valuable land.

Table 14.2 : Planting distance for the fruit trees.

Sr. No.	Fruit trees	Spacing (meter)
1.	Mango	10 × 10
2.	Apple	7.5 × 7.5
3.	Orange	6 × 6
4.	Banana	2.4 × 2.4
5.	Guava	6.8 × 6.9
6.	Pomegranate	3.6 × 2.6
7.	Pineapple	0.45 - 0.60 × 0.45 - 0.60
8.	Awala	8 × 8
9.	Chikoo	8 × 8
10.	Papaya	2.25 × 2.25
11.	Coconut	7.5 × 9
12.	Ber	6 × 6
13.	Strawberry	0.6 × 0.3
14.	Jamun	10 × 10
15	Tamarind	10 × 10

Planting material

Proper selection of planting material is very important for successful fruit growing. The planting material should be genuine, true to type variety, healthy, free from pest and diseases, insects and virus. It is always advisable to procure the planting material from reliable source like government nurseries, agricultural university nurseries.

While purchasing planting material following consideration should be taken -

- (1) The planting material should be true to type and variety. The planting material should have been prepared from healthy mother plant with high productivity record.
- (2) The graft and / or bud joint with stock should be strong and well developed.
- (3) The plant should be budded or grafted on recommended rootstock.

Preparation of pits and planting

Preparation of land

Since the fruit trees remained in the field for a very long duration, the land and plots



should undergo repeated ploughing, harrowing and levelling. Before digging pits green manuring crops should be grown and buried in the soil to enrich the orchard soil and to improve the physical condition of soil.

Digging pits

Having decided to give optimum spacing the plot is laid out with measuring tape, stakes, etc. The pits are taken in advance before planting. The size of pit is decided according to fruit tree and soil type. In poor soils larger pits are taken for larger trees, smaller pits are dug for dwarf trees and in fertile soils smaller pits are generally taken. The size of pit varies from 0.5 cubic meter to one cubic meter. While digging pit upper soil is kept aside. The pits are dug out in advance and are exposed to sun for a week or so. The pits are filled with top soil, farmyard manure or compost, bone meal. Add insecticide powder in soil to prevent attack by pest.

Planting

Having procured genuine and healthy planting material, it should be planted during monsoon where rainfall is not heavy. In region like Konkan, where rainfall is very heavy, planting should be undertaken after rains are over. The planting should be done on cloudy day preferably in the afternoon.

The plants should be carefully removed from polythene bag or earthen pot without disturbing root system and put in a small hole in the pit and covered with soil. Before planting damaged roots should be cut and then plant the seedling. The planting board is used for planting at the right position. After planting press the soil gently. Water the plant as soon as possible if necessary.

14.5 Training and pruning

Training and pruning are important orchard operations

These processes form indispensable operation having direct bearing on growth and vigor of plants. These processes also have effect

on yield and quality of Fruits. Proper training and pruning of the plants sustain heavy crop load and produces good quality harvest. Plants develop strong framework and they are free from drooping branches, narrow crotch angle, water sprout, root and crown suckers.

14.5.1 Training : It refers to removal of part of plant to develop a proper shape of plant capable of bearing heavy crop load. It is related to shape and size of a plant.

Objectives of training

- (1) To develop strong framework.
- (2) To control and regulate shape.
- (3) To maintain better crotch angle.

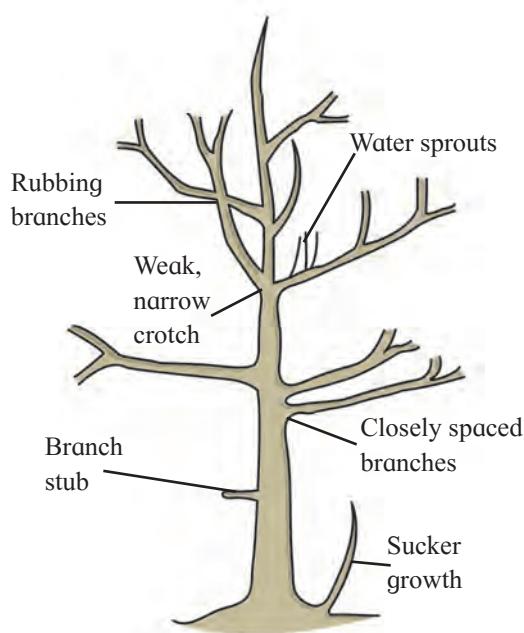


Fig. 14.7 : Training

- (4) To develop balance between vegetative and reproductive branches.
- (5) To facilitate interception of sunlight.
- (6) To remove water sprouts.

Principles of training

- (1) Started from very beginning of plant growth.
- (2) Most are trained in single stem system. Pomegranate, fig and custard apple are

- trained by multi-stem training system as they are prone to insect attack.
- (3) In some plants terminal bud is removed to facilitate emergence of side shoots.
 - (4) Branches with narrower crotch angle are discarded.
 - (5) Remove water sprouts and drooping branches.

According to the height of the tree, the training is grouped in two ways.

(1) High head

In this type the main branches are encouraged about one meter or higher up from the ground level. In this case cultural operations with animal or mechanically drawn implements can be carried out very easily. In the tropical climate the practice is not followed generally as the sunscald and wind may damage the trees. The fruit bearing area on the plants also develops late and it bears fruits slowly.

(2) Low head

In this case the main branches forming the foundation frame work of the tree are managed on the trunk at a low height. Low headed trees come in bearing earlier and this type of practice is now more popular. In this method the plants can resist stormy winds more effectively and the other cultural practices can be done very easily.

Systems of Training

1. Central Leader
2. Open Centre
3. Modified Leader

1. Central Leader

In this system the main trunk grows undisturbed. As the growth of the branches is vigorous and rapid on the main trunk, the tree develops a close centre and grows to greater height. The side branches remain more or less stunted and as the result they would be low in vigour and productivity.

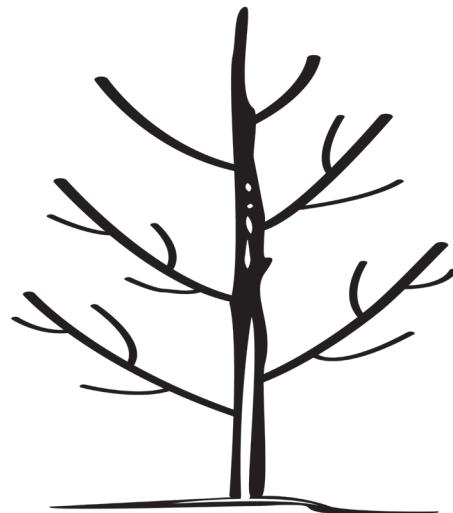


Fig. 14.8 : Central Leader

Advantage

1. Development of strong crotches due to interlacing of fiber at the junction of the limb and the trunk.
2. Strong frame work.

Disadvantages

1. Shading of the interior part of the tree.
2. Weakening of central leader due to shading reduces life of the tree.

2. Open Centre

In this system the main stem is allowed to grow only up to a certain height by heading it within a year of planting. All the subsequent vegetative growth is promoted by lateral branches. This results in low head. Bulk crop is borne closer to the ground.

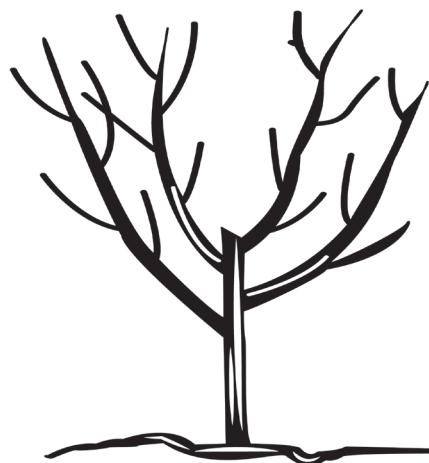


Fig. 14.9 : Open Centre

Advantages

1. Better light penetration for the fruiting in inner branches.
2. Development of a low headed tree.
3. Trees are more fruitful and greatly facilitate the operations like pruning, thinning, spraying and harvesting.

Disadvantages

1. Tree becomes weak because of crowded crotches.
2. Heavy bearing causes breaking of the tree.
3. In high light intensity area trees suffers from severe sunscald and sunburn injuries.

3. Modified leader system

It is the combination of the central leader and open centre. First the central leader is allowed to grow and then is cut back not allowing it to become dominant. Selected laterals are allowed to grow and remaining laterals are removed to obtain proper orientation.

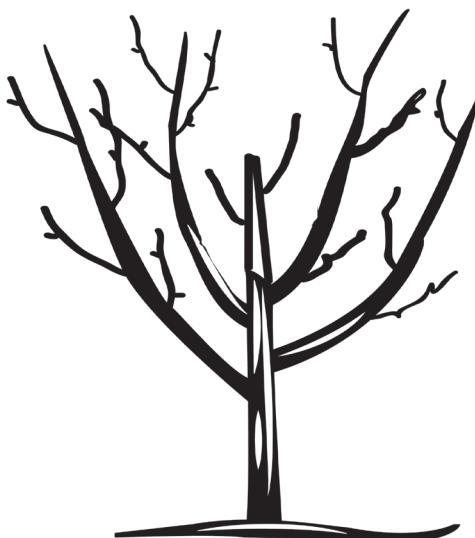


Fig. 14.10 : Modified Leader

Advantages

Most desirable in many trees because.

1. Low and well spaced laterals
2. Well distributed fruiting area.
3. Better light penetration.

4. Strong framework.
5. Easy cultural operations.

14.5.2 Pruning

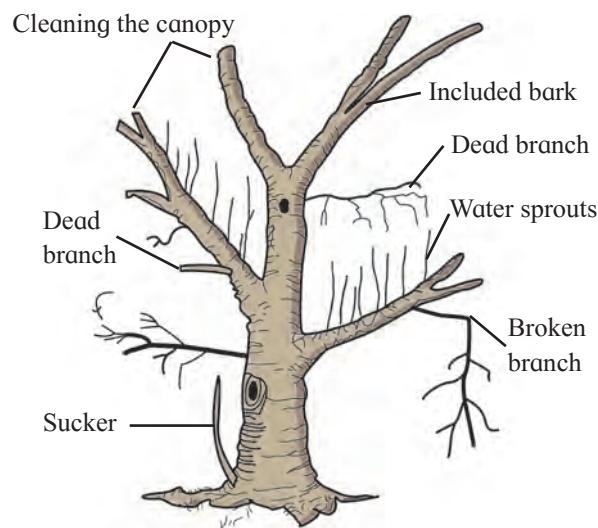


Fig. 14.11 : Pruning

Pruning is an important horticultural practice and its skill is very essential to the grower since the mistake in pruning may result more harm than good rewards.

Pruning is removal of a part of a plant like root, leaf, flower branch, vine or fruit to obtain good and qualitative yield. It is related to better harvesting with good quality fruits.

Definition

According to Gardener, pruning may be defined as “An art and science of cutting away a portion of plant to improve quality of the produce, or to heal, repair the injury”. The parts more commonly removed are branches or leaves or both.

The extent and intensity of pruning of any tree varies from year to year depending on the growth of the tree, its bearing and season.

Objectives

- (1) To control flowering and fruiting
- (2) To augment production in plants which bears on new shoots
- (3) To obtain regular bearing
- (4) To remove diseased, damaged, insect infested and water shoots

- (5) To thin out flowers and fruits
- (6) To ensure access of sunlight to bearing shoots
- (7) To invigorate the plants
- (8) To have a balance between vegetative and reproductive growth

Principles of pruning

- (1) Remove all water sprouts
- (2) If the shoot is to be removed completely it should be removed from the base
- (3) Avoid bark injury
- (4) Pruning should be completed well advance of flowering season
- (5) In deciduous plants pruning should be done in advance of winter to avoid low temperature injury.
- (6) Apply Bordeaux paste immediately
- (7) Crowded, diseased, damaged and insect infested shoots should be removed.

Methods of Pruning

1. **Thinning out** - This refers to the removal of the branches entirely from the base leaving no stubs.
2. **Heading back** - This refers to cutting of main stem or a few of the branches leaving a basal portion. This method is often followed for hedges, ornamental shrubs, first dormant and October pruning in grapes.

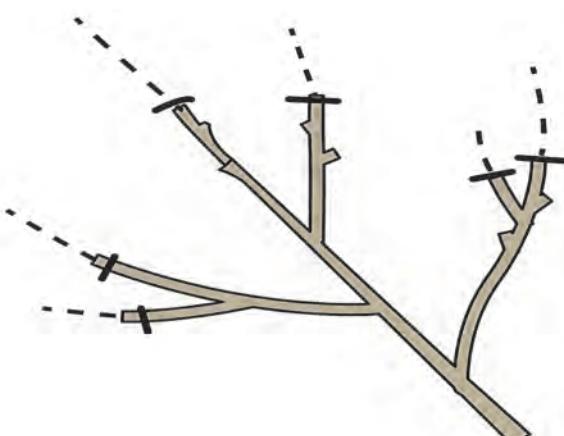


Fig. 14.12 A : Thinning out

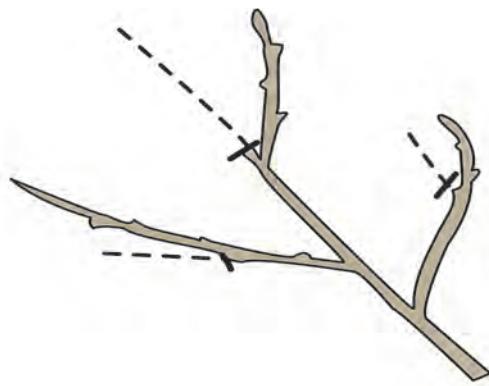


Fig. 14.12 B: Heading back



Use your brain

Find out purpose behind Frame pruning, Maintenance pruning, Renewal pruning.

3. **Disbudding** - The young buds are nipped with giving them no chance to sprout. The bud may be either vegetative or reproductive. This is practiced regularly in flowering plants to make the terminal bud to give a bigger flower.
4. **Pinching and topping** - This refers to the removal of the top of the shoot along with a view to stimulate the lateral growth.

Time and extent of pruning

The time of the pruning in different plant mainly depends upon their dormant and flowering seasons. The best time for pruning in case of the deciduous trees is at the end of the dormant season i.e. about a month before the commencement of flowering.

The extent of pruning to be adopted for a particular crop depends on its growing and fruiting habit, as it directly affect the nutritive condition within the tree and consequently affects the fruit formation. It also increases the size, shape and quality of fruit. Pruning is to be carried out in the month of May. Excess pruning reduces quality of fruits.

14.6 Special horticultural operations

14.6.1 High Density Planting (HDP)

Maximization of production should be the ultimate objective in the fruit cultivation. This

can be achieved by many ways. Increasing number of plants per unit area by adjusting the planting distance and method of planting is one of the ways.

Definition

Planting of fruit trees, closer than their normal spacing and making the plant population dense per unit area is known as high density planting.

Increased plant population may affect the growth and production due to over-crowding, shade effect and intermingling of branches of trees.

This can be avoided by

- (1) Controlling the size of the plant.
- (2) By adjusting the planting distance and method.

Size of plant is controlled by regular pruning or by using dwarfing root stocks. E.g. Vhallai - columban in mango, trifoliate orange in citrus.

In some plants, to avoid over shading the planting density is so arranged that it should not affect the root and shoot balance and should permit better light penetration. In banana, normal planting distance is $1.75\text{ m} \times 1.75\text{ m}$. In high density planting, it is planted at a distance of $1.25\text{ m} \times 1.25\text{ m}$.

In high density planting, there is competition for nutrients and water amongst the plants and hence yield of individual plant is reduced, yield per unit area is also hampered but it can be corrected by adopting proper agro horticultural practices.

Advantages

- (a) More plants per unit area hence yield increases.
- (b) Better utilization of land.
- (c) Production of marketable produce.

Effect on Growth and Yield

- (a) Due to less spacing the growth is erect.
- (b) Over crowding of branches causes fruit drop and infection of pest and diseases.
- (c) The yield is more as compare to normal spacing because plant population is increased.

14.6.2 Bahar Treatment

Bahar treatment is nothing but withholding water for 4-6 weeks prior to flowering with a view to give rest to the tree. The principle involved is, by giving rest to the tree or checking its growth, more carbohydrates are accumulated in the plant body which led to a profuse differentiation of buds and flowers.

This practice is followed in trees like mosambi, santra, guava, pomegranate, etc. in Maharashtra and in south India. Most of the orchards of these crops are planted on medium to deep black cotton soils which have very good water retention capacity. The climatic conditions in our state are such that there is no much more distinction between winter and summer season temperatures. As a result of which plant remains in the active growth throughout the year and refuses to produce flower abundantly, affecting the quality and total yield of crop. Therefore bahar treatment is necessary in these crops.

Method

Bahar treatment consists of withholding the irrigation water prior to flowering. In heavy soils 55-60 days water stress is given where - as in light soils it is of 40 to 45 days. Light ploughing or digging in the orchard is done before treatment. During water stress period plant stops growth, leaves turn pale green or slightly yellow. Over stress is dangerous.

When the stipulated period of water stress is over, basins are prepared, plants are manured at recommended doses of manures and irrigation is provided step by step. The first irrigation must be light one.

There are three types of bahar treatment
1. Mrig bahar 2. Hast bahar 3. Ambe bahar

1. Mrig bahar

- (i) Withholding of water is done in April-May and flowering occurs in June-July.
- (ii) Useful in our region because water withholding is done in summer season which is beneficial.

- (iii) Fruit develops after rainy season thus fruit fly attack is avoided.
- (iv) Dry and bright sunshine during ripening period enhances colour and the quality of the fruit.
- (v) In case of santra in North India mrig bahar is not followed and hence fruits from Maharashtra fetches good price.

2. Hast bahar

- (i) Withholdings of water is done in August and flowering occurs in Sept - October.
- (ii) Not practiced in Maharashtra

3. Ambe bahar

- (i) Withholding of water is done in November-December. flowering is in January - February.
- (ii) Fruit development is during summer. Not possible in Maharashtra as farmers face water scarcity in summer.
- (iii) Fruits are fairly attacked by the fruit flies, sucking moth during rainy season in Maharashtra
- (iv) In our region, fruit ripen in rainy season which affect the colour and quality of the fruit.

The choice of bahar depends upon

1. Availability of water.
2. Quality of fruits.
3. Attack of insects pest and diseases.
4. Availability of market and market prices.

14.6.3 Bending

Bending is generally followed in erect growing varieties of guava to increase yield. In such varieties branches and shoot grow erect and the buds situated on the top of the branch sprout which bear flower and fruits. The buds on the lower side of the branches remain dormant and fail to sprout. So the fruit bearing area becomes less and naturally it decreases the yield.

The reason behind this particular phenomenon is the apical dominance. The



Fig. 14.13: Bending

terminal buds synthesize auxins which controls cell elongation and plant growth. The auxin thus produced moves downwards and inhibits the growth of lateral buds on the shoot. Auxin gets accumulated on the lower side of branch (side which is away from the sun) and cause cell elongation on that side to turn to new shoot growth towards the sun.

To break this apical dominance and to bring all the buds at the same level in order to increase the fruit bearing area. The erect growing branches are bent down wards. i.e. horizontal. More auxins get accumulated on the lower side causing cell elongation. The lateral buds are brought at the same level which sprout and give more fruiting area which ultimately increases the yield.

Varieties like Lucknow-49 (Sardar) because of their horizontal growing character do not require bending.

14.6.4 Ringing

Ringing is followed in mango to induce fruitfulness. It is nothing but removal of bark on the branches, in circular fashion of the width of $\frac{1}{4}$ inch to $\frac{1}{2}$.inch. The object behind this operation is to interrupt the downward flow of carbohydrate and to accumulate it at above the portion of operation to induce fruitfulness.

Many times, tree produces only vegetative growth and all the carbohydrates are utilized for vegetative growth without any accumulation.

In alternate bearing trees, during on year all the carbohydrate is utilized for

development of fruit and hence very little quantity is available for differentiation of buds resulting in off year next season. For sprouting of flower buds, accumulation of carbohydrates is essential. To achieve this, ringing is done in mango.

This operation is done in the month of August i.e. 4 months, before the expected date of flowering. It is done on main limbs of at least 6 inch in diameter by removing a circular bark ring of $\frac{1}{4}$ inch to $\frac{1}{2}$.inch thickness. The

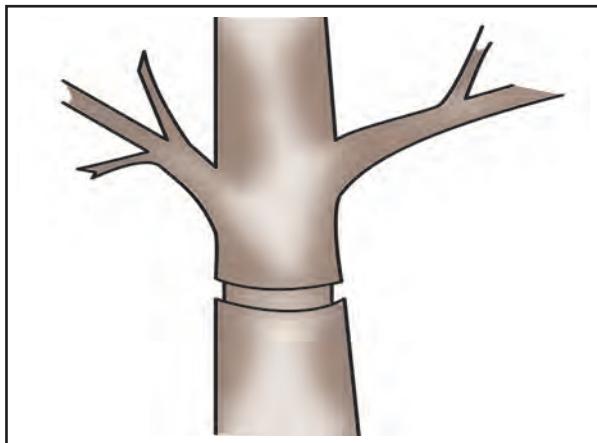


Fig. 14.14: Ringing

cut given to the stem or branch of the tree should not be too deep, and it should not injure the cambium otherwise the upward nutrient supply will be checked. Bordeaux paste should be applied on the ringed part to check the fungal attack. It is not followed as a regular orchard practice. Normally, healing of the wound take place in about a month after the purpose of the operation is over.

14.6.5 Girdling

Girdling is a special horticultural operation followed in grapes. Removing of a circular piece of bark from the cane, main branch or primary or secondary arms for maximizing the yield of good quality is done.

Objectives

1. Better development of berries.
2. To increases the size of berries and the TSS (Total soluble solids) of berries.
3. To interrupt downward flow of carbohydrates.

4. To obtain early fruit maturity and enhance the quality of bunch. Girdling is done one week after the fruit set and on Cane, Main bark, Primary or Secondary arms.



Fig. 14.15: Gridling

Cane girdling is normally followed because in case of trunk girdling, if the operation is not performed systematically, there lays a danger of dying of the vine.

In cane girdling, a ring of bark of the width 2.5 mm is removed carefully from the basal portion of cane. With a sharp knife, clear cut is given. Proper sanitation is followed before and after the operation to avoid disease incidence. The operated portion should unite in 3-4 weeks.

14.6.6 Notching

Notching operation is followed in fig and involves giving a slanting cut little above or below the buds and removing the slice of the bark of particular depth and width depending upon the size of the branch. The main object behind notching is interruption of downward flow of carbohydrate and induce flowering when done below the bud and also induce laterals on vigorous shoots when done above the bud.

It includes partial removal of slip of bark of 2-6 mm breadth and 15-20 mm in length. Bud selected for notching should be large, plump, healthy and which is produced on perfect mature wood.

Generally 3-4 buds in the middle portion of shoot are best for operation.

When it is done above the bud, carbohydrates will accumulate above bud and there will be more nitrogen in bud which will give vigorous vegetative shoots on which flowers and fruits will be borne. In Maharashtra notching above the buds is generally followed in August -September.

When it is done below bud, there is more accumulation of carbohydrates than nitrogen, resulting in more fruit buds on the tree. It is done in the month January - February. Bordeaux mixture paste needs to be applied on the wound to avoid attack of pest and diseases.

14.6.7 Hardening

The term hardening is defined as any treatment that makes the tissues firm to withstand unfavourable environment like low temperature, high temperature and hot dry wind.

Hardening is physiological process. Plants accumulate more carbohydrates reserves and produce additional cuticle on the leaves.

In this process seedlings are given some treatments at least 7-10 days before removing from the beds and transplanting.

These treatments include

- (1) Exposure to the full sunlight,
- (2) Removal of all the shedding nets.
- (3) Stopping irrigation slowly.

Techniques of hardening

The hardening is done by the following ways.

- (1) By withholding the watering to the plant by 4-5 days before transplanting. Lowering the temperature also retards the growth and adds to the hardening processes.
- (2) By application of 4000 ppm NaCl with

irrigation water or by spraying of 2000 ppm of cycocel.

Duration and degrees of hardening

It is very necessary that plants should be hardened according to their kind so that there is an assurance of high percentage of survival and slow growth under the condition to be expected at the time of transplanting. Hardening should be gradual to prevent or check the growth. Warm season crops like tomato, brinjal and chillies do not favour severe hardening. Under Indian conditions, allowing the soil to become dry, 5-6 days are enough for desired hardening.

Effect of hardening

The following effects may be observed by the hardening

- (1) Hardening improves the quality and modifies the nature of colloids in the plant cell enabling them to resist the loss of water.
- (2) Hardening increases the presence of dry matter and regards in the plants water and transpiration per unit area of leaf.
- (3) Decreases the rate of growth in the plants
- (4) Hardened plants can withstand better against unfavourable weather conditions like hot day winds or low temperature.
- (5) Hardening of the plants increases the waxy covering on the leaves.
- (6) Development of pinkish colour on leaf petioles and blades.

Exercise



Q 1 A. Fill in the blanks.

1. Horticulture is a branch of agriculture that deals with cultivation of ----- plants.
2. The branch of horticulture that include study of vegetables is known as -----.
3. The central plant in quincunx system is called as ----- tree.
4. Training aims in development of strong ----- of fruit tree.
5. Better light penetration is possible in ----- method of training of fruit crops.

B. Make the pairs.

A	B
(1) Pomology	(a) Hill slopes
(2) Olericulture	(b) Study of flowers
(3) High density planting	(c) Study of vegetables
(4) Rectangular system	(d) Study of fruit crops
(5) Contour system	(e) Declining land to plant ratio
	(f) Wind breaks
	(g) Mechanical cultivation

Q 1 B Find the odd out.

1. Square, Rectangular, Triangular, Hexagonal, Fencing
2. High head, Low Head, Girdling, Open centre, Central Leader
3. Girdling, Bending, Ringing, Bahar treatment, Bearing
4. Road side site, Fertile soil, Cheap labour, High density planting, Availability of market, FYM.
5. Insecticide, Compost, Bone meal, Leaf mould

C. State true or false.

1. Wind breaks protect fruit orchard from hot and dry winds.
2. One of the objectives of pruning is to control flowering and fruiting.
3. Flowering occurs in June – July in case of ambe bahar.
4. In cane girdling a ring of bark of the width 2.5 cm is removed.
5. In high density planting banana plants are planted at 3m × 3 m spacing.

Q 2 Answer in brief.

1. Write short notes on
 - (i) Bahar treatment
 - (ii) High density planting in Mango
 - (iii) Open centre method of training
 - (iv) Ringing
 - (v) Bending
2. Give difference between
 - (i) Ringing and girdling
 - (ii) Training and pruning
 - (iii) Central leader and open centre
 - (iv) High head and low head system of training
3. Give reasons
 - (i) It is necessary to plan carefully while developing new orchard.
 - (ii) Open centre method is better method of training fruit crops.
 - (iii) In case of cane girdling, width of removed bark should be 2.5mm only.
 - (iv) High head system of training is not practiced in tropical region.
 - (v) Bahar treatment is necessary for santra in Maharashtra .
4. Give examples of
 - (i) Methods of crop maximization
 - (ii) Types of bahar.



(iii) Methods of training.

5. Answer in brief.

- (i) What are the advantages of planting wind breaks?
- (ii) What are the objectives of training?
- (iii) What are the types and benefits of fencing?
- (iv) Which points are required to be kept in mind while planning a new fruit orchard?

Q 3 Answer the following questions.

1. Complete the table.

Method	Crop	Width	Benefits
Girdling			
Ringing			

2. Explain with the help of examples.

- (i) Planting of wind breaks
- (ii) Live fencing

3. Calculations.

- (i) Calculate number of fruit plants required for planting one hectare area in hexagonal system at 6×6 m distance.
- (ii) Calculate number of fruit plants required for planting three hectare area in quincunx system at 2.5×2.5 m distance.

Q 4. Answer in detail.

1. Write the importance of horticulture.
2. Explain the scope of horticulture.
3. Write in detail about selection of site for an orchard.
4. Complete the table.

Sr. no.	Method	Main Objective	Followed in Crops	Time
1	Training			
2	Pruning			
3	Bahar treatment			
4	Bending			

5 . Read the given following paragraph and answer the questions.

Fencing is essential to prevent destruction of the trees from stray cattle and also to protect the orchard from stress passing. It is necessary to provide some kind of fencing on all sides of the garden and this should be done preferably before planting the fruit trees. Fencing helps to mark the borders of the orchard. Fences may be made using thorny and dead bushes but these are not satisfactory and require frequent repair and replacement. Barbed wire fencing is very good but its initial cost is rather high.

Types of Fencing:-There are two types of fencing used for protection of orchard.

1. Live fencing 2. Non-living fencing

(1) Live fencing - The best protection is however, a construction of live fence. Some of the plants are very useful as live fence.

1. *Prosopis juliflora (vilyati babul)* and *Caesalpinia sepiaria (Chillari)*:- These can be established in May June the seed should be sown in a trench 30 cm wide and 22.8 cm deep all around the orchard boundary.
2. *Carissa carandas (Karonda)*:- This makes an effective dense hedge. In addition it bears fruits if not pruned too closely.

Other live plant use as fence:-

Lantana camara (ghaneri), cacti, Coenel, dedonia, mendi, casurina (*khadsarni, sher*), *adulsa, shendri* etc.

Questions

- a. Which are the two types of fencing?
- b. Why fencing is necessary for fruit orchard?
- c. Mention some plant species used for live fencing.
- d. Can you suggest any alternative system of fencing?
- e. What is the significance of live fencing?

Activity: Practice different special horticultural operations





Let's recall

- What is meant by Horticulture?
- Which crops are covered under the Horticulture?
- Importance and scope for horticultural crops in India.
- Recent developments in Horticulture industry.
- Nutritional importance of fruits and vegetables.
- Which horticultural crops have export potential?



Remember this

Certain horticultural crops have special economic importance and these crops are grown by farmers with commercial approach. Such crops are useful for changing farmers economic condition .The special horticultural crops are the alternative for traditional agriculture, however they can be grown along traditional crops. These crops can be grown on commercial scale as well as an amateur scale .These crops can be cultivated in various combinations and with different objectives

15.1 Different horticultural crops having special economic importance

The special horticultural crops are categorized in following way

- (1) Plantation crops (2) Spice crops
- (3) Aromatic crops (4) Medicinal plants
- (5) Vegetable crops (6) Exotic crops
- (7) Flower crops (8) Ornamental Plants

One or few crops from the each group are known be special as they have distinctive characters and uses



Remind

- Have you seen sugarcane plantation and sugar factory?
- Have you visited jaggery production unit?

15.1.1 Plantation Crops

Plantation crops are those which are cultivated on extensive scale.

Plantation is a large scale unit usually of a single crop.

Plantation is a large scale estate meant for farming that specializes in cash crop.

These crops are grown in huge plantations and need to undergo certain processing .Such processing units are established in plantation areas, there by having great impact on socio economic development of that region.

Different plantation crops are as follows

a. Tea - *Camellia sinensis*

Family - Theaceae

Tea plant is an evergreen shrub grown for its leaves. Top shoots along with two youngest leaves are removed and cured to impart taste and flavor. Leaf, broken and dust are the three grades of tea.

Tea is important crop of Assam, Nilgiri, Dargiling and hilly areas of India.



Fig. 15.1 Tea

b. Coffee - *Coffea robusta* *Coffea arabica*

Family - Rubiaceae

All coffee plant species are woody evergreens, but the plants range in size from small shrubs to trees more than 10 meters tall. Leaves vary in colour from yellowish to dark green, with touches of bronze or purple. The plant produces white flowers and red berries or "cherries" that contain seeds. Most coffee berries contain two seeds, which are known as "beans". Beans are harvested from matured fruit, dried and powdered and used to make coffee beverage. Coffee is one of the important crops of Karnataka.



Fig. 15.2 Coffee



Use your brain power

You may have drunk coffee which is made by conventional filtering method or an instant coffee. Can you find how both the type of coffee powders are made?

c. Cocoa - *Theobroma cacao*

Family - Malvaceae

Cocoa fruit contain seeds with pulp. The matured seeds are fermented, washed and powdered and then used for chocolate making.

Foresterio and Criollo are the two famous varieties of cocoa.



Fig. 15.3 Cocoa



Do you know ?

Cocoa beans were used as currency during ancient period

d. Rubber- *Hevea brasiliensis*

Family- Euphorbiaceae

Natural rubber, also called Indian rubber, as initially produced, consists of polymers of the organic compound isoprene, with minor impurities of other organic compounds, plus water. Currently, rubber is harvested mainly in the form of the white latex from rubber plant trunk. The latex is a sticky, milky colloid drawn off by making incisions in the bark and collecting the fluid in vessels in a process called "tapping". The latex then is refined into rubber ready for commercial processing. Latex is allowed to coagulate in the collection cup and lumps are collected and processed into dry forms for marketing. Natural rubber is used extensively in many applications.



Fig. 15.4 Rubber

e. Coconut- *Cocos nucifera*

Family - Arecaceae

The coconut tree is a member of the palm tree family. The term "coconut" can refer to the whole coconut palm, the seed, or the fruit, which botanically is a drupe and not a nut. Coconuts are known for their versatility of uses, ranging from food to cosmetics. The inner flesh of the mature seed forms a regular part of the diets of many people known as *khobara*.

Coconuts are distinct from other fruits

because their endosperm contains a large quantity of clear liquid and when immature, may be harvested for their coconut water known as *shahale*. Mature, ripe coconuts can be used as *prasad* or *nariyal* (edible seeds), or processed for oil and coconut milk from the flesh, charcoal (active carbon) from the hard shell, cocopeat and coir from the fibrous husk. Dried coconut flesh is called *copra*, and the oil derived from it is commonly used in cooking as well as in making soaps and cosmetics. The hard shells, fibrous husks and long pinnate leaves can be used as raw material to make a variety of products for furnishing and decorating, brooms, *chatai*, etc. The coconut fruit also has cultural and religious significance in certain societies.



Fig. 15.5 Coconut

**f. Areca nut - *Areca catchue* (*Supari*)
Family- Arecaceae**

It is a species of palm which grows in much of the tropical Pacific, Asia, and parts of East Africa. The palm is believed to have originated in the Philippines, but is widespread in cultivation and is considered naturalized in India, widely grown in Karnataka state. The species has many common names including the areca palm, areca nut palm, betel palm, Indian nut, etc. This palm is called the betel tree because its fruit, the areca nut, is often chewed along with the betel leaf. Further is has medicinal and industrial uses.



Fig. 15.6 Areca nut

**g. Cashew nut - *Anacardium occidentale* (*Kaju*)
Family - Anacardeaceae**

The cashew nut, often simply called a cashew, is widely consumed. It is eaten on its own, used in recipes, or processed into cashew cheese or cashew butter. The shell of the cashew seed yields derivatives that can be used in many applications including lubricants, waterproofing, paints, and arms production. The cashew apple has a light reddish to yellow colour. Its pulp can be processed into a light sweet, astringent fruit drink or distilled into liquor (called fenny in Goa). Cashew nut is known as dollar earning crop. India is the world's leading producer and exporter of cashew kernels.



Fig. 15.7 Cashew nut

15.1.2 Spice Crops

Spice is a substance that is used in cooking to add flavour to food which comes from dried plant part, powder or seed.

Spice is a seed, fruit, root or other plant part primarily used for flavouring, colouring or preserving food.



Remember this

India produces 75 varieties of spices of the 109 listed by International Spice Organisation and is also the largest producer of spices

Spices are classified according to their share in spice trade industry of the world.

(i) Major spices

Contribute about 75-90% of total spice trade .These are pepper, cumin, cardamom, ginger, turmeric and chilli.

(ii) Minor spices

These have less contribution in trade and are further classified as follows

- (a) Seed spices - Coriander, mustard, poppy, caraway, celery, fenugreek, etc.
- (b) Bulbous spices - Garlic, onion, leek, shallot, etc.
- (c) Aromatic spices - clove, cinnamon, all spices, ani seed, nutmeg, etc.
- (d) Leafy spices - Curry leaf, mint, rosemary, parsley, bay leaf, etc.
- (e) Acidulant tree spices - *Tamrind*, *kokum*, *anardana*, etc.

a. Cardamom (*Veldoda*) - *Elettaria cardamomum* Family-Zingiberaceae

Cardamom is grown for small black seeded pods. Spindle shaped pods contain black seeds. These are used for flavoring as well as cooking spice. Cardamom is known as Queen of spices.



Fig. 15.8 Cardamom

b. Black Pepper (*Kali Miri*) – *Piper nigrum*

Family - Piperaceae

A vine crop cultivated for its small fruits which are usually dried and used as spice. Universally known as King of spices. Black pepper and white pepper are the types and have been used for different purposes.



Fig. 15.9 Black pepper

c. Ginger (Ale) - *Zingiber officinale*

Family Zingiberaceae

Ginger is a flowering plant whose rhizome, is widely used as a spice and for medicinal purposes. It is a herbaceous perennial, which grows annual pseudostem about a meter tall bearing narrow leaf blades. The inflorescences bear pale yellow with purple flowers and arise directly from the rhizome on separate shoots.

Ginger originated in Island Southeast Asia. Ginger produces a hot, pungent fragrant taste. Young ginger rhizomes are juicy and fleshy with a mild pungent taste due to gignrol. They are often pickled in vinegar . They can be steeped in boiling water to make ginger herb tea. Ginger can be made into candy or ginger wine. Ginger sets are dried into 'sunth', powder, ginger oil and oleo-resin. Ginger essence is used in pharmaceutical products.



Fig. 15.9 Ginger



Remind

Medicinal property of ginger is because of gingrol.

Have you eaten alepak or sunth vadi? And When?

d. Turmeric (*Halad*) - *Curcuma longa* Family - Zingiberaceae

The plant is native to the Indian subcontinent. After harvesting the rhizomes are boiled in water for about 30–45 minutes and then dried in hot dryer, after which they are ground into a deep orange-yellow powder. It is commonly used as a coloring and flavoring agent in ayurvedic medicines.



Fig. 15.11 Turmeric

e. Cinnamon (*Dalchini*) - *Cinnamomum zealandicum* Family - Lauraceae

Cinnamon is a spice obtained from the inner bark of a perennial shrub. Cinnamon is used mainly as an aromatic condiment and flavouring spice additive .The aroma and flavour of cinnamon is derived from its essential oil and principal component, cinnamaldehyde, as well as numerous other chemical constituents, including eugenol.



Fig. 15.12 Cinnamon

f. Clove (*Lavang*) - *Eugenia caryophyllata* Family - Myrtaceae

Clove is native to India grown in South India. Clove flower buds are used as a spice in India. It is an evergreen tree of humid tropical climate and hilly tract of the Western Ghats and the red soils are best suitable for clove cultivation. A major component of clove taste is imparted by the chemical compound eugenol and it is used in traditional medicines. The clove oil is effective for toothache pains or other types of pains related health problems. It is widely used in all types of masala preparations.



Fig. 15.13 Clove

g. Chilli – *Capsicum annuum* Family Solanaceae

Chilli fruit is used in green and red form (The dried ripe fruit). The chilli is an annual shrub. The flowers converted in red peppers after maturity, *Capsicum frutescens* is a perennial chilly with small sized pods which are highly pungent. It is commonly known as ‘bird chilly’. Green chilli pods and dried chilli powder are commonly used in food preparation to get desired pungent taste and red colour. The pungency in chilli is due to capsaicin compound.



Fig. 15.14 Chilli

Find information on

Allspice-Plants Allspice, also called pimenta, *Jamaica pimenta*, or myrtle pepper, is the dried unripe fruit of *Pimenta dioica*, a mid canopy tree, native to the Greater Antilles, southern Mexico, and Central America, now cultivated in many warm parts of the world.

15.1.3 Aromatic crops

These are plants that produce and exude aromatic substances which are used in making perfumes, in cooking and in the food, pharmaceuticals and liquor industries.

Odoriferous and volatile substances occur as essential oils, gum extract, balsam and oleoresin in one or more parts viz. root, wood, bark, foliage, flower and fruit of the aromatic plant. The aromatic substances are obtained by the methods like distillation, maceration, expression and solvent extraction.

a. Sandalwood- *Santalum album* (*Chandan*) Family - Santalaceae

Sandalwood is a class of woods from trees in the genus *Santalum*. The wood is heavy, yellow, and fine-grained, and unlike many other aromatic woods, they retain their fragrance for decades. Sandalwood is the second-most expensive wood in the world. Both the wood and the oil produce a distinctive fragrance that has been highly valued. Sandalwood trees are medium sized hemiparasitic. It is a threatened species indigenous to South India. Oil has a distinctive soft worm, smooth, creamy and

milky precious wood scent. Used in perfume, acts as finative, cosmetic and soap industry Sandalwood oil prices have risen to Rs 1.4 lakh per kg.



Fig. 15.15 Sandalwood

b. Senna (*Sonamukhi*) - *Senna alexandrina* Family - Fabaceae

Senna is a large genus of flowering plants in the legume family .This diverse genus is native throughout the tropics, with a small number of species in temperate regions. The leaves of senna plant are used in tea hot drink and may help to relieve constipation. Some senna species are used as ornamental plants in landscaping. The plant is adapted to many climate types. Cassia gum, an extract of the seeds of Chinese senna is used as a thickening agent.



Fig. 15.16 Senna

c. Geranium - *Pelargonium graveolens* Family - Geraniaceae

The family includes both the genus Geranium (the cranesbills, or true

geraniums) and the garden plants are called geraniums, which modern botany classifies as genus pelargonium, along with other related genera. The oil of geranium has a refreshingly delicate rose like aroma. As such itself is a perfume.



Fig. 15.17 Geranium

**e. Khus (Wala) - *Vetiveria incognito*
Family - Poaceae**

Khus is a perennial bunch grass native to India. The plant helps to stabilize soil and protects from erosion, but it can also protect fields against pests and weeds. It is also used as animal feed. Its spongy branched fine rootlets contain fragrant oil. Oil is extracted and used for cosmetics, aromatherapy, herbal skin care and ayurvedic soap. Due to its fibrous properties, the plant can also be used for handicrafts, ropes, food and flavourings, perfumery, etc.



**Fig. 15.18 Khus
15.1.4 Medicinal plants**

The plants having medicinal property in their any of the plant parts are known as medicinal plants. They provide basic raw

material for the ingenious pharmaceuticals, perfumery, flavour and cosmetic industry.

The curative property of drugs are due to the presence of complex chemical substance of varied composition in one or more parts of the plant.

India is known as rich wealth of medicinal plants. One of the oldest book 'Charak samhita' records the use of over 340 drugs of vegetable origin.

During last few decades the pharmaceutical industry has made massive investment on pharmacological, clinical and chemical researches all over the world.

**a. Opium (Aphu)– *Papaver somniferum*
Family Papaveraceae**

Latex of unripe fruit contains codeine, morphine used for pain relief. Approximately 12 % of opium latex is made up of analgesic alkaloid morphine which is processed chemically to produce heroin and other synthetic opioids for medical use and for illegal drug trade.



**Fig. 15.19 Opium
b. Psyllium (Isabgol) *Plantago ovata*
Family – Plantaginaceae**

Psyllium is mainly used as a dietary fibre to relieve symptoms of both constipation and mild diarrhea and occasionally as a food thickener. Research has shown that lowering of blood cholesterol levels in people with high cholesterol, and lowering of blood glucose levels in people with type 2 diabetes. The plants from which the seeds are extracted tolerate dry

and cool climates and are mainly cultivated in northern India. Fruit, husk and seed coat are used against chronic constipation.



Fig. 15.20 Isabgol

**c. Mints (*Pudina*) *Mentha piperata*
Family – Lamiaceae**

Mint is aromatic perennial herb. It has wide spreading underground and over ground stolons and erect branched stems. Volatile oil of plant is used as antiseptic, carminative and stimulant.



Fig. 15.21 Mint

**d. Rouwolfa (sarpagandha) -
Rouwolfa serpentina
Family - Apocynaceae**

Roots contain alkaloids like reserpine, serpentine. Antidote for snake bite and medicine for blood pressure. Reserpine is an alkaloid first isolated from *R. serpentina* and was widely used as an antihypertensive drug. It had drastic psychological side effects and has been replaced as a first-line antihypertensive drug by other compounds that lack such adverse effects, although combination drugs that include it are still available in some countries as second-line antihypertensive drugs.



Fig. 15.22 Sarpgandha

**e. Lemon grass (*Gavati chaha*) –
Cymbopogon schoenanthus
Family - Poaceae**

Lemon grass is widely used as a culinary herb in Asian cuisines and also as a medicinal herb in India. It has a subtle citrus flavour and can be dried and powdered, or used fresh. It is commonly used in teas, soups, and curries. Lemon grass oil is used as a pesticide and a preservative. Research shows that lemon grass oil has antifungal properties. Despite its ability to repel some insects, such as mosquitoes, its oil is commonly used as a "lure" to attract honey bees.

Used in tea, soups and curries



Fig. 15.23 Lemon grass

**f. Vasaka (*Adulsa*) – *Adhatoda vasaca*
Family Acanthaceae**

Adhatoda, commonly known adulsa, vasa or *vasaka* is a medicinal plant native to Asia. The plant is native of Indian subcontinent.. This shrub has a number of traditional medicinal uses in Ayurvedic and Unani systems. Drug *vasaka* is obtained from dried leaves of the plant. *Vasaka* is mainly used in treatment of

chronic bronchitis and asthma. Leaf juice is given in the treatment of dysentery and diarrhea. Leaves contain vaccine which is expectorant and antiplasmodic.



Fig. 15.24 Adulsa

g. Amla – *Emblica officinale*
Family - Euphorbiaceae

The tree is small to medium in size, usually deciduous. The fruit is nearly spherical, light greenish-yellow, quite smooth and hard on appearance, with six vertical stripes or furrows.

After ripening the berries are harvested by hand. The taste is sour, bitter and astringent and it is quite fibrous in nature. Indian gooseberry is a common constituent, and most notably is the primary ingredient in an ancient herbal Chyawanprash. The fruit is commonly pickled with salt, oil, and spices. Murambah, a sweet dish is made by soaking the berries in sugar syrup until they are candied. It is traditionally consumed after meals. Popularly used in inks, shampoos and hair oils. Fruit contains large quantity of Vitamin C (600 mg/ 100 g) and is used against cough, cold and as a laxative in hyperacidity. Amla fruit is commonly used squash, juice, syrup, and crush.



Fig. 15.25 Amla

15.1.5 Vegetable Crops

Vegetables are parts of plants that are consumed by humans as food or as a part of a meal.

Vegetables collectively refer to all edible plant matter including the flowers, fruits, stems, leaves, roots and seeds.

Vegetables supply vital vitamins and minerals and known as protective food. They enhance palatability and intake of food.

According to plant part consumed vegetables are classified as under,

- (1) Leafy vegetables – Spinach, Amaranthus, Cabbage, Fenugreek
- (2) Fruit vegetables – Bottle gourd, Bitter gourd, Brinjal, Tomato, Capsicum, Pumpkin, Cucumber, Okra, etc.
- (3) Immature seeds and pods – Pea, Cowpea, French bean, Cluster bean, Indian bean, etc.
- (4) Root vegetables - Radish, Turnip, Carrot, Beet root
- (5) Tuber and bulb vegetables – Onion, Garlic, Potato, Sweet potato
- (6) Other vegetables – Cauliflower, knolkhol, Yam, Colocasia, etc.

a. Tomato – *Lycopersicon esculentum*
Family – Solanaceae

It is grown for its mature or ripe fruit, which has various culinary uses and used in preparation of many preserved products. It is very much popular all over the world. The tomato red color is due to antioxidant lycopene.

Important varieties – Arka sourabh, Arka vikas, SI -120, Pusa early dwarf, Pusa rubi, etc.



Fig. 15.26 Tomato

b. Brinjal – *Solanum melongena*

Family – Solanaceae

It is one of the most common tropical vegetables grown in India. Many delicious dishes are prepared from fruits. Important varieties – Pusa kranti, manjarigota, Pusa purple long, etc.



Fig. 15.27 Brinjal

c. Cauliflower – *Brassica oleracea* var. *botrytis*

Family – Cruciferae

Edible part of cauliflower is known as curd which consists of a shoot system with short internodes, branches apices and bracts.

Important varieties – Early kunwari, Pusa synthetic, Pusa sharad, Pant shubhra, Pusa shubhra, etc.



Fig. 15.27 Cauliflower

d. Okra (Bhendi) - *Abelmoschus esculentus*

Family - Malvaceae

The crop is cultivated for its young tender fruits. It is major vegetable crop, available round the year having high export potential. Important varieties Arka anamika, Pusa makhamali, Parbhani kranti, Pusa sawani, etc.



Fig. 15.29 Okra

e. Potato - *Solanum tuberosum*

Family-Solanaceae

It is the top ranked vegetable grown in the world. It has high food value. It is grown for its stem tubers. It is a cool season crop. The aerial part of the stem is hollow, except its nodes. The tuber is shortened, thickened stem bearing buds. Potato tubers are used as a fresh vegetables and can be processed into many products.

Important varieties-Kufri Badashaha, Kufri Sindhuri, Kufri chandramukhi, Kufri Chamatkari, Kufri Jyoti, etc.



Fig. 15.30 Potato

f. Cucumber - *Cucumis sativus*

Family - Cucurbitaceae

Vine crop grown for its tender fruits which are usually used as salad. The stems are long and trailing. The fruits are elongated and



Fig. 15.31 Cucumber

cylindrical, vary in size and sometimes can be oval or short.

Important varieties - Japenese long green, Poona Khira, Sheetal, Pusa Sanyog, etc.

g. Carrot - *Daucus carota*

Family - Umbeliferae

Grown for its delicious tap roots. Roots are highly nutritive and useful as a salad

Important varieties - Nantes, Pusa yamdagni, Pusa kesar, Chantaney, etc.



Fig. 15.32 Carrot

h. Amaranthas - *Amaranthas species*

Family - Amaranthaceae

Entire young plant is used as a leafy vegetable

Important varieties - *Chhoti Chaulai*, *Badi chaulai*.



Fig. 15.33 Amaranthus

i. Onion - *Allium cepa*

Family - Amarylidaceae/ liliaceous

It is biennial herb with a characteristics smell. Bulb is formed by the attachment of swollen leaf bases the is formed by the

attachment of to underground part of stem which is small and rudimentary.

Varieties – Arka kalyan, Arka Pragati, Baswant-780, N-53, Agrifound dark red, Agrifound light red.



Fig. 15.34 Onion

15.1.6 Exotic Crops

The crops which are not indigenous to country are known as exotic crops.

Certain exotic crops are becoming popular in India. Indian farmers have started growing exotic crops as they are in great demand in Indian market and have scope for export. Exotic fruit like dragon fruit is becoming popular and fetches higher price in domestic market.

a. Broccoli - *Brassica oleracea var.italica*

Family - cruciferae

Braccoli is a cruciferous vegetable. It contains high amount of many nutrients, fibre, Vitamin C, Vitamin K, etc. Braccoli also contains more protein than other vegetables. Varieties-Calabrease, Brouzino, etc.



Fig. 15.35 Broccoli

b. Zucchini - *cucurbita pepo*

Family - cucurbitaceae

It is known as type of summer squash which can reach nearly 1 m in length. It is usually harvested when still immature. Some cultivars have dark green or deep yellow colour. Varieties - Raven, Bush baby, Black beauty, faudbook, etc.



Fig. 15.36 Zucchini

c. Dragon fruit (*Pitaya*) - *Hylocereus species*

Family - Cactaceae

Dragon fruit is very strange looking fruit. The dragon fruit is also known as a pitahaya or pitaya. Dragon fruit plant sowing is excellent in the less rainfall areas. Varieties - Pitaya rosa, pitaya blanca, etc.



Fig. 15.37 Dragon fruit



Remember this

Dragon Fruit is used in jams, ice creams, jelly production, fruit juice, wine face packs.

d. Celery - *Apium graveolens L.*

Family - Apiaceae

It is marshland plant has been cultivated

as vegetable since antiquity. Celery has long fibrous stalk tapering into leaves. Its stalk, leaves or hypocotyle are eaten and used in cooking.

Varieties - standard bearer, weigh grove giant, etc.



Fig. 15.38 Celery

f. Lettuce - *Lactula sativa L.*

Family - Asteraceae

It is an annual plant. It is often grown as a leafy vegetable but sometimes for stem and seeds. Lettuce is mostly used for salads. It can also be used in soups, sandwiches and wraps.

Varieties - Great lakes, Chinese yellow, slobolt, etc.



Fig. 15.39 Lettuce

15.1.7 Flower crops

Flowers symbolize beauty, love and tranquility. Besides their aesthetic value, they are important for their economic uses such as cut blooms and for extracting essential oils. In India flowers are sanctified and used for worshipping.

The important flower crops.

a. Rose - *Rosa spp.*

Family - Rosaceae

It is a beautiful flower and accepted all over the world. It is grown on commercial scale and on amateur basis.

Rose is propagated by shield budding method.

Varieties-Gladiator, Superstar, Double delight, Devine, Dekore, etc.



Fig. 15.40 Rose

b. Jasmine - *Jasminum species*

Family - Oleaceae

About 200 species of jasminum have climbing or shrub type growth habit.

Mogra, Jai, Jui, Chameli are the Important types they are particularly grown for their scented loose flowers

Parimullai and Co-2 (Jui)

CO-1 (Chameli)

Gundumalli, Ramban, Madanban (Mogra)



Fig. 15.41 Jasmine

c. Chrysanthemum - *Chrysanthemum species*

Family - Asteraceae

Annual and perennial types are found. It is grown for flowers, in pots and garden for decorative purposes. It is propagated by suckers.

Snowball, Potomal, M-24, Agnishikha, Navneet yellow, Gauri, Pournima, etc.



Fig. 15.42 Chrysanthemum

d. Marigold (*Zendu*) : *Tagetes erecta* (African marigold) *Tagetes patula* (French marigold)

Family - Asteraceae

Grown for composite flowers which are in great demand during festive season.

Varieties - Giant double, Cracker jack, Charm, Butter scotch, etc.



Fig. 15.43 Marigold

e. Tuberose (*Gulchadi / Nishigandha*) - *Polyanthes tuberosa*

Family - Amaryllidaceae

White scented flowers are used for garlands

Essential oil is extracted from flowers is used in perfumery and cosmetic. Tuberose is propagated by bulbs.

Varieties - Arka Nirantara, Shringar, Prajwal, Kalyani double, Vaibhav, Pearl, Svasini, etc.



Fig. 15.44 Tube Rose

f. Gerbera - *Gerbera jamesonii*

Family - Asteraceae

Gerbera is also known as Transval daisy. Long stalked flowers also stay long in Vases. It is grown in open fields and under cover also. Flower have export potential. It is propagated by suckers and tissue cultured seedlings.

Varieties -Ruby red, Dusty, Shania, Superniva, Maria, Black jack, etc.



Fig. 15.45 Gerbera

15.1.8 Ornamental plants

Ornamental plants are those plants which are used for beautification of surrounding by virtue of the attractive form, flower, foliage, growth habit of the plant.

Botanically ornamentals are widely spread over entire plant kingdom. They are used in garden, houses, pots, roads, etc.

There are different categories of ornamental plants. They are classified according to their growth habit and use

- (1) Herbaceous perennials-coleus, aglonema, diffenbachia, etc.
- (2) Flowering annual-Aster, marigold, hollyhock, spider flower, etc.
- (3) Shrubs-Croton, duranta, hamelia, tecoma, hibiscus, musanda, etc.
- (4) Trees- Gulmohar, Pilmohar, Bahavra, Kanchan, etc.
- (5) Climbers and creepers- *sankrant vel*, Argannillea, etc.
- (6) Grasses and bamboos- Ribbon grass, etc.
- (7) Bulbous plants- lilies, gladiolus, dahlia, Tulip, etc.
- (8) Cacti and succulents –Sanpendro cactus, oldman, old lady, etc.
- (9) Palms –Areca palm, fishtail palm, bottle palm, etc.
- (10) Hydroplants-Lotus, Nehmbo, hyacinth, etc.

Exercise

Q 1 A. Fill in the blanks.

1. Plantation is the term used for large scale unit usually of a ----- crop.
2. Cardamom is universally known as ----- of spices.
3. Amla contain Vitamin ----- in large scale.
4. Potato is an example of ----- tuber.
5. Lettuce leaves are used as ----- vegetable.

B. Make the pairs.

- | A | B |
|-----------------|-----------------|
| 1. Tea | a. Exotic crop |
| 2. Coconut | b. Kerala |
| 3. Sandalwood | c. Assam |
| 4. Brinjal | d. Savoy |
| 5. Dragon fruit | e. Edible oil |
| | f. Valuable oil |
| | g. Manjarigota |

C. Find the odd out.

1. Tea, Coffee, Cocoa, Coconut, Clove.
2. Black pepper, Cinnamon, Cardamom, Chilli, Cabbage
3. Rose, Chrysanthemum, Gerbera, Marigold, Coriander
4. Aster, Marigold, Hollyhock, Croton, Gaillardia
5. Sandalwood, Geranium, Khus, Senna, Cucumber

D. State true or False.

1. Tea and coffee are prepared from same plant part.
2. Coir is an important product made from coconut husk.
3. Edible part of cauliflower is known as curd.
4. Tamrind is used as seed spice.

5. Fruit of *Curcuma longa* plant has commercial use.

Q 2 Answer in brief.

1. Write short notes on
 - (i) Write short note on importance of spice crops.
 - (ii) Ornamental plants
 - (iii) Indian medicinal plants
2. Give difference between.
 - (i) Plantation crops and field crops.
 - (ii) Vegetable crops and flower crops
 - (iii) Medicinal and aromatic plants
3. Give reasons for.
 - (i) Vegetables are called as protective food.
 - (ii) Exotic crops are getting popularity in India.
 - (iii) Sandalwood is a valuable commercial tree.
4. Give examples of
 - (i) Commercial beverage crops
 - (ii) Aromatic plants
 - (iii) Medicinal plants
 - (iv) Vegetable crops
 - (v) Ornamental plants
5. Answer in brief.
 - (i) Write in brief about commercial importance of rubber.
 - (ii) Write in brief – Importance of coconut

Q 3 Answer the following questions.

1. Explain with the help of examples.
 - (i) Medicinal properties of vasaka
 - (ii) Uses of lemon grass.

2. Complete the table.

Crop	Botanical name	Useful plant part	Commercial uses
Cocoa			
Coconut			

Q 4 Answer following questions in detail.

1. Explain in detail importance and classification of spices.
2. Complete the following table

Sr. No.	Crop	Growth Habit	Useful plant part	Productive areas
1	Coconut	Tall monocot tree		
2	Cardamom		Black seeds	
3	Rose		Flower	
4			Stem tuber	Kufri
5		Evergreen shrub		Assam

3. Read the given following paragraph and answer the questions.

The tree of amla is small to medium in size, usually deciduous; the leaves are simple, subsessile and closely set along branchlets, light green, resembling pinnate leaves.. The fruit is nearly spherical, light greenish-yellow, quite smooth and hard on appearance, with six vertical stripes or furrows. Ripening in autumn, the berries are harvested by hand after climbing to upper branches bearing the fruits. The taste is sour, bitter and astringent and it is quite fibrous. Indian gooseberry is a common constituent, and most notably is the primary ingredient in an ancient herbal Chyawanprash. The fruit is commonly pickled with salt, oil, and spices, murabbah, a sweet dish made by soaking the berries in sugar syrup until they are candied. It is traditionally consumed after meals. Popularly used in inks, shampoos and hair oils. Fruit contains vitamin C and is used against cough, cold and as a laxative in hyperacidity.

Questions

- a. Which is an ancient herbal product made from amla?
- b. Which Vitamin is obtained from Amla fruits on large scale?
- c. How amla fruit looks in appearance?
- d. Mention uses of amla fruit.
- e. How amla fruit is in taste?

Activity :

Visit any farm growing horticultural crop and collect information on package of practices of that crop.

Agriculture Science and Technology

Practical syllabus std - XI

Practicals

1. Identification of rocks and minerals.
2. Study of soil profile. Collection and preparation of soil sample for analysis.
3. Study of meteorological equipments.
4. Study of important measurement units used in agriculture and their conversion.
5. Identification of seed and plant parts.
6. Calculation of seed rate, plant population,
7. Study of seed treatments and practicing different methods of sowing
8. Calculation of pure living seed percentage and physical purity percentage of seed.
9. Identification of manures and fertilizers and calculation of their quantity as per the recommendations.
10. Calculation of duty and delta of irrigation.
11. Erection and maintenance of drip and sprinkler irrigation systems.
12. Estimation of cost of fitting drip irrigation system for unit area.
13. Identifying and handling of different tillage implements and garden tools.
14. Practice of seed bed preparation.
15. Identification of different types of weeds and study of their control methods.
16. Study of major pest and diseases and their control measures.
17. Layout preparation for fruit orchard and preparation of pits for plantation.
18. Practicing training, pruning and other horticultural operations.
19. Study of design and construction of farm pond.

Visits

At least four visits from the following list should be conducted.

Separate section of visit report should be kept in the journal.

1. Visit to soil testing laboratory.
2. Visit to meteorological observatory.
3. Visit to seed farm / seed plot.
4. Visit to fertilizer factory.
5. Visit to bio-gas plant/vermicompost unit.
6. Visit to farmers producer company/multi purpose co-operative society.
7. Visit to farm for observing drip and sprinkler irrigation unit.
8. Visit to fruit orchard to observe different horticultural operations.

Project work

Complete any one of the following projects.

1. Collection of weeds and preparation of weed album.
2. Collection of insects and preparation of insect box.
3. Collection of organic and inorganic fertilizers.
4. Collection of seed samples and preparation of herbarium.

Agriculture Science and Technology
Specimen question paper (Practical) std - XI

	Marks
Q. 1) Identification	6

- A) Identify**
- B) Subquestion**

Note : In all 6 Specimens should be kept, each carrying 1 mark ($\frac{1}{2}$ mark for identification and $\frac{1}{2}$ mark for correct answer of subquestion)

Q. 2) Solve any two of the following.	6
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- A) Mathematical problem from practical syllabus (viz. seedrate / plant population / physical purity / pure living seed).**
- B) Mathematical problem from practical syllabus (viz. quantity of fertilizers / duty and delta of irrigation / conversion of measurement unit from one system to another system).**
- C) Theoretical question from practical syllabus.**

Q. 3) Practical exercise (any one)	6
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- A) Seed treatment**
- B) Seed bed preparation**
- C) Method of sowing**
- D) Practice of training or pruning or any other horticultural operations.**
- E) Collection and preparation of soil sample for analysis**
- F) Tying and handling of tillage implements**

Q. 4) A) Viva-voce - 02	6
B) Journal - 04	

Q. 5) Project or visit report	6
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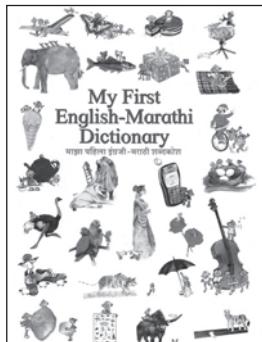
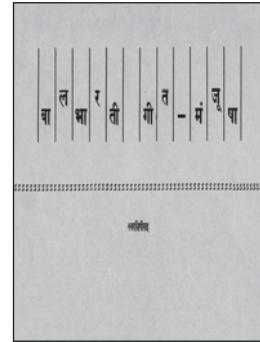
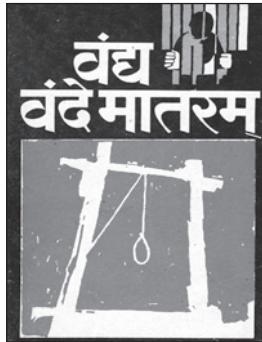
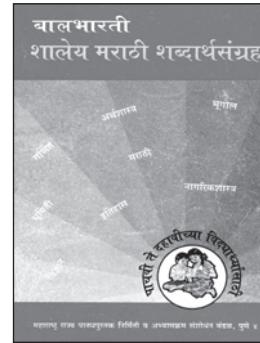
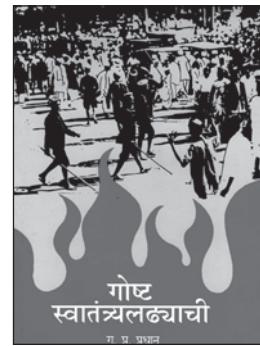
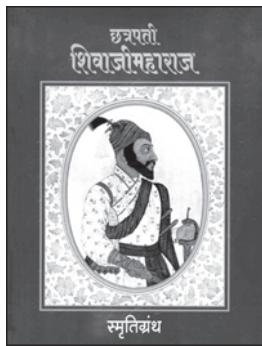
Any one report on project or the visit actually given by the student during the academic year.

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22. Commercial Production of Horticultural Crops - H. N. Samaddar, Naya Udyog, Kokata.
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32. Textbook of Crop Production Std-XI and Std-XII - Maharashtra State Board of Secondary and Higher Secondary Education, Pune.

NOTES

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- पाठ्यपुस्तक मंडळाची वैशिष्ट्यपूर्ण पाठ्येतत्र प्रकाशने.
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