BOTANY

CROP PRODUCTION

UNIT-I: SOILS, SOIL FERTILITY TILLAGE & WEED CONTROL

UNIT-II: CROP PRODUCTION

DR. B.R. AMBEDKAR OPEN UNIVERSITY
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P R E F A C E

This book deals with crop production included in the syllabus for the third year of the B.Sc Course offered by the Andhra Pradesh Open University. The topics generally cover a special area of the subject to be studied in the Third Year of the Three Year Degree Course in Science. The syllabus for the sake of convenience, is divided into Blocks, each of which comprises a number of units. Each Block generally covers a specific area of the subject. The units are prepared by the specialists in accordance with a format so designed as to enable the student to read and understand them without much difficulty. Each unit begins with a statement of its contents followed by objectives. In order to cheque the students understanding ability some questions are introduced here and there in the unit. The students can write the answers in the space given below the every question and compare their answers with those given at the end of the unit. Each Block has at its end assignments intended to test the students comprehension of the subject matter. Technical terms with which the student may not be generally familier are also given at the end of each Block under the head "Glossary".

The special paper on "Crop production" is included mainly to acquint the students with the modern techniques of Agriculture. India has been known since times immemorial as a country rich in natural resources. Its economy is essentially agrarian which is the reason why its economic progress or prosperity depends upon the improvement of its agriculture as evidenced by the upward turn taken by it as a result of the 'Green Revolution'. The extensive research undertaken today to step up agricultural production through new cultivational technologies and production of improved varieties of seeds is of utmost importance to India's economic future.

The University hopes that this material will help the students to undertake the cultivation of different crops. Critical suggestions for improving the text are most welcome and they will be incorporated in the future edition.

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BLOCK - I
SOILS, SOIL FERTILITY TILLAGE AND WEED CONTROL

UNIT-1 : AGRICULTURAL METEOROLOGY

Contents

1.1. OBJECTIVES

By the end of this Unit you will be able to:

1. define Solar Radiation and describe the sunshine recorder used for the measurement of the duration of sunshine,
2. define temperature and list out the factors that affect the atmospheric temperature,
3. describe the effect of temperature on the growth of different crops,
4. define windward and leeward sides and name the instruments for identifying the wind direction and wind velocity,
5. describe the effect of wind on crop growth,
6. define atmospheric humidity and describe its effect on crop growth,
7. list out the factors affecting evaporation,
8. describe the different types of rain and different instruments for the measurement of rainfall, and
9. describe the effect of rainfall on crop growth.

1.2. INTRODUCTION

Agricultural meteorology is a branch of physics dealing with day to day conditions of atmosphere and reasons for variations that occur in the atmosphere, and their influence on crop production.

Climatology is a science that deals with average atmospheric conditions including trends, probabilities and extreme weather conditions for a longer period of time, covering different regions on earth surface.

When it is desired to describe the physical condition of the atmosphere at any place which is normally expressed in terms of weather, the following weather elements must be studied- (1) Solar radiation (2) Air temperature (3) Atmospheric pressure (4) Wind movement (5) Relative humidity (6) Evaporation and (7) Clouds and rainfall.

1.3 SOLAR RADIATION

Transmission of radiant energy through electromagnetic waves, emitted by the Sun to the Earth, without any medium (radiation) is known as solar radiation. Of the total solar radiation, 23% is reflected by clouds, 9% is scattered back to space by suspended particles and 2% is reflected to space by Earth surface (albedo). About 19% solar radiation is absorbed by water vapour, gases and suspended particles and 47% absorbed by Earth. The radiant energy absorbed by the Earth is converted into heat energy resulting in a rise in temperature. When the temperature rises, the Earth radiates back the heat to the atmosphere which is known as 'terrestrial radiation'. The atmosphere is not directly heated by solar radiation though it stands between the Sun and the Earth (Fig. 1.1).

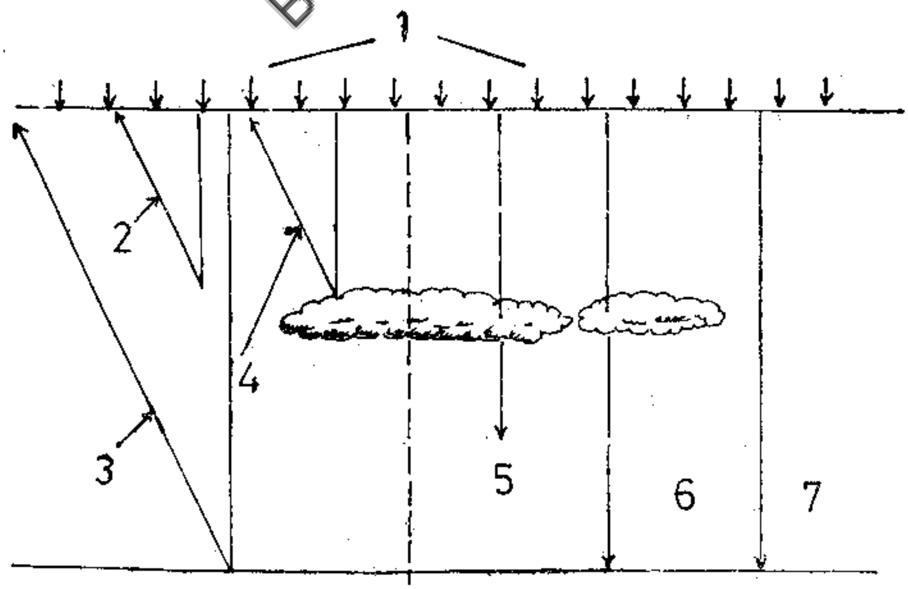

Fig. 1.1. Heating of earth and its atmosphere by insolation. 1. Radiation from sun 100%. 2. Scattered into space 9%. 3. Reflected by earth 2%. 4. Reflected from clouds 23%. 5. Absorbed in atmosphere 19%. 6. Absorbed at Earth, diffuse and scattered 23%. 7. Absorbed directly by Earth 24%.

Solar radiation provides two essential needs of plants.

a) It provides light. This is required for the synthesis of green chlorophyll pigment in the plant. It is capable of absorbing radiant energy, and convert it into chemical energy of carbohydrates through the process of photosynthesis. It is also required for seed germination, growth, flowering and fruiting.

b) Thermal energy required for normal physiological functions of the plant.

1.3.1. Measurement of Sunshine

The number of bright sunshine hours available during the crop growth, influences the growth activity, photosynthetic rate and yield.

Campbell Stokes Sunshine Recorder is commonly used for measuring the duration of the sunshine (Fig. 1.2). It consists of a glass sphere which converges the sun's rays to focus on a graduated strip of chemically treated card inserted in grooves of a metallic hemispherical bowl. The hot sun rays reaching the card burn the card and leave a charred line. The extent of charred line in the card indicates the period of bright sunshine hours in a day.

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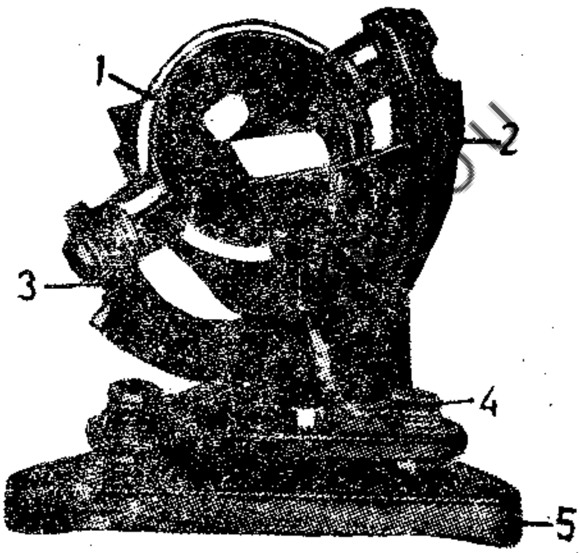

Fig. 1.2. Sunshine recorder. 1. Glass sphere. 2. Hemispherical metallic bowl. 3. Chart. 4. Levelling screw. 5. Base.

Light affects the plant in three ways : intensity, quality (Wavelength) and duration (Photoperiod).

1.3.2. Light Intensity

The variations in light intensity are always interlinked with change in temperature and relative humidity and it would be difficult to estimate the light effects alone. In photosynthesis about one per cent of the light energy is converted into potential chemical energy. Very low light intensity reduces the rate of photosynthesis. This results in reduced vegetative growth of the plants. very high light intensities increase the rate of respiration and disturb the photosynthesis and respiration balance. It causes rapid loss of water, resulting in closure of stomata. Further, at high light intensities, cell contents are oxidised by atmospheric oxygen which is known as photooxidation (solarisation).

1.3.3. Quality of Light

When white light is passed through a prism it is dispersed into wavelengths of different colours from violet to red with wave lengths ranging from 400 to 750 millimicrons. This is being absorbed during photosynthesis, Red light seems to be the most favourable light for growth followed by violet-blue. Short wave radiation below 400 millimicrons such as X-rays, gamma rays, ultra-violet rays and long wave radiation beyond red such as infrared are detrimental to growth.

1.3.4. Duration of Light

The response of plants to the relative length of day and night is known as 'Photo-periodism'. Plants which grow normally when the photoperiod is greater than a critical minimum (more than 12 hours of illumination) are called 'long day' plants and those develop normally when the photoperiod is less than a critical maximum (less than 12 hours of illumination) are called 'short day' plants. Some plants not affected by photoperiod are called 'dayneutral' plants. Plant characters like flower initiation, floral development, bulb formation, rhizome production etc. are influenced by photoperiodism. If a long day plant is subjected to short day periods, the internodes may be shortened to give a rosette appearance and flowering will not take place. In the same way when a short day plant is subjected to a long day period, the growth of the plant becomes abnormal and there is no flower initiation. Among crop plants soyabean, maize and millets are examples of short day and sheat barley and sugar beet are long day plants. The others are intermediate.

Check Your Progress - 1

What is meant by Photoperiodism?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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1.4. ATMOSPHERIC TEMPERATURE

Temperature is considered a measure of intensity of heat energy. There will be differences in temperature from place to place and from time to time. The factors affecting temperature of atmosphere are : (1) Difference in latitude, (2) Difference in altitude, (3) Prevailing winds, (4) Proximity to water body and oceanic currents, (5) Clouds and rainfall, (6) Slope of the land, mountains etc., (7) Other conditions of atmosphere.

1.4.1. Temperature Measurement

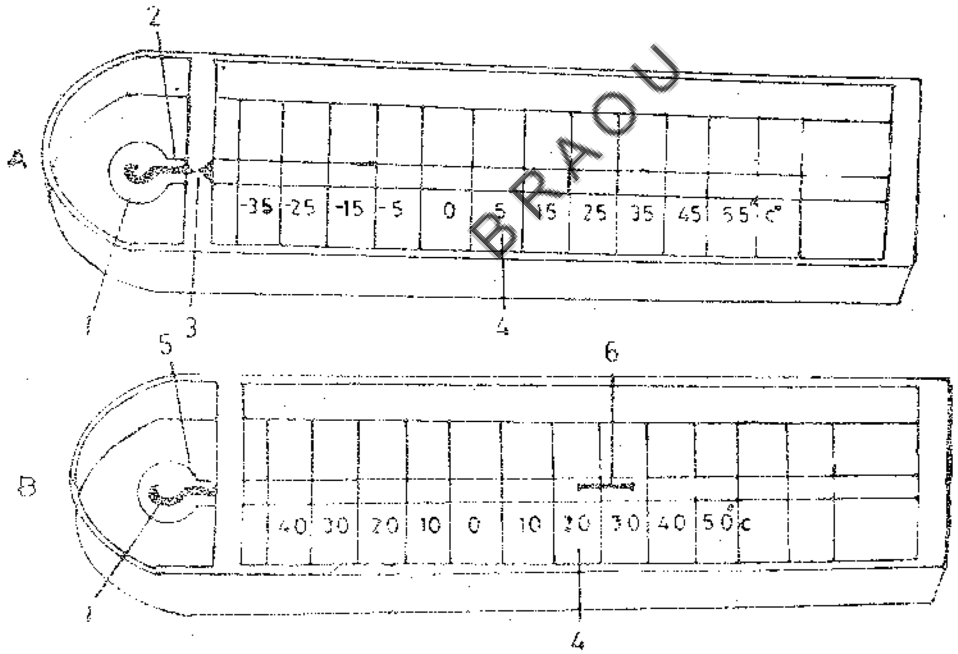
There are two common scales or units for measuring temperature viz., Fahrenheit and Centigrade. The Fahrenheit scale is invented by a German Scientist. Daniel Fahrenheit in the year 1710. The Centigrade thermometer which is also called Celsius thermometer is invented by the Swedish Astronomer, Andus Celsius in the year 1742. The Conversion formula is :

$$C = (F - 32) \times \frac{5}{9}$$

$$F = C \times \frac{9}{5} + 32$$

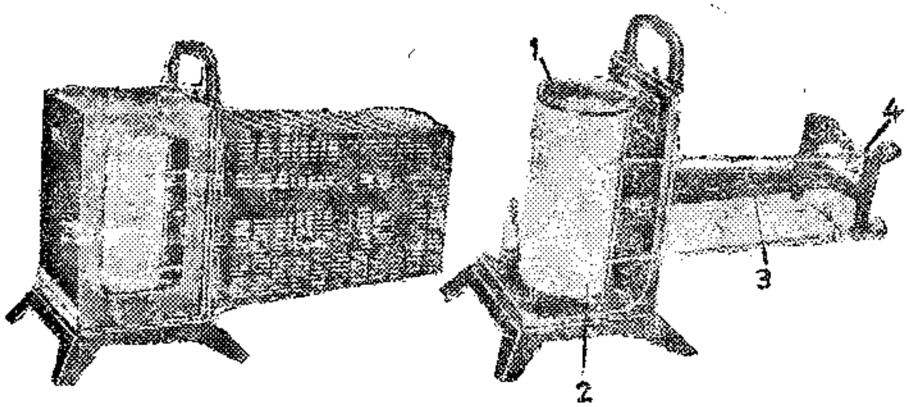
For recording the temperature of the atmosphere, it is useful to know the highest and lowest temperatures that occur in a day. The maximum thermometer is a glass mercury thermometer with a constriction in the bore near the bulb (Fig.1.3). The constriction allows the expanding mercury to pass as the temperature rises but when cooling occurs, the column of mercury breaks at the constriction leaving a part in the bore to register highest temperature. It is reset by whirling (thorough jerking) so that the detached thread of mercury passes through the constriction.

The minimum thermometer has a larger bore and it is filled with colourless alcohol. A tiny dark index in the shape of a long dumbbell is placed in the bore below the top of the alcohol column (Fig.1.3). With decrease in temperature during night the alcohol contracts and its concave surface pulls the index towards the bulb. When alcohol expands with a rise in temperature, it leaves the index behind to record the lowest temperature. Resetting of minimum thermometer is accomplished by tilting until the index slides down to touch the miniscus. Maximum and minimum thermometers are mounted horizontally in Stevenson screen.



(Fig) 1.3. Maximum and minimum thermometer. A. Maximum thermometer. B. Minimum thermometer. 1. Bulb. 2. Mercury. 3. Constriction. 4. Scale. 5. Alcohol. 6. Index.

A thermograph which works on a principle of varying coefficient of expansion and contraction of bimetallic element with indicating pointer which makes ink marking on graph sheet mounted on clock drum. This records continuous temperature of air (Fig. 1.4).



(Fig) 1.4. Thermohygrograph. 1. Rotating drum. 2. Thermo-hygrograph chart. 3. Pen arm. 4. Lever mechanism.

1.4.2. Effect of Temperature on Crop Growth

Plants can grow only within certain limits of temperature. For each crop there are minimum, optimum and maximum temperatures for different stages of crop growth, known as cardinal points.

(1) The minimum growth temperatures below which growth does not take place.

(2) The optimum temperatures at which growth takes place most rapidly and

(3) The maximum temperature above which growth ceases.

When light is not a limiting factor the various bio-chemical processes associated with photosynthesis are controlled by temperature. Crops vary in their response to low light temperatures. Certain crops such as potatoes and sugar beets store carbohydrates more rapidly during periods with cool nights. Cotton, maize and tobacco require warm nights for maximum development.

In general, high temperature accelerates growth processes. When moisture supply is adequate, high temperatures rarely cause the death of plants. High temperature causes sterility in flowers. The photosynthetic process appears to be heat inactivated at excessively high temperatures which however do not inhibit respiration. The harmful effects of excessive temperatures are aggravated when soil moisture becomes a limiting factor. The damage is further increased with hot dry winds.

Heat Injury: Very high temperature often stops growth. The plant faces starvation due to high respiration rates. If such conditions persists for a longer period, the plant is killed. Excessive heat results in defoliation, and premature dropping of fruits.

Chilling Injury: Plants adapted to warm conditions, when exposed to chilling temperatures below freezing point for some time, get killed or injured severely. Some effects of chilling are chlorotic condition or bands on leaves of sugarcane, sorghum and maize when exposed for 60 hours at 2 to 4^{0} C.

1.4.3. Soil Temperature

Seed germination is markedly influenced by temperature. High soil temperatures prevent the seed from germination and even kill the seed. Germination was found to decrease steadily as soil temperatures increased above 20^0 C and ceased completely at 45^0C.

Soil temperature controls the microbial activity and the process involved in the availability of nutrients to plants. Nitrification does not begin until the soil reaches a temperature of above 5^0 C.

1.5. ATMOSPHERIC PRESSURE

The air molecules have a certain weight, and exert force, known as atmospheric pressure. The force exerted is proportional to the number and speed of air molecules which strike in a unit area. Atmospheric pressure is defined as pressure exerted by a column of air on a square inch boundary of the atmosphere and altitude. When air gets heated up, it expands and occupies more space, and the pressure exerted will be less. The atmospheric pressure will be high in regions of low temperature and vice versa. With increase in elevation, the quantity of air mass decreases and will be low. The atmospheric pressure decreases approximately at a rate of 1 inch of mercury column for every 1000 ft. rise in elevation.

1.6. WIND MOVEMENT

Air, in horizontal motion, which moves from a high pressure area to a low pressure area, is known as wind. Vertically moving air columns are called currents. Vertical air movement is connected with formation of clouds and rainfall.

Wind is caused by differential pressures which occur mainly through differences in temperature. When air gets heated, it expands and becomes less dense, and starts ascending. The pressure of heated air will be less in comparison to the surroundings, and therefore denser air is rushed to equalise pressure differences. The wind is best described by its (1) direction and (2) speed or velocity.

The wind is named after the direction from which it comes. Thus wind blowing from the south to the North is called the south wind or southern wind, and the South is the 'windward side' and the North is the 'leeward side' (direction towards which the wind blows).

Wind direction can be noted by a wind vane (Fig.1.5). In a wind vane, the arrow is pointed to the direction from which the wind is coming (windward side).

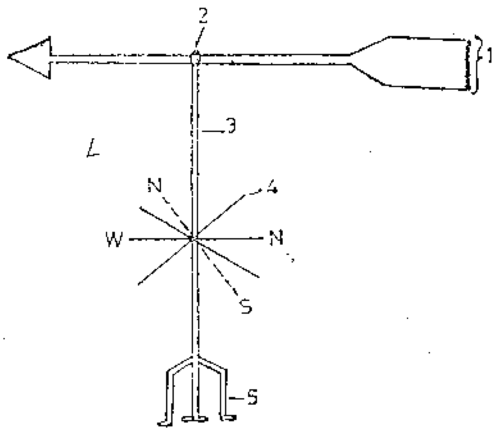


Fig. 1.5. Wind vane. 1. Lever. 2. Top bearing assembly. 3. Vertical axis. 4. Arm. 5. Base.

1.6.1. Wind Velocity

The magnitude of wind is expressed in terms of its velocity. The average velocity of the wind increases with the height from the ground level. Wind velocity is greater at 33 feet height which is about twice than at 1 1/2 feet height. Its velocity is generally more during the day than at night over the land surface, specially in summer and on clear days.

Wind velocity can be measured by means of Robinson's Cup Anemometer (Fig. 1.6).

1.6.2. Effect of Wind on Crop Growth

Winds affect growth mechanically and physiologically. The sand and dust particles carried by the wind may damage plant tissue. Emerging seedlings may be covered or alternatively the roots of young plants may be exposed. Winds cause considerable losses to field crops by inducing lodging, breaking of stalks and the shedding of grain. They cause serious loss to horticultural crops by felling fruit and breaking the branches of trees.

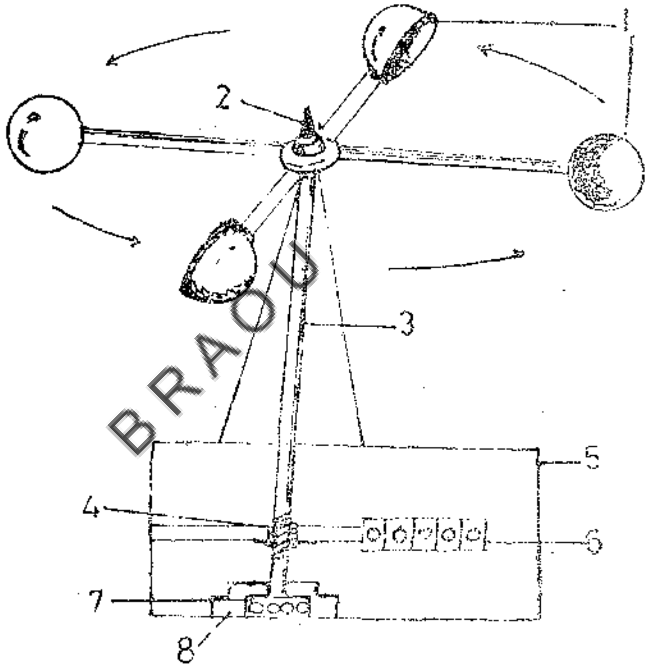


Fig. 1.6. Anemometer. 1. Hemispherical cups. 2. Top bearing. 3. Spindle. 4. Gear. 5. Anemometer box. 6. Cyclometer. 7. Steel ball bearing. 8. Hollow box.

The physiological effects of winds consist mainly in increasing the transpiration and evaporation losses which result in higher water requirement of crops. Hot, dry winds adversely affect the photosynthesis by closing the stomata even under enough soil moisture conditions which results in ill-filled grains. In deserts, wind causes constant soil erosion and makes it difficult for plants to grow.

Moderate winds have a beneficial effect on photosynthesis by continuously replacing the carbon dioxide absorbed by the leaf surfaces. They also help in pollination of crops. They aid in winnowing of grains (separating the grain from glumes and other plant materials): wind is also useful for lifting water from a well by means of a wind mill. They keep down the atmospheric temperature.

Check Your Progress - 2

What for the windvane and anemometer are used?

Note: (a) Write the answer in the space given below.

(b) compare your answer with the one given at the end of this unit.

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1.7. ATMOSPHERIC HUMIDITY

Humidity refers to the water vapour content in the atmosphere. when water is converted into vapour by evaporation. it gets distributed as minute droplets suspended throughout the atmosphere. The humidity of the atmosphere depends upon the temperature, the wind speed, the vegetation and the water content of their soil. The higher the temperature, the higher the amount of water vapour held in the atmosphere. It is this reason why the humidity in summer is higher than in winter season.

1.7.1. Relative Humidity

Relative humidity values can be recorded by a hair hygrometer or hygrograph. Both work on the principle that human hair lengthens with increase in relative humidity and contracts with decreasing relative humidity. The tension of a small bundle of hair is linked to an indicator in a hygrometer which gives, directly, relative humidity values on a dial. In a hygrograph there will be an amplifying lever to which a pointer is fixed, which makes marking on a graph fixed on a clock drum just as in the thermograph.

1.7.2. Effect of Humidity on Crop Growth

The evaporation of water from the soil and transpiration from plants is mainly dependent on the relative humidity of the atmosphere. The amount of evapo-transpiration losses are directly proportional to the difference between the amount of water vapour actually present and the amount that would be needed to saturate the atmosphere. High humidity reduce evapotranspiration losses, and thereby reduce the water requirement of fungi, bacteria and insect pests which affect the crop seriously. Low humidity in the atmosphere increases evapo-transpiration losses, resulting in greater water requirement of crops. Prevalence of low humidity at the grain filling stage, reduces the yields.

1.8. EVAPORATION

It is the process in which the liquid form of water is converted into a vapour form. When water is heated by solar radiation, it is converted into a vapour form, and escapes into space, and is mixed with other gases in the air. The supply of water vapour to the atmosphere is through the process of evaporation from the soil, open water bodies and also from droplets of water held in the form of clouds or fogs.

1.8.1. Factors Affecting Evaporation

(a) Temperature of water: Evaporation increases with an increase in temperature, and vice versa.

(b) Relative humidity: Evaporation is inversely proportional to humidity of the atmosphere.

(c) Wind movement : Wind is the transport agency of water vapour from its site to different parts of the atmosphere. The greater the wind movement the more will be the evaporation.

(d) composition of water : the presence of salts and other impurities reduces the evaporation. Ocean water evaporates five per cent less than fresh water.

(e) Area of water bodies : Evaporation is considerably less when the area of exposure to heat energy is reduced.

1.8.2. Measurement of Evaporation

Evaporation is measured by an instrument known as U.S.W.B.Open Pan Evaporimeter (Fig. 1.8). It consists of a cylindrical reservoir made of copper or G.I.sheet having a diameter of 120 cm and a height of 25 cm. It is protected from the birds by a covering of hexagonal wire mesh and both are painted with white paint. A 'hook gauge' which rests on a "stilling well" works on a principle of screw guage to determine the evaporation accurately by measuring the differences in the level of water from the previous day. The hook guage has its stem divided into 100 divisions so that the level of water may be read correct to one thousand of an inch.

Stilling well is merely a metal cylinder mounted on a steel platform with levelling screws and is kept in an open pan and the water level in this is maintained at the same level as the open pan through a small hole at the bottom of the stilling well. The object of the stilling well is to isolate a small portion of the water in the reservoir to keep it free from waves produced by the wind. This enables the measurement of the water level to be made by the hook guage accurately. The open pan rests on a wooden platform of 10 cm height.

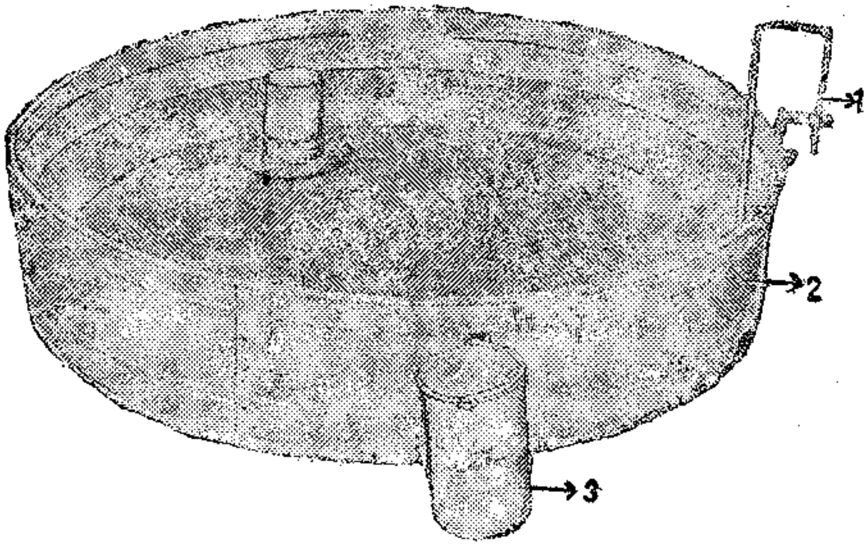

Fig. 1.7. Open pan evaporimeter U.S.W.B. class 'A'. 1. Hook guage. 2. Open Pan. 3. Still well.

Check Your Progress - 3

List out the factors that affect evaporation.

Note: (a) Write the answer in the space given below.

(b) compare your answer with the one given at the end of this unit.

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1.9. CLOUDS

When the air gets heated, it rises upward and expands, and is cooled at the regular adiabatic rate until the dew point temperature is reached. It is the temperature at which vapour form condenses with visible water droplets around the nuclei of condensation which form clouds or fogs. Cloud is an aggregation of minute droplets of water or ice crystals, suspended in the air. Rising air currents tend to keep the clouds from falling since the water droplets held in the cloud are very small and light. This is the usual way of cloud formation. Clouds are also formed when air masses from the ocean blow over the cool land surface.

1.10. RAINFALL

Small droplets of water in the form of cloud remain suspended in the air due to ascending heated air from the Earth surface. When they are carried upward with the ascending air, there is further cooling, and coalescence of water drops through collision may be achieved. When water droplets increase to a size of 0.2 mm or more, the upgoing air cannot support them against gravity, and they fall down as rain. During their downward passage through the warm air, they are subjected to evaporation and if the amount of water descending down is small, the entire quantity may be converted into vapour form except some traces which are received as a light drizzle.

1.10.1. Types of Rain

1. **Rain due to convection** :Air close to the ground, first gets heated by insulation, thereby getting light in weight and starts an upward motion which is known as convectional motion. As it ascends, it goes on progressively cooling and reaches a stage when precipitation can result: such rains occur mostly in the tropics.

2. **Rain due to cyclones** :Winds from different directions and of different temperatures and densities tend to come towards the centre of low pressure. As a result, the moistureladen huge column of air is lifted and cooled, resulting in a steady and long period of rain. Cyclonic rains commonly occur in the temperate zone and rarely occur in the equatorial region.

3. **Rain due to mountain barrier (Orographic)** : When a moisture laden current of air strikes a mountain range, it is forced to move upward causing condensation and precipitation; rain especially occurs on the wind ward side of the mountain range.

1.10.2. Rainfall Measurement

The amount of rainfall is recorded by an ordinary rain guage. The amount, duration and intensity of rain are recorded by a self recording rain guage. The ordinary rain guage consists of metal cylinder of 12.5 or 20 cm diameter. This is filled with a covering funnel having the same diameter which directs the water into a collecting jar which is kept in the cylinder. The rainfall gathered in the collecting jar is transferred into the glass measuring jar calibrated according the diameter of the funnel for noting down the amount of rainfall for the last 24 hours (Fig. 1.8).

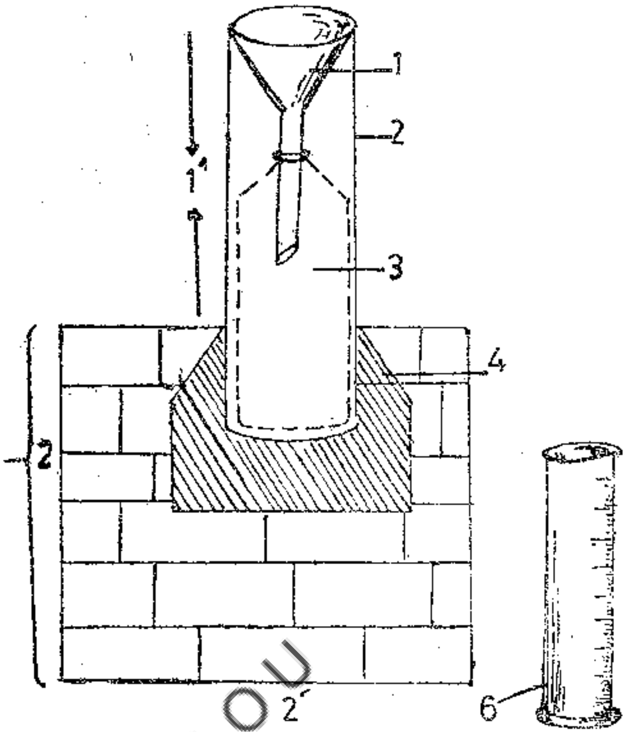

Fig 1.8. Ordinary rain guage. 1. Funnel. 2. Cylindrical body. 3. Collecting jar. 4. Base. 5. Masonary foundation. 6. Measuring jar.

The automatic rain guage consists of a funnel of 20 cm diameter, and the rainfall received is collected through the funnel, into a chamber having a float. The float is connected to an arm with a lever mechanism. The other end of the arm is pointed and inked, which draws the

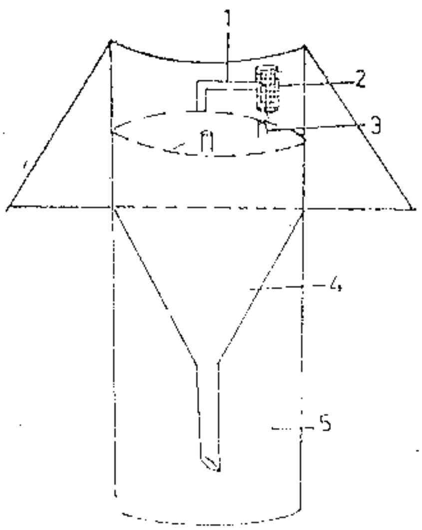

Fig. 1.9. Self recording rain guage. 1. Lever mechanism. 2. Graph sheet. 3. Siphon system. 4. Funnel. 5. Chamber.

mark, on a graph sheet. The graph sheet is wrapped around a drum with a clock mechanism and completes one rotation in a week or a day (Fig. 1.9). The X axis of the graph gives the duration (time) and Y axis gives the rainfall. In case of excess rainfall the apparatus is provided with a siphon system which empties the water from the chamber to bring back the pointer to zero on the Y-axis.

1.10.3. Effect of Rainfall on Crop Growth

Rainfall is one of the most important factors influencing the vegetation. Rain water is the source of soil moisture so essential for the growth of crops. There are optimum moisture conditions for crop development, just as there are optimum temperature conditions. The annual rainfall and its distribution, greatly affects the choice of cultivated crops. Low and ill- distributed rainfall are common features of dry land farming where in drought resistant crops like sorghum, pearl millet (*Pennisetum typhoides*) and Italian millet (*Setaria italica*) and other crops like castor and groundnut are commonly grown. In heavy rain fall regions like the Western ghats of India, rice is grown in flat areas while tea, coffee, rubber, etc are grown on sloping land.

Excessive amounts of water in the soil, limits oxygen supply and alter various chemical and biological processes that increase the formation of compounds that may be toxic to plant roots. On the other hand, a high rate of percolation of water through the soil tends to remove plant nutrients beyond its root zone and affect plant or interfere with flowering and pollination. It packs the surface soil and makes it difficult for tender seedlings to emerge. small grains are often beaten down or lodged by the rain so that the harvest is difficult, and lodged grain is susceptible to spoilage.

Under natural conditions, drought is a serious problem compared to excessive moisture conditions. Thornthwaite defines drought as 'a condition in which the amount of water needed for transpiration and direct evaporation exceeds the amount of available moisture in the soil. The deficiency of soil moisture leads to scarce vegetation, which in turn supply less organic matter to the soil. The plant growth is affected and yields are drastically reduced. Drought occurs under conditions of low and erratic distribution of rainfall and it is further aggravated in soils having less water holding capacity and land use practices which increase run off. Crops grown in soils which have high-water holding capacity are less susceptible to short periods of drought weather.

1.11. SUMMARY

Solar radiation provides light required for photosynthesis and thermal energy for normal physiological functions of plant. Light intensity, quality and duration are important. Temperature of air is mainly influenced by latitude, altitude and other factors like presence of water bodies, winds, clouds and rainfall etc. Each crop has its own cardinal temperature for growth and development. Seed germination was found to be highest at 20^{0} C soil temperature and maximum absorption of water and nutrients take place between 20 to 30^{0} C soil temperature. Atmospheric pressure is influenced by temperature and altitude differences resulting in the formation of low and high pressure belts causing wind movement. Moderate winds are useful in increasing photosynthetic efficiency, pollination of crops, cleaning of the grain from chaffy material (winnowing), and generating power. Strong, dry winds increase the evapo-transpiration losses resulting in partial closure of stomata which effect photosynthetic rate and cause mechanical damage to crop plants. The evapo-transpiration losses resulting in low water requirement of crops but at the same time increase the incidence of pest and diseases. Prevalence of low humidity accompanied by dry winds at grain filling stage results in shrivelling of grain and low yield. Cooling of atmosphere causes condensation of water vapour into small visible water droplets or ice crystals which form cloud or fog. The size of water droplets held in the cloud increases with further cooling and condensation which fall as rain, as vertical air currents cannot support water droplets beyond 0.2 mm diameter. Rain occurs either due to vertical movement of air or cyclonic depressions or mountain barriers. The amount and distribution of rainfall influence the choice depressions or mountain barriers. The amount and distribution of rainfall influence the choice of cultivated crops. Excessive rain limits the oxygen supply and form compounds which may be toxic to roots and cause leaching of nutrients beyond the root zone. Low rainfall conditions lead to poor growth and scarce vegetation with less organic matter supply and this results in low yield of crops.

1.12. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Photoperiodism is the response of plants to the relative lengths of day and night.
2. The wind vane is used to note the direction of wind and the Anemometer is used to measure the velocity of wind.
3. The factors that affect the evaporation are: (a) Temperature of water, (b) Relative Humidity, (c) Wind Movement, (d) Composition of Water and (e) Area of water bodies.

1.13. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. What are the effects of high and low temperatures on crop growth?
2. Explain the process of rain fall occurrence. Describe the effects of high and low rainfall on crop growth.

II. Answer the following questions in about 10 lines each.

1. Explain the importance of solar radiation.
2. What are the effects of wind and humidity on crop growth?
3. What are the different factors that affect the evaporation? How to reduce the evaporation in a cropped area?

UNIT-2: SOILS

Contents

2.1. OBJECTIVES

By the end of this unit you will be able to:

1. list out and describe different types of soils including the problematic soils,
2. suggest the different methods for the reclamation of acid, saline and alkali soils,
3. describe the different ways of losing the soil fertility,
4. describe the different methods for the restoration of soil fertility,
5. define soil erosion and describe the different types of soil erosion,
6. list out the losses due to soil erosion,
7. define soil conservation and describe different methods for the conservation of soil.

2.2. INTRODUCTION

Soil is the natural medium for plant growth. Soils are formed due to weathering of rocks. Weathering refers to the physical and chemical disintegration and decomposition of rocks which are not in equilibrium under temperature, pressure and moisture conditions on the earth's surface.

There are three major types of rocks. They are (1) Igneous rocks, (2) Sedimentary Rocks and (3) Metamorphic rocks.

The productivity of soil depends on the physical properties like texture, structure, density, pore space, plasticity and cohesion, soil temperature, soil air and soil water and chemical properties like, mineral composition, organic matter content and soil pH. Based on the characteristic features of the soils, they have been classified into different groups. The classification of soils helps in their productive use. The following are the types of soils prevalent in A.P.

2.3. COASTAL SANDS

These are very deep 180 cm to 5 meters and over. They are coarse textured, with sandy sub-soils. The Water table is close to the surface. The Groundwater is strongly saline. The pH range from 6.5 to 7.5 (neutral). They are with low exchangeable capacity due to negligible clay content. Generally nurseries of rice and tobacco are raised. Vegetables are also grown in small areas. *Casuarina* and cashew plantations can be taken up. These soils are present all along the eastern coast, in the districts of Srikakulam, Vizag, East and West Godavari, Krishna, Guntur, Prakasam and Nellore.

2.4. DELTOIC ALLUVIUM

These soils are very deep, over 180 cm. The soils reaction is neutral to alkaline (pH 7.0 to 9.0). The exchange capacity is usually high. Fertile clay minerals are varying due to deposition of silts of varying composition. The crops that can be grown are rice, turmeric, sugarcane, banana, chillies, vegetables, maize, cotton and groundnut mostly under irrigation. These soils are prevalent in some parts of East and West Godavari, Krishna and Guntur districts.

2.5.. RED SANDY SOILS (DUBBA AND CHALKA SOILS)

The depth of the soils varying from very shallow to shallow (20- 60 cms). The Soils are neutral (pH 6.5 to 7.5). They are very low in nitrogen content. The exchange capacity is also low. The crops that can be grown are jowar, bajra, redgram, castor, groundnut etc., under rainfed conditions. Rice is grown under irrigation. A high dose of nitrogen application in splits is necessary to get higher yields of crops. These soils are present in the tracts of Hyderabad, Medak, Guntur, Prakasam. Nellore and Kurnool districts.

2.6. RED EARTHS WITH LOAMY SUB-SOILS

They are extremely shallow to moderately deep (8-75 cm). The pH of the soils range from 6.5 to 7.5. The exchange capacity is low. They are poor in nitrogen content. Nitrogen fertilizers should be applied in splits at intervals. Crops like Jowar, Bajra, Maize, Groundnut under rainfed conditions and Rice, Sugarcane, Turmeric, Cotton, Maize, Chillies under irrigation are grown. These are present in Telangana region and parts of Nellore and Ananthapur.

2.7. RED EARTHS WITH CLAY SUB-SOILS

These are shallow to moderately deep (30-75 cms). They are neutral to weakly alkaline (pH 6.5 to 8.0), and low in nitrogen and phosphorus content. They have a comparatively high exchange capacity than Chalka and dubba soils. These soils are present in parts of Kurnool and Anantapur districts.

2.8. RED LOAMY SOILS

These are shallow to moderately deep (20-75 cms). The pH ranges from 7.0 to 8.5. The soils are low in nitrogen and phosphorus. Crops like Jowar, Bajra, Ragi, Korra, Pulses, Groundnut under rainfed conditions and Rice, Sugarcane are grown under irrigated conditions. These soils are located in parts of Cuddapah, Ananthapur, Chittoor and Nellore districts.

2.9. RED LOAMY SOILS WITH LOAMY AND CLAYEY SUB-SOILS

These are deep to very deep (90 to 180 cm and above). The soil pH vary from 6.0 to 7.2. The nitrogen content is low to medium but phosphorus content is very low. The exchange capacity is low to medium. Some of these soils are famous for mango orchards in Krishna and West Godavari districts. Jowar, Bajra, Redgram and Groundnut are grown under rainfed conditions. Crops like Rice, Chillies, Groundnut and Tobacco are grown under irrigation.

2.10. RED SOILS WITH CLAY SUB-SOILS

The depth of these soils is more than 180 cm. They are non- saline, low in nitrogen and phosphorus but moderate in potassium content. The exchange capacity is also low. Nitrogen should be applied in more number of splits to increase the applied nitrogen use-efficiency. This type of soils are present in the districts like Srikakulam, Vizag and parts of West Godavari and Krishna. The crops grown on these soils are potato, turmeric, ginger, tobacco, Mango and Cashewnut.

2.11. BLACK SOILS (Regurs)

These soils are medium deep to deep 45-90 cms). The pH of the soil ranges from 7.0 to 8.5. They are non-saline, but the salt content is more than in red soils. With regard to fertility status, these soils are low in nitrogen, very low in phosphorus, and medium in potassium. The exchange capacity is high. Nitrogen fertilizer can be applied in less number of splits. These soils are prevalent in parts of Adilabad, Nizamabad, Warangal, Khammam, Medak, Hyderabad, Mahboobnagar, Kurnool, Ananthapur, Nellore and Guntur districts. Rainfed crops like Jowar, Bajra, Pulses, Gingelly, Cotton, Tobacco, Groundnut and irrigated crops like Rice and Sugarcane are grown.

Black cotton soils are very deep heavy clay soils (90-180 cms, and over, depth). The pH ranges from 8.0 to 9.0. Nitrogen and phosphorus contents are low but potassium content is at medium level. This type of soils is predominant in major areas in parts of Cuddapah, Ananthapur, Kurnool, Mahboobnagar, Guntur, Prakasam, Krishna, Khammam and Nellore and smaller areas in Warangal, Adilabad and Nizamabad. Rainfed crops like jowar, maize, pulses, cotton, tobacco, chillies, wheat are raised. Rice, sugarcane, cotton, chillies etc. are grown under irrigation.

Check Your Progress - 1

What are the differences between black soils (regurs) and black cotton soils?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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2.12. LATERITE SOILS

These are deep to very deep (90-180 cm and over), with acidic nature (pH 4.0 to 6.0). They are poor in fertility, and low in nitrogen, phosphorus and potassium. Considerable area is present in Zaheerabad taluk of Medak district and some patches in Kavali taluk of Nellore and Vizag districts and a small pocket in Srikakulam district. Crops like potato, turmeric, ginger, tobacco can be grown.

2.13. PROBLEMATIC SOILS

Soils which cannot be used economically for the cultivation of crops without adopting proper reclamation measures owing to land or soil characteristics are termed problem soils. Highly eroded soils, ravine lands, soils on steeply sloping lands are one set of problem soils. Another set of problem soils are acid, saline and alkaline soils. In these soils crop production is limited due to acidity, and accumulation of soluble salts and exchangeable sodium.

2.13.1. Acid Soils

In humid regions with heavy rainfall, the soluble bases formed in the course of weathering of rocks are leached down and carried away by the drainage water. The continued leaching of salts result in the replacement of calcium, magnesium, potassium and sodium ions by hydrogen ions and the formation of acid soils with low pH. Distinctly, acid soils are situated in the whole of Assam and in some parts of Manipur, Tripura, West Bengal, Bihar, Orissa, M.P., Maharashtra, Karnataka, Tamilnadu, Kerala and Punjab.

Mainly the pH of the soil is used as the criterion to distinguish acid soils from non-acid soils. Based on the pH measurements of the soil, the degree of soil acidity may be indicated as follows:

pH	Reaction
6.6 to 7.5	Nearly neutral
6.1 to 6.5	Slightly acidic
5.6 to 6.0	Medium acidic
5.1 to 5.5	Strongly acidic
4.6 to 5.0	Very strongly acidic
4.5 and below	Extremely acidic

Effects of Soil Acidity: If soil acidity exceeds a particular limit, it is injurious to plant growth. The availability of plant nutrients in soil like phosphorus, calcium and magnesium is decreased with increasing acidity. On the other hand, nutrients like aluminium, iron, manganese and copper accumulate to toxic levels and injure the plant growth. The activity of beneficial micro-organisms like *Azotobacter, Rhizobium* etc. in the soil decreases, as the acidity increases.

Acidity also affects the soil texture. Correction of soil acidity is necessary for cultivating crops successfully.

Reclamation of acid soils: Reclamation of acid soils is done by adding to the soil any compound containing calcium alone, or both calcium and Magnesium capable of reducing acidity known as liming.

Effects of liming on soil and plants: (1) It helps in Neutralising soil acidity (2) The activity of beneficial soil bacteria is encouraged by supplying lime to soil. The bacteria decompose the organic matter quickly and promote nitrification. Thus, liming increases the availability of nitrogen by hastening the decomposition of organic matter, and free living organisms. (3) Liming increases the availability of phosphorus by reducing the solubility of iron and aluminium. (4) It helps in increasing the availability of potassium and molybdenum, (5) Liming supplies calcium for plant nutrition, (6) It improves the soil physical conditions.

The most common liming materials are ground lime stone, burnt lime and hydrated lime. The efficiency of liming materials depends on the chemical composition of material, purity of the material and fineness of the material.

The amount of lime required depends on the following factors; (1) Intensity of soil acidity, (2) Texture of the soil, (3) Lime requirement of the crops included in rotation, (4) Purity of the liming material, (5) Chemical composition of the material, (6) Fineness of particle size.

Table 2.1. Lime requirements of various acidic soils as affected by different soil groups

Soil type	Lime stone requirements (tons/ha)		
	pH 3.5-4.5	4.5-5.5	5.5-6.5
Sandy and loamy sand	0.75	0.75	1.00
Sandy loam	-	1.25	1.75
Loam	-	2.95	3.45
Silt loam	-	2.95	3.45
Clay loam	-	3.75	5.00

Methods of Application: Lime should be evenly broadcasted before ploughing or applied on ploughed land and then worked into the soil several weeks before sowing the crop. when a large quantity of lime is to be applied, it is desirable to apply small quantities two or three times. On strongly acid soils, where three to six tonnes of lime are required, half the quantity should be applied before ploughing and remaining half after ploughing. Keeping the land moist hastens the exchange process.

2.13.2. Saline and Alkali Soils

Saline and alkali soils are formed in arid and semi-arid areas with low rainfall where salts formed in the weathering of soil minerals are not fully leached. During the periods of higher rainfall, than average rainfall, the soluble salts are frequently leached down. By irrigating, the soils rich in soluble salts percolate to the sub-soil or lower layers. If the water from the sub-soil does not drain out easily, the soil water gradually accumulates a high concentration of salts. In areas having a salt layer at lower depths in the profile, seasonal irrigation may favour the upward movement of the salts. Salinisation is also caused due to irrigaiton of soils with saline water.

About 7 million hectares of land are affected by soil salinity or alkalinity in India. These soils occur in the states like U.P. Gujarat, West Bengal, Rajasthan, Punjab, Maharastra, Haryana, Orissa, Karnataka, and M.P. In A.P. about 0.42 lakh hectares is affected. These soils generally occur in association with normal soils in small patches or in big blocks.

Hazards of Soil Salinity or Alkalinity: (1) Causing low yields of crops or crop failure in extreme cases (2) The limiting of the choice of crops because some crops are sensitive to salinity or alkalinity, or to both (3) Affecting the quality of produce (4) Causing excessive run off and floods owing to low infiltration, resulting in damage to crops in the adjoining areas.

Reclamation of Saline and Alkali Soils

1. Test the soil and irrigation water before reclamation.
2. If irrigation water used is saline, switch over to good quality of water
3. Lower the water table beyond 5 feet by drainage.
4. Prepare strong bunds of 2 ft. high around each field
5. If pH is more than 9.0, apply 2.5 to 8.5 tons of powdered gypsum per hectare. Broadcast and mix thoroughly by repeated ploughings.
6. Wash excess salts by flooding the field and allowing water to stand for a fortnight.
7. Apply 80-200 kg Ammonium Sulphate and 200-250 kg of Super- Phosphate/ha and broadcast 25-30 kg of Dhaincha seed for green manuring.
8. After 8 weeks, the Dhaincha crop can be incorporated as green manure crop.
9. Transplant paddy after 2 to 3 weeks of green manuring incorporation. Apply 300 kg Ammonium Sulphate, 1200 kg Super Phosphate and 50 kg Muriate of Potash per hectare for a good crop.
10. Senji, Barley, Berseem or sugarbeet may be sown after paddy.
11. If irrigation is not available, sow Barley after Dhaincha is ploughed, i.e., green manure crop.
12. Repeat the process till normal crop yields are obtained. Addition of gypsum in subsequent years is not necessary.

2.14. SOIL FERTILITY & SOIL PRODUCTIVITY

Soil fertility is the inherent capacity of the soil to supply the essential plant nutrients in adequate amounts in a proper balance for specified plants when other conditions are favourable such as climate, soil moisture, soil reaction etc.

Soil productivity refers to the ability of the soil to produce crop yields. Soil fertility is one of the factors that determine the magnitude of crop yields. The other factors controlling the productivity are the water supply, climate, cultivation practices etc. A soil may be fertile and yet it may not be productive. Thus, a water logged soil may be highly fertile but may not produce a good crop because of the unfavorable physical conditions. Hence, soil productivity is the resultant of various factors influencing the soil management.

Factors controlling the fertility of a soil can be summed up as:

(1) The inorganic plant nutrients of a soil depend on the origin of a soil and the rocks from which the soil was formed.

(2) Organic matter content and water holding capacity in combination with other factors like texture, structure, depth etc.

(3) Biological nature of the soil-capacity of the micro-organisms present in the soil to convert un-available forms of plant nutrients into available forms (mineralisation).

2.15. SOIL FERTILITY LOSSES

Soil fertility loss refers to the loss of plant nutrients from the soil: thereby, the fertility status of the soil is reduced. Soil fertility is lost through different ways as mentioned here under:

1. **Removal of Nutrients by Harvested Crops:** The largest loss of plant nutrients from the soil is by the removal of nutrients by harvested crops from the field. A high yielding crop removes the plant nutrients to a greater extent than the crop raised by traditional varieties. However, the loss of nutrients should be recouped by adding organic residues back to the soil in a proper way.
2. **Removal of Nutrients by Weeds:** Weeds compete with crop plants for nutrients. Weeds have a fast growing habit, thereby removing nutrients from the soil, if weeding is not done early.
3. **Loss of Nutrients by Leaching:** Water soluble fractions of plant nutrients are subjected to loss by leaching into deeper layers of soil to leaching than heavier soils like clayey. Nitrogen is the major nutrient lost mostly by leaching.
4. **Loss of Nutrients by Erosion:** Erosion is the physical removal of soil by water or wind. Due to either water or wind erosion, the top soil, along with its nutrients, is lost.
5. **Loss of Nutrients in Gascous form or Volatilisation:** Nitrogen is lost through this process. Due to the activity of soil micro-organisms, nitrate is denitrified into elemental N_2 and is lost from the soils as a gas.

Check Your Progress - 2

List out different ways through which soil fertility is lost.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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2.16. SOIL FERTILITY MANAGEMENT

Maintenance of soil fertility is important from the productivity point of view. Hence, soil fertility management should be viewed on a permanent as well as a temporary basis. It can be done as follows:

2.16.1. By Cultural Practices

Fallowing (Keeping the field vacant without growing any crop) is a practice to restore the soil fertility. However, this practice is not feasible since there is need to produce more to meet the food requirements of a growing population. Crop rotation is a practice to minimise the loss of soil fertility. Rotation of cereal crops like rice, maize, jowar etc., with legume crops like redgram blackgram, greengram, cowpea, groundnut etc. is a good practice for management of soil fertility.

2.16.2. By Addition of Organic Manures

Addition of concentrated organic manures like oil cakes, bone meal etc. with high nitrogen content and bulky organic manures like farm yard manure compost, night soil, ashes etc. improve the soil fertility. These manures add organic matter to the soil and also supply plant nutrients to the growing crops. By the addition of these materials soil fertility can be improved and also increase the crop yields.

2.16.3. Growing Green Manure Crops and Incorporation in Soil.

Green manure crops like sesbania, pellipesara, cowpea, sunhemp etc. can be grown. When the green manure crops are at flowering stage they have to be ploughed into the soil. This practice improves the organic into the soil content. They add as much as 30- 40 Kg N/ha through the nitrogen fixed in root nodules. Green manuring also improves the soil structure which inturn increases the water-holding capacity of the soil.

2.16.4. Addition of Commercial Fertilizers:

Addition of fertilizers having plant nutrients in high percentage either singly or with one or two nutrients is necessary for proper growth and production of crops. Hence, to maintain soil fertility and sustaining crop production it is necessary to apply both organic manures and inorganic fertilizers.

2.16.5. Addition of Soil Amendments

Soil amendments are added to it primarily to correct unfavourable soil conditions like acidity, salinity and alkalinity, toxicity or poor soil structure. Lime is generally used to correct soil acidity which also supplies calcium. Similarly, to correct salinity and alkalinity, gypsum is used which also supply calcium and sulphur. Silt is added to poor sandy soils to improve the water holding capacity.

2.16.6. Use of Weedicides and Fungicides

Application of weedicides controls weeds properly and eliminates the loss of nutrients by weeds Fungicides like Bordeaux mixture, when used, control diseases and also supply copper and calcium to the growing crop.

2.16.7. Bio-Fertilizers

The role of bio-fertilizers in maintaining soil fertility has been recognised long back. Bio-fertilizers also known as 'microbial inoculants' are the preparations containing living cells of efficient strains of nitrogen fixing organisms used for seed or soil application with the objective of increasing the number of such micro-organisms in the soil to increase the atmospheric nitrogen fixation. Utilisation of biofertilizers decrease dependence on inorganic nitrogenous fertilizers. In many legume crops, about 30 to 40 Kg N/ha is fixed by the activity of *Rhizobium* (bacteria) present in the root nodules. The fixed nitrogen is used by the present growing crop. At the same time some quantity of fixed nitrogen is excreted into the soil, which can be utilised by the succeeding crop.

Check Your Progress - 3

What are Biofertilisers? Give one example.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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2.17. SOIL EROSION

Soil erosion is the process of detachment of soil particles from the parentbody and transportation of detached soil particles by wind and water.

There are three types of soil erosion. They are water erosion, wind erosion and wave erosion.

2.17.1. Water Erosion

Soil erosion due to water occurs in four forms.

1. **Sheet Erosion:** Uniform removal of soil in this layer from the field due to run-off water. This is the first stage of erosion.
2. **Rill Erosion:** After run-off starts, channelization begins and erosion is no longer uniform. In low lying areas small Rills are formed on the ground due to the run-off. This is the second stage of erosion.
3. **Gully Erosion:** Gullies are formed when heavy run-off from a vast slipping land is sufficient in volume and velocity to cut a deep or wide in the field.
4. **Ravines:** Ravines are formed due to prolonged gully erosion. This type of ravines are found in deep alluvial soils. Ravines are deep and wide gullies, and are of advanced stages of gully erosion.

2.17.2. Wind Erosion

The wind picks up lighter soil particles and transports them to long distances depositing them sometimes on fertile soils. Absence of vegetation and trees will enhance the erosion due to wind. The Rajasthan desert is mainly formed by blown sand. It is extending at the rate of half a mile a year over a front of about 100 miles and damaging about 30,000 acres annually.

2.17.3. Wave Erosion

Water and wind combine to form waves. Waves cut back river banks and sea and lake share lines. They swallow fertile land bit by bit.

2.17.4. Losses due to Erosion

The following are the losses due to erosion.

1. **Loss of Fertile Top Soil:** The soil losses from unprotected fields vary from 150 to 350 tons/hectare per year. It takes for nature about 40 to 1000 years to build one inch of top soil from the parent materials.
2. **Loss of Rain Water:** About 80 to 120 mm of rain water is lost by run-off. Loss of rain water in an area of inadequate and uncertain rainfall is very serious.
3. **Loss of Plant Nutrients:** The organic matter of surface soil is removed by erosion. The plant nutrients like nitrogen, phosphorus and potassium are also removed from the top soil to a certain extent. the annual loss of nitrogen, phosphorus and potassium through erosion is estimated at 2.15, 3.8 and 2.6 million tons respectively in India.

4. **Reduction in Soil Depth:** Erosion reduces the depth of the soil which leads to lower crop yields

5. **Reduction of Cultivable Area:** The area under gullies and ravines is unsuitable for cultivation as such:the area under cultivation is reduced.

6. **Increase in Land Slope:** The land slope increases with loss of top soil.

7. **Loss of Fertile Lands:** Wind erosion transforms fertile lands into sandy deserts by covering them with sand.

8. **Silting up of Reservoirs and Ranks:** Eroded soil carried by run off water gets filled up in huge quantities behind dams, water ways etc. The sediment deposited will reduce the storage capacity and life of reservoirs. Ayacut area is reduced and generation of power is reduced.

9. **Floods:** Floods occur when there is heavy rainfall because the runoff is greater than the flow carrying capacity of the rivers. Floods cause loss of human life, cattle, sub-merging villages and towns.

10. **Reduction of Ground Water:** Soil erosion seals the pores on the surface of the ground and prevents or slows down percolation of rain water, thereby, reducing ground water supply leading to drying of wells.

11. **Reduction in Ultimate Crop Yields:**. Because of all the ill effects of erosion, the ultimate yield of any crop will be reduced.

2.18. SOIL CONSERVATION PRACTICES

Soil conservation is using and managing of land, based on the land capabilities by adopting the best practice to achieve profitable production without any damage to the land. Soil conservation practices include mechanical, agronomical and forestry measures. The main aim of soil conservation is to obtain the greatest possible permanent benefit from the land which is subjected to erosion.

2.18.1. Mechanical Measures

Contour Bundling: Construction of a series of bunds on the contour across the slope of the land to intercept flow of water down the slope and hold back water to soak into the soil. In the scarce rainfall areas, where every drop of water has to be conserved for growing crops, certain bunds are formed. In this system of bunding, all the water accumulated along the bunds will be allowed to soak into the soil slowly.

The graded bunds are formed in heavy rainfall areas where the conservation of soil is more important than the conservation of moisture. Hence, bunds and graded bunds lead this water of the field at slow erosive velocity. If there is excessive water, it is necessary to provide stone weirs at the graded bunds to drain off water slowly. The graded bunds make the water 'walk' instead of 'run'. Bunds without many curves and with a length not exceeding 1000 ft are desirable.

Gully Control: It involves reduction of peak flow rates through a gully and a provision of a stable channel for the flow. The first one can be done by retention of run-off by adopting agronomic measures and bunding and also by providing diversions to divert runoff from the gully. The second one can be done by stabilizing gully sides by planting *ipomoca, Agave, pineapple, mulberry* etc.,

Brush-Wood Dams: For gullies of 8 ft deep and 20 ft wide brush wood dams are constructed to prevent further increase in the width and depth of gully.

Rock Fill Dams: When the depth of the gully is 15 ft deep, these are essential to control its further expansion.

Bench Terracing: This is the transforming of relatively steep land into a series of level strips or platform across the slope of the land. These steps are separated by vertical drips which are rock or earth, protected by heavy growth of grass. Adoption of bench terraces is favoured on slopes steeper than 15% and upto 33% with the soil types having sufficient depth.

2.18.2. Agronomic Measures

Agronomic measures are useful where (1) the rainfall intensities are low, (2) the soil absorbs the rain rapidly, (3) the slopes are gentle and soils are erosion resistant and (4) profitable crop rotations can be introduced that will provide an erosion cover during erosive rains.

In cases, where the slopes are very steep and high rainfall intensities prevail, the agronomic measures have to be supplemented with mechanical measures.

The following are the agronomic practices to conserve the soil.

(1) **Contour Cultivation:** It includes contour ploughing and contour sowing. By ploughing across the slope, each ridge of the plough furrow and each row of the crop acts as a cheek of run-off. This reduces runoff and its velocity, and allows more time for rainwater to penetrate into the soil. Contour cultivation alone has resulted in 20 per cent increased yield in Jowar and Setaria over cultivation up and down the slope. Contour cultivation is also recommended as a supporting practice to stabilise the contour bunds.

(2.) **Strip Cropping:** It is a system of crop production in which long and narrow strips of erosion resisting crops (groundnut, horsegram and beans) are alternated with strips of erosion permitting crops (jowar, maize and cotton). Legume crops are better in controlling runoff and soil losses compared to cereal crops. The relative anti-erosion values of different crops was estimated at Hagari on black soils (1938-42).

Check Your Progress - 4

Define strip cropping?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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3. **Ley Farming:** Growing of pasture of grasses in rotation with crops is known as ley farming.

The effective way of protecting the soil is to provide it with a thick vegetative cover for a long period. Grasses are known for providing protective cover to the soil. After two years grass will be removed and a regular crop can be taken up. Again after one or two years, grasses can be grown on the same land. A rotation of two years of grass followed by one year of crop is recommended.

4. **Crop Rotation:** Rotation of crops in sequence tends not only to reduce erosion but also to improve the fertility status of the soil. If some crops like cotton and jowar are grown in the same field year after year, there will be a fixed type of cultivation which leads to increased erosion losses. the soil between the rows of these crops has to be kept free of

weeds by intercultivation, which increases erosion. But, if a crop with quick growing nature and covering the soil completely, is included in the rotation, soil erosion losses are reduced considerably. Inclusion of legume crops in rotation is essential.

2.19. SUMMARY

Soils are formed due to weathering of igneous, sedimentary and metamorphic rocks. The various physical properties of soil such as soil texture, structure, density, pore space, plasticity and cohesion, soil temperature, soil air and soil water and chemical properties like mineral composition, organic matter and soil pH influence the fertility and productivity of organic matter and soil pH influence the fertility and productivity of the soil. The soils are broadly classified into three major categories viz. sandy soils, loamy soils (alluvial) and clayey soils and based on the proportion of sand, silt and clay factions in soil profile, they can be differentiated into different types. Different soils types found in A.P. and their suitability to different crops are furnished. soils which can not be used economically for the cultivation of crops without adopting proper reclamation measures are known as problematic soils e.g., acid soils, saline and alkali soils. The soil fertility is the inherent capacity of the soil to supply essential plant nutrients to plants; which depends on the nature of the rock from which the soil is formed, the organic matter content and the activity of microorganisms present in the soil. Soil productivity refers to the ability of the soil to produce crop yields-which depends not only on soil fertility, but other factors like climate, water supply and management practices etc. Soil fertility losses occur through the removal of nutrients by crops and weeds, leaching of nutrients, loss of nutrients by erosion, and loss of nutrients in gaseous form. Soil fertility is maintained by adopting proper crop planning such as crop rotation, intercropping, green manuring, addition of bulky organic manures and commercial fertilizers and correcting problematic soils through suitable soil amendments. Removal of surface soil by wind and water is known as soil erosion. Along with soil, there will be loss of nutrients and rain water, besides reduction in soil depth and cultivable area. depth of reservoirs and tanks is also reduced due to the deposition of silt. Soil conservation practices are classified as mechanical, agronomical and forestry. among the mechanical methods, contour bunding and gully control are important. Agronomic practices include contour cultivation, strip cropping, and crop rotation. Forestry methods include affforestation and ley farming.

2.20. CHECK YOUR PROGRESS: MODEL ANSWERS

1. Black Soils (Regurs) are medium deep to deep (45-90 cms) with the pH ranging from 7.0 to 8.5 and are low in nitrogen, very low in phosphorus and medium in potassium. The black cotton soils are very deep heavy clay soils (90-180 cms or over depth) with the pH ranging from 8.0 to 9.0 and are low in nitrogen and phosphorus contents and medium level of potassium.

2. The fertility of the soils is lost by the removal or loss of nutrients by (a) harvested crops (b) weeds (c) leaching (d) erosion (e) gaseous form or volatilisation.

3. The preparations containing the living cells of efficient strains of Nitrogen fixing organisms used for seed or soil application are known as Biofertilisers. *Rhizobium* is one of the examples for Biofertilisers.

4. The alternation of long and narrow strips of erosion resisting crops such as groundnut, horse gram and beans with strips of erosion permitting crops such as jowar, maize and cotton is known as strip cropping.

2.21. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. Explain in detail how the soils are formed?
2. Write briefly the physical and chemical properties of clayey soils and sandy soils.
3. Write briefly the physical and chemical properties of red soils and alluvial soils.
4. Describe the soil types normally found in A.P. and give a list of crops that can be grown in each of these soils.
5. Briefly discuss the effects of soil acidity and how it is corrected?
6. How the saline, saline-alkali and non-saline alkali differ in their characteristics? Briefly write down the procedure that has to be followed to reclaim saline and alkali soils.
7. Discuss the various practices adopted for maintaining soil fertility.

II. Answer the following question in about 10 lines each.

1. What are the effects of liming on soil and plants?
2. Briefly discuss about saline and alkaline soils?
3. Discuss briefly how the losses are occurring in soil fertility?
4. Briefly discuss the losses due to wind and water erosion.
5. Briefly discuss the agronomic measures to control water erosion.

UNIT-3: AGROCLIMATIC ZONES OF ANDHRA PRADESH

Contents

3.1. OBJECTIVES

By the end of this unit you will be able to:

1. describe the basis for the grouping of the Andhra Pradesh State into 3 physical regions,
2. list out the major groups of soils that are found in Andhra Pradesh,
3. describe the climatic conditions, irrigation facilities and cropping patterns in Andhra Pradesh in general,
4. describe the basis for the classification of Agricultural zones in Andhra Pradesh and also describe the various climatic conditions, irrigation facilities and cropping pattern in various Agricultural zones in Andhra Pradesh.

3.2. INTRODUCTION

Andhra Pradesh is the fifth largest state of India having a land area of 2,76,254 sq. K.M. It is located in the Southern part of India extending from 12^{0} 37' to 19^{0} 54' North Latitudes and 76^{0} 46' to 84^{0} East Longitudes. It is predominantly an agriculture State. The state can be grouped into three major physical regions based on altitude.

(i) The Coastal plain being between 0-150 metres above sea level, covering whole of coastal Andhra region with some of the best agricultural land of the state occupying about 35% of the land area.

(ii) The Peninsular plateau (Deccan plateau) with 150-600 meter altitudes covering the entire Rayalaseema region and most part of the Telangana region, occupying 52 per cent of the land area of the state

(iii) The Eastern ghats (600 metres and more above sea level) consisting of broken hills and ridges covering 13 per cent of the land area of the state.

Check Your Progress - 1

What is the basis for the classification of the State into 3 physical regions?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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3.3. SOILS

All major groups of soils are found in Andhra Pradesh (Fig. 3.1). Red soils are predominant covering above 65 per cent of the total area followed by black soils (with 25 per cent), alluvial soils (five per cent), coastal sands (three per cent), laterite and lateritic soils (one per cent) and problem soils including saline, saline-alkali, and non saline-alkali soils (one per cent).

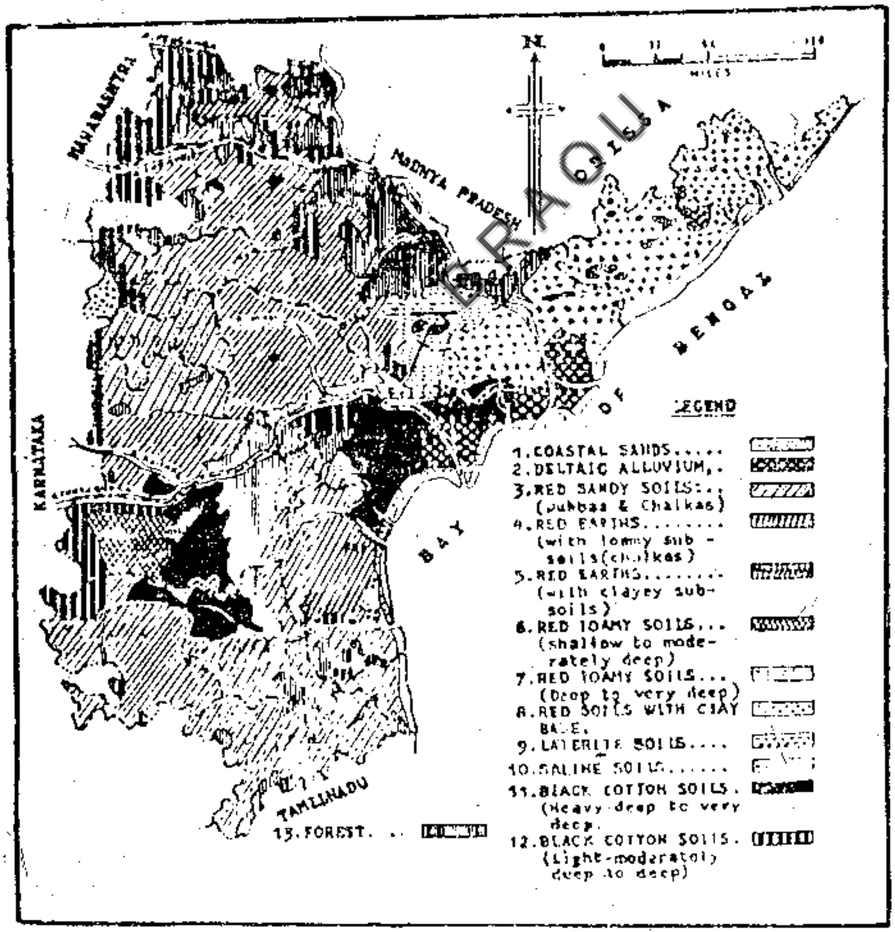

Fig. 3.1. Soil map of Andhra Pradesh

3.4. CLIMATE

The climate is predominantly semi-arid to arid except for the coastal belt which has a humid to sub-humid climate. There are three distinct seasons. The rainy or monsoon season (Kharif) is from June to October, the winter (rabi) from November to February, and the summer from March to May.

The maximum and minimum temperatures in the state vary between 24-44^{0} C and 12-25^{0} C respectively. The average annual rainfall of the state is 890 mm which varies from 500 to 1500 mm (Fig. 3.2). About 70 per cent of the annual rainfall is received during the S.W. monsoon, 20 per cent during the N.E. monsoon (October-December) and 10 per cent during the winter and summer months.

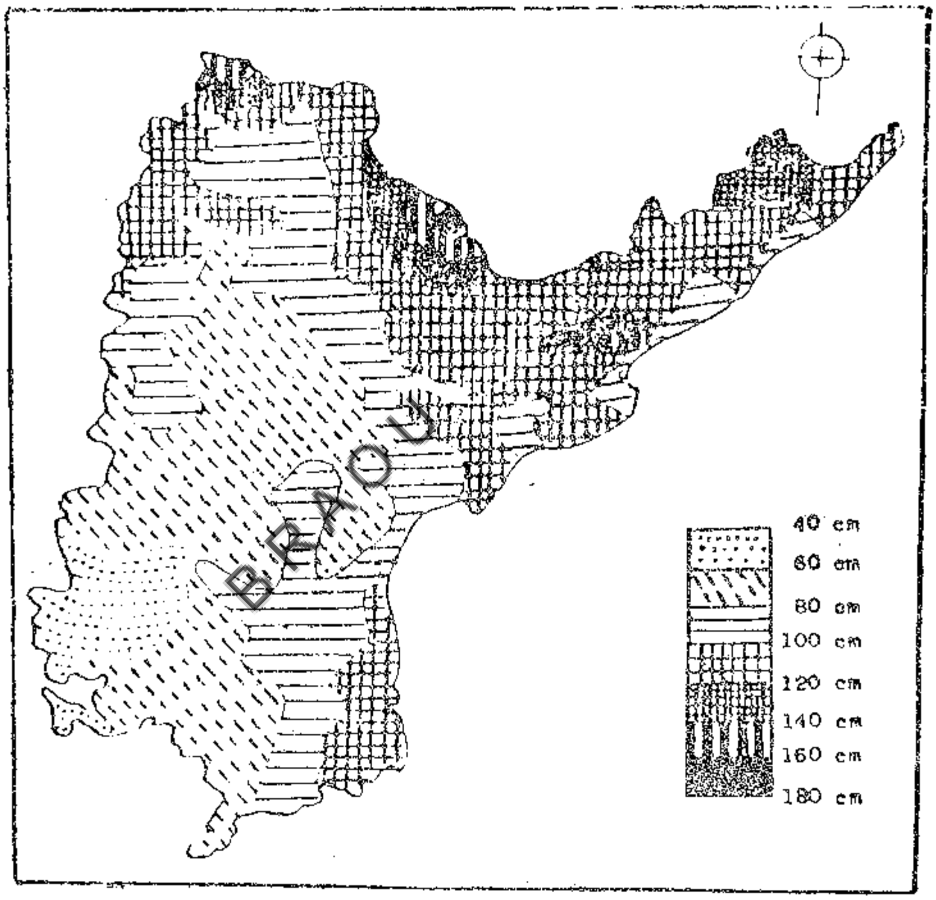

Fig. 3.2. Mean annual rainfall of Andhra Pradesh (1956-70) Scale : 1 : 5,000,000.

3.5. IRRIGATION

The total geographical area of Andhra Pradesh is 274.4 lakh hectares, out of which 109.18 lakh hectares (40 per cent) is net cultivated area. An area of 16.17 lakh hectares is sown more than once bringing the gross cropped area to 125.35 lakh hectares with a cropping intensity of 115 per cent. Various irrigation systems, including tanks and wells irrigate a gross area of about 43.78 lakh hectares which accounts 35 per cent of gross cropped area. Of the total irrigated area, rice accounts for 78.9 per cent followed by sugarcane (4.4 per cent) and groundnut (4.1 per cent).

3.6. CROPPING PATTERN

Out of a gross cropped area of 125.35 lakh hectares, food crops predominate occupying about 100.06 lakh hectares, while non-food crops occupy the remaining 25.29 lakh hectares. The important food crops are rice, sorghum, bajra (pearl millet), ragi (finger millet), maize, minor millets and pulses. Groundnut, castor, cotton, sugarcane, chilli and tobacco are the important non-food crops. Rice occupies the largest acreage of 36.62 lakh hectares (29.2 per cent of gross cropped area) followed by sorghum with 23.09 lakh hectares (18.4 per cent) and groundnut with 10.99 lakh hectares (8.6 per cent). No other crop accounts more than 5 per cent of the gross cropped area.

3.7. CLASSIFICATION OF AGRO-CLIMATIC ZONES IN A.P.

Soils and climate are the two main factors that determine cropping in any area. In Andhra Pradesh, red soils predominate in most parts (65 per cent of total area) except in parts of Adilabad, Kurnool and Guntur where black soils predominate. In some other districts, light black soils occur. Therefore, soil type variations do not play a significant role in delineating the agro-climatic zones in the state. With regard to climate factors, temperature differences are not very large in the state except in Telangana district where minimum temperatures are lowest during rabi. It is, therefore, the total rainfall and its distribution that mainly determine the agro-climatic zones of the state. Based on this, the state can be divided into seven agroclimatic zones (Fig.3.3). They are (1) Krishna-Godavari Zone. (2) North Coastal Zone. (3) Southern Zone. (4) Northern Telengana Zone. (5) Southern Telangana Zone. (6) Scarce Rainfall Zone of Rayalaseema. (7) High Altitude and Tribal areas.

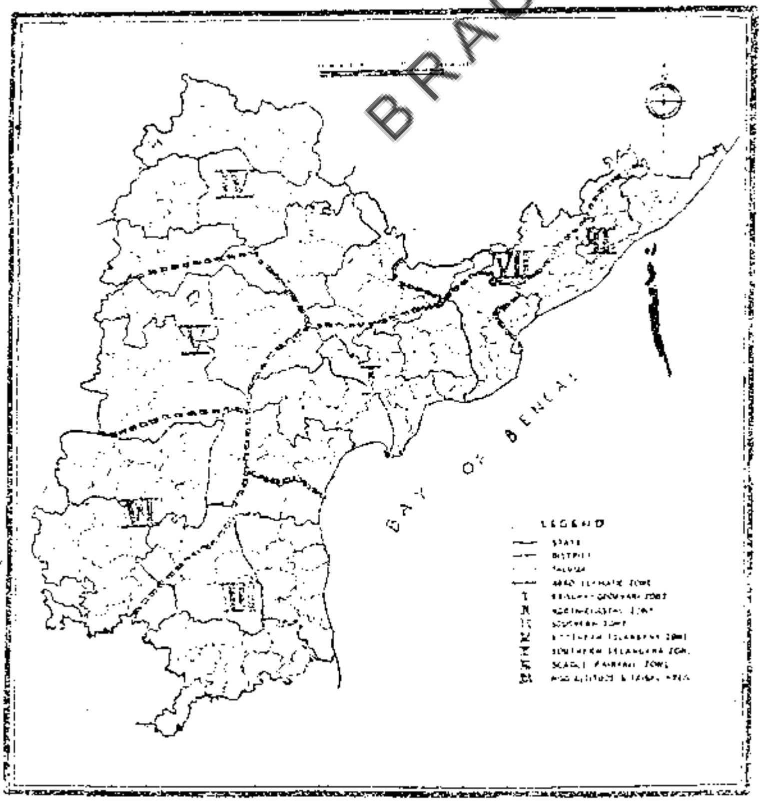

Fig. 3.3. Agroclimatic Zones of Andhra Pradesh.

3.7.1. Krishna-Godavari Zone

This zone includes districts of East Godavari excluding uplands, West Godavari, Krishna and Guntur and adjoining parts of Khammam, Nalgonda and Prakasam districts. The annual rainfall in this zone is 800-1100mm of which about 550-670mm is received during the S.W. monsoon, 200-310 during the N.W. monsoon, and the remaining 50-120 mm during the non-monsoon period.

The maximum and minimum temperatures range from 32° to $36^{\circ}C$ and 23° to $24^{\circ}C$ respectively during the S.W. monsoon period. In the N.W. monsoon period the maximum and minimum temperatures range from 29° to $32^{\circ}C$ and 16° to $21^{\circ}C$ respectively. During the non-monsoon period the range of maximum and minimum temperatures is 29° to $38^{\circ}C$ and 16° to $24^{\circ}C$ respectively.

The important soil groups of the zone are deltaic alluvium (association of Entisols and Vertisols), red soils with clay base (Alfisols), deep black, cotton soils (Vertisoils), deep red loamy soils (Alfisols), coastal sand (Entisols), and saline soils (association of Aridisols, Alfisols and Inceptisols). In uplands, red and black soils are found while alluvial soils occur in the deltas and costal sands are formed along the coast.

The gross cropped area of the zone is 27 lakh hectares. About 59 per cent of gross cropped area is under irrigation mainly with Krishna Godavari river canal system. This zone is known as the 'Rice bowl' of the state accounting for about 43 per cent of both the area and production of rice in the state. The other important crops of this zone are rabi sorghum tobacco, cotton, blackgram, greengram, sugarcane, groundnut and chilli.

The area of crops and the relative percentage of area occupied by the crop in the zone and also in the state are given below in Table 2.1.

This zone receives heavy rain during September-October. Cyclones are common during November. Cloudiness during a considerable part of the kharif season result in low light intensity. The soil nitrogen is high. An area of 75,000 hectares of the Kolleru lake basin will have the problem of standing water upto 2 to 3 feet in the paddy fields. In the eastern part of the zone, irrigated alluvial delta, and irrigated uplands of both red and black soils are found. The un-irrigated areas comprising red loams of East and West Godavari districts, deep black soils of Krishna, Guntur, Prakasam and Khammam are found in the Western part of the zone. Sandy and saline soils occur along the entire coastal belt.

Water congestion and impeded drainage lead to deterioration in the soil structure, a rise in the water table and development of salinity over considerable areas in the lower reaches of the delta system. Besides this, heavy rains and cyclones at the time of harvesting are the major constraints of crop production in this zone.

3.7.2. North-Coastal Zone

It consists of Srikakulam, Visakhapatnam, Vijayanagaram districts (excluding the Western hill areas) and upland areas of East Godavari districts. The average annual rainfall of this region is 1000-1100 mm of which 600-660mm (60 per cent) is received during the S.W.monsoon, 260-286 mm (26 per cent) during the N.W.monsoon and the remaining 140-154 mm (14 per cent) during the winter and summer months. The rainy season commences in the month of May.

The maximum and minimum temperatures during S.W.monsoon range from 33° to $35^{\circ}C$ and 26° to $27^{\circ}C$ respectively. The corresponding temperature range for the N.W.monsoon period is 29° to $36^{\circ}C$ and 18° to $24^{\circ}C$, while during the non-monsoon period it is 29° to 36° and 18° to $27^{\circ}C$.

The soils are predominantly red with clay base (Alfisols). There are several small pockets of acidic laterite soils (Oxisol) with pH between 4.0 to 5.0.

The gross cropped area in this zone is 11.9 lakh hectares, of which 5 lakh hectares are under irrigation (42 per cent). Rice, bajra (Pearl millet) ragi, greengram, horsegram, groundnut, sesamum, mesta (*Hibiscus sabdariffa and H. cannabinus*) and sugarcane are the important crops.

The main cropping seasons, in order of importance, are Kharif (May/June to November), early Kharif (April-May to July-August), and summer (January to May). The extent of the area under crops during each of these seasons is dependent on the seasonal rainfall and the availability of irrigation water.

In tank fed irrigated areas, the time and quantity of irrigation is uncertain because of low capacity of tanks which needs to be filled by seasonal rains 2 to 3 times during the crop growth period. Even all the areas covered by canals do not have assured irrigation. In this zone the uncertainty with regard to quantum and time of availability of irrigation water is the major constraint on crop production. This problem is further aggravated because of predominance of red soils which have low water holding capacity.

3.7.3. Southern Zone

It comprises of the entire Nellore and Chittoor districts, parts of Prakasam and Cuddapah, and the eastern part of Anantapur. The average annual rainfall of this zone is 700 to 1050 mm. It is equally influenced by the S.W. and the N.E. monsoon. During the S.W.monsoon period about 350-500 mm (50 per cent) is received. The rainfall in the N.E.monsoon period ranges from 250-400 mm (36 per cent) and the remaining 100-150 mm rainfall is received during non-monsoon period. Nellore district receives 60 per cent of its rainfall from the N.E.monsoon.

The maximum and minimum temperatures during the S.W.monsoon range from 35°-40°C and 23°-25°C respectively. The corresponding temperature range during N.E. monsoon period is 28° to 33°C and 15° to 20°C while for the non-monsoon period, it is from 31° to 39°C and 13° to 25°C respectively.

Red loamy soils are predominant which are shallow to moderately deep (association of Alfisols and Entisols) followed by red earths with loamy sub soils i.e., Chalkas (association of Inceptisols and Alfisols). Very small patches of black cotton soils which are light, and moderately deep to deep (association of vertisols and Inceptisols) also occur.

The gross cropped area in this zone is about 18,72,000 hectares out of which 8.1 lakh hectares (43 per cent) is under irrigation. Rice, groundnut, sorghum, ragi, bajra, Korra, (*Setaria italica*), horsegram, sugarcane and tobacco are the principal crops of this zone.

The total seasonal rainfall is not sufficient for getting a good crop. Further, it is erratically distributed. Dry spells for a longer period and high intensity rains are common, and these result in run-off of water, and soil erosion. These situations contribute to low yield levels and instability in production. The main sources of irrigation, i.e., tanks and wells which depend on seasonal rainfall for their filling cannot provide assured irrigation due to erratic and low rainfall.

3.7.4. Northern Telangana zone

This zone includes the districts of Adilabad, Karimnagar, Nizamabad, Medak (except the southern borders), Warangal (except the north western portion), the eastern strip of Nalgonda, and Khammam (except extreme southern and eastern parts). It receives an annual average rainfall of 900-1150 mm of which 740-940 mm (82 per cent) is received during the S.W.monsoon, 90 to 120 mm (10 per cent) during the N.E. monsoon and 70 to 90 mm (eight per cent) during the non-monsoon period.

The maximum and minimum temperatures during the S.W. monsoon period vary from 32° to 37°C respectively. During the N.E. monsoon period, the maximum and minimum temperatures range from 29° - 32°C and 13° - 17°C, while in the non-monsoon months, the range is from 30° - 52°C and 13° - 27°C respectively.

Red soils are predominant in the zone. They include (i) The chalkas, i.e., Red earths with loamy sub-soils (association of Inceptisols and Alfisols) (ii) Red sandy soils i.e., dubbas and chalkas (association of Entisols, Inceptisols and Alfisols), and (iii) deep to very deep red loamy soils (Alfisols). The second important group is that of black soils which include (i) light and moderately deep to deep black cotton soils (association of vertisols and Inceptisols), and heavy and deep to very deep black cotton soils (Vertisols). A small patch of acidic laterite soils (Oxisols) occurs in the South Western corner of the zone (Map-I). Considerable area in this zone is under forests, the soils of which were not classified.

The gross cropped area in the zone is about 26.7 lakh hectares of which 6.61 lakh hectares (24.7 per cent) is under irrigation. The principal crops of this zone are jowar, rice, maize, cotton, groundnut, pulses, bajra and sesamum etc.

Rice and Sugarcane are the important irrigated crops. The main crop seasons are the kharif and the rabi. Jowar is grown under rainfed conditions in the Kharif as well as the early rabi conditions (maghi). Pulses like redgram and horsegram are extensively grown. The Khammam area and the adjacent area of Warangal district get the benefit of the late N.E. monsoon rains. In this N.E. monsoon influence belt, two crops, pulses in kharif followed by early rabi jowar, are taken.

Check Your Progress - 2

What is the annual average rain fall of Northern Telangana Zone.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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3.7.5. Southern Telangana Zone

This zone includes the districts of Rangareddy, Mahaboobnagar (except the southern border), Nalgonda (except the south-eastern border), the North-Western part of Warangal, and the Southern part of Medak. It receives an annual rainfall of 700-900 mm. About 500-700 mm rainfall (77 per cent) is received during the S.W.monsoon, 90-120 mm (13 per cent) during the N.E. monsoon, and 70-130 mm (10 per cent) during the non-monsoon period.

The maximum and minimum temperatures during the S.W.monsoon, range from 28^{o} - $34^{o}C$ and 22^{o} - $23^{o}C$ respectively. During the N.E. monsoon the maximum and minimum temperatures vary from 28^{o} to $37^{o}C$ and 16^{o} to $26^{o}C$ respectively.

It is predominantly dominated with red soils consisting of red earths with loamy sub-soils i.e., Chalkas (association of Inceptisols and Alfisols) and red sandy soils i.e., dubbas and Chalkas (association of Entisols, Inceptisols and Alfisols). Small areas along the Western boundary have light and moderately deep to deep black cotton soils (Association of Vertisols and Inceptisols).

The main crops of this zone are Jowar, Rice, Bajra, Castor, Groundnut, Ragi, Horsegram and maize. It is not only the castor belt of Andhra Pradesh but also of the country, accounting for about 40 per cent of the castor area in the country. The area under different crops and their relative percentage in this zone, as well as in the state, is give below (Table 2.5).

There are only two main crop seasons i.e. Kharif and Rabi. Cropping is mostly jowar or rice based. The main sources of irrigation are tanks followed by wells. As such the quantity and time of availability of irrigation water, acts as the major constraint on agricultural production. Gall midge pest problem on rice in Warangal district is another constraint in rice production. The soils of this zone are sandy to sandy loam in texture with low nitrogen, phosphorus and zinc content and have poor water holding capacity.

3.7.6. Scarce Rainfall Zone of Rayalaseema

The districts of Kurnool, Anantapur, the Western parts of Prakasam and the northern parts of Cuddapah constitute this zone This zone receives the lowest rainfall in the state. The average annual rainfall of the zone is 500 to 750 mm. During the S.W.monsoon period 280-420 mm of rainfall (56 per cent) is received while in the N.E. monsoon period 165-250 mm of rainfall (33 percent) and 55-80 mm of rainfall (11 per cent) during the non-monsoon period is received.

The maximum and minimum temperatures during the S.W. monsoon range from 32^{o} to $36^{o}C$ and 24^{o} to $30^{o}C$ respectively. The corresponding temperature range during the N.E.monsoon period is 30^{o} to $32^{o}C$ and 15^{o} to $20^{o}C$, while for the non-monsoon period it is 32^{o} to $40^{o}C$ and 17^{o} to $27^{o}C$.

The following important groups of soils are found in this tract.

(i) Red earth with loamy sub soils (association of Inceptisols and Alfisols).

(ii) Red earths with clayey sub soils (association of Alfisols and Inceptisols).

(iii) Red sandy soils (association of Entisols, Inceptisols and Alfisols)

(iv) Black cotton soils which are light and moderately deep to deep (association of Vertisols and Inceptisols).

(v) Black cotton soils which are heavy and deep to very deep (Vertisols).

Anantapur is the driest district with predominance of red soils. These soils are shallow and have low fertility and low moisture holding capacity. These soils are subjected to serious soil erosion problem. This district receives the lowest rainfall (544 mm) in the zone. The rainfall is uncertain and erratic during the Kharif season leading to frequent occurrence of severe droughts and famines. Anantapur district is a chronically drought prone area in the state.

The gross cropped area in this zone is about 21.26 lakh hectares. The gross irrigated area in this zone is only 3.35 lakh hectares which is 15.8 per cent of gross cropped area. the principal crops of this zone are sorghum, groundnut, korra, rice, cotton, pearl millet, horsegram, redgram and ragi. Area under different crops and relative percentage of the area occupied by crops in the zone as well as in the state is given below (Table 2.6).

Most of the cultivated area is rainfed and dependent on the S.W. monsoon. The main constraint is low rainfall with uneven and erratic distribution. The problems is further aggravated with low water holding capacity of the soil, and having meagre irrigation facilities. Crop production in this drought prone area is a high risk proposition. Many small and marginal farmers combine crop production with livestock base of sheep or goats.

3.7.7 High Altitude and Tribal Areas

This zone comprises the areas along the northern borders of the state in the districts of Srikakulam, Visakhapatnam. East Godavari and Khammam. These areas are inhabitated by tribals. The annual rainfall of this zone is more than 1400 mm and large areas in this zone are lying at high altitudes upto 1000 metres. The distribution of rainfall is as follows: 765 mm during the S.W. monsoon, 410 mm during the N.E. monsoon and 220 mm during the non-monsoon period. The zone has a sub-humid climatic conditions.

Red soils with a clay base (Alfisols) and forest land are found in this zone. The gross cropped area in this zone is about 4.23 lakh hectares of which 56,000 hectares (13 per cent) are under irrigation, In this zone Rice, millets, groundnut, pulses and sesamum are important crops.

Shift cultivation is a common practice (podu cultivation). Since the inhabitants are tribals, they need to be educated with regard to the hazards of shift cultivation, pest and disease problems of crops. They should be supplied high yielding varieties of crops. Plantation crops like coffee, pepper, and cocoa which were recently introduced in the forest areas of this tract should be popularised. They should be trained and demonstrated improved crop management practice, soil conservation practices, agriculture and cattle and sheep improvement.

Check Your Progress - 3

How many Agroclimatic Zones are there in Andhra Pradesh? What are they?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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3.8. SUMMARY

Andhra Pradesh is predominantly an agricultural state having irrigation facilities to an extent of 35 per cent of gross cropped area. Type of soil and climate of the region are the basis for delineation of agro-climatic zones. Andhra Pradesh is divided into seven agro-climatic zones mainly based on variation in rainfall. The Krishna-Godavari zone receives an annual rainfall of 800-1100 mm, having the highest gross cropped area of 27 lakh hectares of which 16 lakh hectares are under irrigation. Rice is a predominant crop. The other important crops are sugarcane, chillies, Sorghum, Tobacco and Cotton. The average annual rainfall of north coastal zone is 1000-1100 mm with the early onset of the monsoon in the month of May. The gross cropped area of this zone is 11.9 lakh hectares having irrigation facilities to an extent of 42 per cent. Rice, Mesta, Groundnut, Finger millet and Bajra are important crops of this zone. The Southern zone comprising Nellore, Chittor and parts of Prakasam and Cuddapah, receives an annual rainfall of 700-1050 mm both from S.W. (50%) and N.W. (36%) monsoon. Of the total gross cropped area of 18.7 lakh hectares 43 per cent area is under irrigation. Rice, groundnut, jowar, bajra, and finger millet are the important crops of this zone. North Telangana zone receives an annual rainfall of 900-1150 mm having a gross cropped area of 26.7 lakh hectares with irrigation facilities to an extent of only 24.7 per cent. Jowar, rice, maize, and cotton are important crops of this zone. The annual rainfall of Southern Telangana zone is 700-900 mm. The gross cropped area of this zone is 17.28 lakh hectares having irrigation facilities to an extent of 23.7 per cent only. Red and Chalka soils are common. Jowar, Rice, Bajra and Castor are important crops of this zone. Rayalaseema zone receives the lowest rainfall of 500-750 mm per annum both from S.W.(58%) and N.E. (33%) monsoons. The gross cropped area of the zone is 21.26 lakh hectares of which 3.35 lakh hectares is under irrigation. The principal crops of this zone are sorghum, groundnut and korra. The High altitude and tribal areas found along the northern borders of the state receive an annual rainfall of more than 1400 mm both from S.W. (54.6%) and N.E.(29.3%) monsoons. The gross cropped area of this zone is 4.23 lakh hectares having irrigation facilities to the extent of 13 per cent only. Rice, millets, groundnut and pulses are commonly grown, besides newly introduced plantation crops, like coffee and pepper.

3.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Basing on the altitude the state is divided into 3 physical regions.
2. Northern Telangana Zone receives an annual rainfall of 900- 1150 mm.
3. There are seven Agroclimatic Zones in Andhra Pradesh. They are: (1) Krishna-Godavari Zone (2) North Coastal Zone (3) Southern Zone (4) Northern Telangana Zone (5) Southern Telangana Zone (6) Scarce Rainfall Zone of Rayalaseema and (7) High altitude and Tribal areas.

3.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the soils and climatic conditions prevalent in Andhra Pradesh.
2. How are climate, soils and cropping patterns different in Southern region compared to North Coastal Zone?

II. Answer the following questions in about 10 lines each.

1. In Telangana region which are the districts that receive more than 900 mm rainfall and what crops are grown in that tract?
2. What are the characteristic features of scarce rainfall Zone of Rayalaseema and how it differs from Southern Region?
3. Mention the districts which receive less than 750 mm of rainfall. Name the major crops cultivated in these areas.

UNIT - 4: MANURES AND FERTILIZERS

Contents

4.1. OBJECTIVES

By the end of this unit you will be able to:

1. classify the manures and describe each one of them separately,
2. define green manures and list out the advantages and disadvantages of green manures,
3. describe the characteristics of the good green manuring crop,
4. list out the various concentrated organic manures and describe each one of them,
5. classify the fertilisers and describe each one of them with examples,
6. explain the time and method of application of fertilisers,
7. define biofertilisers with some examples,
8. list out various types of soil amendments that influence plant growth.

4.2. INTRODUCTION

The productivity of soils and crop yields obtained from them are dependent on the quantities of plant nutrients present in soils. Soils gradually become infertile owing to the continuous loss of nutrients in many ways. Thus, the loss of soil nutrients may be due to removal of nutrients by harvested crops or by leaching or by erosion etc. However, fertility of the soils can be restored by supplementing with plant nutrients through organic manures, fertilizers and soil amendments.

4.3. MANURES

The manures are added in bulk quantities to improve the physical condition of the soil and for maintenance of soil fertility. The plant nutrients present in soil-applied manures are liberated in an available form after they are decomposed by soil microflora. Manures include bulky organic manures, concentrated organic manures and green manure crops.

4.3.1. Bulky Organic Manures

These organic raw materials are used to maintain the organic matter content of the soil, and to improve physical condition of the soil thereby increasing water holding capacity of the sandy soils, and to open the clay soil and help aeration and better root growth. They supply plant nutrients in small quantities. The bulky organic manures provide food for soil microorganisms and help the microbial activity there by rapid decomposition of organic matter and releasing plant nutrients in available form. Besides providing major nutrients, the bulky organic manures also supply traces of micronutrients which are very essential for plant growth. Farmyard manure or compost from organic waste, town compost, night-soil or poudrette, sewage and sludge, sheep penning green manures and other bulky sources of organic matter are included in this category.

(i) Farmyard mannure (FYM): This form is the most commonly used organic manure in India. Farmyard manure consists of a decomposed mixture of cattle dung, urine, the bedding material and remnants of straw and plant stalks fed to the cattle and other domestic wastes like ashes, sweepings etc., collected and dumped into a pit or heaped in the corner of a back yard. Factors influencing the quality and the composition of Farmyard manure are: (1) Source of manure (2) Food of the animal (3) Age and condition of the animal (4) Function of the animal (5) Nature of the bedding material etc. (6) Mode of storage or preservation.

Addition of FYM contributes largely in soil improvement in the following three ways: (a) improves the soil physical condition (b) increases the water-holding capacity of the soil and (c) stimulates the microbial activity necessary for the release of plant nutrients.

The use of this manure alone may not cause an imbalance in plant nutrition as it is estimated that well decomposed FYM contains, on an average, 0.5% N, 0.2% P_2O_5 and 0.5% K_2O. Therefore, to keep the soils well supplemented with plant nutrients, the bulky organic manures must be used along with superphosphate and other artificial fertilizers.

(ii) Farm Compost: Farmhouse and cattle-shed wastes of all types are used in the preparation of compost, and the other type of bulky organic manures. There are two recommended methods of composing waste organic materials. They are: 'heap method', and pit method. Farm liter compost contains 0.5% N, 0.15% P_2O_5 and 0.5% K_2O.

Heap Method: The normal practice of storing dung and litter in exposed heaps above the ground, is defective, and leads to great losses in manurial ingredients. Urine is lost as no attempt is made either to collect it in a tank or soak it in a bedding of litter and earth spread on the floor of the cattleshed. Both these losses can be reduced considerably if improved methods are followed.

Pit or Trench Method: Trenches of suitable size of 6m long 1.5m broad and 1m deep are constructed. All the available dry litter and other material from the farm are spread daily on the floor of the cattle shed in the evening for absorption of urine. Each morning the urine soaked litter and dung is well mixed and taken to the manure trench. A section of the trench from one side, is filled with the daily collection of dung mixed with urine soaked litter. When the section is filled up 45 to 60 cm above the ground level, the top of the heap is made dome shaped and plastered with cow dung and earth slurry. Then another trench is taken up for filling.

After a couple of months the entire trench will be filled up. The second trench is taken up for filling in a similar manner.

By the time the second trench is filled up the manure in the first trench will be completely decomposed and ready for use in the fields. Two such trenches will be sufficient for a farmer, who has 4 to 5 heads of cattle. When there are more cattle, the length of the trenches or their number is increased keeping the breadth and depth of the same.

This method gives almost double the quantity of manure compared to the heap method.

(iii) Town Compost: The town refuse or waste consists of night- soil, sewage, sludge, street and dustbin refuse, factory waste, etc. The waste contains nutrent elements like nitrogen, phosphorus and potassium. Large scale compositing of urban refuse and night soil has been taken up by many municipalities in India. This is effected by filling properly constructed trenches with successive layers of night soil, town refuse and earth. The compost which is well decomposed and ready for use as manure contains 1.4% N, 1.0% P_2O_5 and 1.4% K_2O. These values indicate that town compost is richer in fertilizer value compared to farmyard manure.

(iv) Night Soil or Poudrette: This manure is obtained from human excrement by a method known as poudrette system and hence the material is also called poudrette. night soil or poudrette is richer in manurial value as compared to farmyard manure or compost because it contains 1.2 to 1.3% N, 0.8 to 1.0% P_2O_5 and 0.4 to 0.5% K_2O, on fresh weight basis.

(v) Sewage and Sludge: Sewage disposal systems are operated by many municipal bodies and big cities in India. It has a solid portion, technically known as sludge and a liquid portion, commonly known as sewage-water. Sewage contains large quantities of plant nutrients and are used for growing crop plants by operating sewage farms. The raw sewage is treated to remove the sludge portion. The settled sludge is allowed to undergo oxidation. It provides an activated sludge containing 2 to 2.5%N 1 to 1.2% P_2O_5 and 0.4 to 5% K_2O which can be readily applied to the soil.

Activated sludge is produced by passing air rapidly through the raw sewage, which accelerates aerobic decomposition of the material. It has no offensive odour. After proper drying, it can be marketed. It contains 8 to 10% moisture 5 to 6% N, 3 to 3.5% P_2O_5 and 0.5 to 0.7% K_2O.

(vi) Green Manures: The practice of cultivating a quick-growing crop and ploughing it under to incorporate it into the soil is called green manuring. It improves physical condition as well as fertility status of the soil.

The green manure crops are grown either as a pure crop or as an intercrop with the main crop and buried in the same field which is to be green manured. This is,known as green-manuring in site. Both legumes and non-legumes are used as green manure crops. The most common green manure crops are sunhemp (*Crotolaria juncea*), dhaicha (*Sesbania aculeata*), pellipesara (*Phaseolus trilobus*). Green-leaf manuring refers to turning into the soil, green leaves and tender green twigs collected from waste lands and near by forests. They are spread in the field and incorporated into the soil. Green manures have a marked residual effect also. Usually 30 to 50% increase in crop yield is realized due to green manuring. The common shrubs are *Sesbania speciosa, Pongamia pinnata and Glyricidia maculata.*

Advantages of Green Manuring: (1) It adds organic matter to the soil and the microorganisms of the soil are stimulated. (2) It improves the soil structure thereby improving the water holding capacity of the soil. (3) The green manure crop utilizes nutrients from the lower depths of the soil and adds to the top most layer of the soil in which it is incorporated. (4) The leguminous green manure crops fixes the atmospheric nitrogen in the root nodules which will be utilized by the succeeding crops. (5) It increases the availability of certain other plant nutrients through releasing organic acids.

Disadvantages: (1) Under rainfed conditions it depletes the soil moisture for its growth and decomposition to such an extent that succeeding crops are affected adversely unless there are sufficient rains. (2) Incidence of pests and diseases may increase due to the succulent nature of the crop.

Characteristics of Good Green Manuring Crop: The crops used for green manuring should have the following characteristics (1) It should come up well even on poor soils. (2) It should give a large quantity of green material within a very short period. (3) Initially, it should be quick growing, to suppress the weeds. (4) It should have well developed, deep and fibrous root system, so that it can utilize nutrients from the lower depths of the soil. (5) It should be succulent, and decompose quickly (6) Preferably it should be a legume, so as to fix the atmospheric nitrogen.

Check Your Progress - 1

What is meant by night soil?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

4.3.2. Concentrated organic manures

Concentrated organic manures are organic in nature and contain higher percentage of major plant nutrients like N, P and K, compared to other organic manures. The common concentrated organic manures such as oil cakes, bloodmeal, fish manure, meatmeal and wool waste are made from raw materials of animal or plant origin.

(i) Oilcakes: Both the types of oilcakes viz., edible Oilcakes (suitable for feeding to cattle) and non-edible Oilcakes are applied to the soil. Oilcakes contain N,P, K along with a large percentage of organic ammonia and finally into nitrate nitrogen. Therefore, these manures are relatively slow in acting, compared to fertilizers, but supply available nitrogen for a long period. These bulky organic manures may also supply small quantities of minor elements needed by the plants.

For the uniform spread in the field the oilcakes should be powdered before application. In about six weeks nearly all nitrogen is nitrified and is, therefore, used by the crop. Hence the residual effect on subsequent crops is not worth mentioning.

(ii) Bloodmeal: Completely dried and powdered blood collected from slaughter-houses is sold as bloodmeal. It contains 10 to 12% of N, 1 to 1.5% of P_2O_5 and 0.6 to 0.8% of K_2O. Bloodmeal is also a quick acting manure and can be applied to all crops on all soil types. It is best used by mixing with the soil, so that it may be distributed evenly in the soil.

(iii) Meatmeal: Meat from animals is dried and converted into meatmeal. Meatmeal contains 10.5% N and 2.5% phosphoric acid. It is a very quick-acting manure and is effective for all crops on all soil types.

(iv) Fish Manure: Fish manure or fishmeal is prepared from nonedible fish, carcasses of fish by drying and crushing or powdering. Fish manure contains 4 to 10%N, 3 to 9% P_2O_5 and 0.3 to 1.5% K_2O. Like the other concentrated organic manures, fishmeal is quick acting in all soils. This manure often contains a considerable quantity of salt due to crude drying on the sea- side. As salt is considered favourable to coconut tree, it is largely applied to these trees which grow along the coast.

(v) Horn-and Bonemeal: This is another type of dried and powdered organic manure derived from the horn and hoof of animals.

(vi) Bone Meal: Raw Bone meal contains 3 to 4%N, 20 to 25% P_2O_5 and 28 to 32% lime. Usually bones are powdered before they are applied to the soil.

Steamed bones are brittle and easy to crush and they decompose more readily. Steaming, although, removes some nitrogen, increases the phosphoric acid and lime contents. Steamed bone contains 1 to 2%N, 25 to 30% P_2O_5 and 23% lime. Bone meal is suitable for acid soil and it works well on light well drained soils that have good aeration. It can be used for all crops but mainly for paddy and fruit trees. It has to be applied as a basal dressing at the time of sowing or planting.

Check Your Progress - 2

Define Blood Meal?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the the end.

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4.4. FERTILIZERS

Fertilizers are applied mainly to increase the supply of one or more of the essential nutrients such as nitrogen, phosphorus, and potassium. Fertilizers contain these nutrients in the form of soluble or readily available chemical compounds.

The fertilizers are sometimes called 'Chemical' or artificial manures. The commercial fertilizers are of two types: inorganic and organic. Inorganic fertilizers are ammonium sulphate. calcium nitrate, superphosphate, nitrate of potash, etc. Organic fertilizers are urea and calcium cynamide.

Fertilizers are usually classified, based on the particular plant nutrient which forms their principal constituent. Thus, fertilizers may be grouped into nitrogenous fertilizers, phosphatic fertilizers, potassic fertilizers, etc. complex fertilizers contain two or more of the primary essential nutrients.

4.4.1. Nitrogenous Fertilizers

Based on the chemical form in which the nitrogen is combined with other elements, the nitrogenous fertilizers are divided into four groups. These are : nitrate fertilizers ammonium fertilizers nitrate and ammonium fertilizers and amide fertilizers. Of these, the first three groups are inorganic in nature while the amide fertilizers are organic.

(i) Nitrate Fertilizers: These are obtained both as natural products (e.g. Chilean nitrate or sodium nitrate) and as manufactured products from synthetic ammonia. Nitrogen combines as NO_3 with other elements. Sodium nitrate with 16%N and calcium nitrate with 15.5%N are examples of such fertilizers. The nitrate fertilizers are quickly dissociated in soil solution, releasing the nitrate ion for plant absorption. However, there is also the increased danger of leaching of these fertilizers.

(ii) Ammonium Fertilizers: Ammonium sulphate, ammonium chloride, ammonium phosphate are some examples of this group of nitrogenous fertilizers. These fertilizers are less rapidly utilized by growing plants than nitrate fertilizers. Ammonium fertilizers are much more resistant to loss by leaching.

(a) Ammonium Sulphate: It contains 20.6% of Nitrogen and 23.7% of sulphur. It is a crystalline salt, completely soluble in water and fixed by clay and humus in the soil soon after application. The ammonium is converted into nitrate by nitrifying bacteria in the presence of oxygen. This conversion is very rapid in India due to high temperatures and hence nitrogen becomes available to the crop, soon after application. Paddy crop prefers ammonical form of nitrogen, and hence ammonium sulphate is most suitable for the paddy crop.

(b) Ammonium Chloride: It contains 25% of N. It is also white in colour and possesses the same properties as that of ammonium sulphate.

(iii) Nitrate and Ammonium Fertilizers: It this group of nitrogenous fertilizers, nitrogen is present in both ammonical and nitrate forms. The most important examples of this type are ammonium nitrate, calcium ammonium nitrate and ammonium sulphate nitrate. These fertilizers have the properties of both nitrate and ammonical forms.

a) Calcium Ammonium Nitrate: It contains 20.5% of N of which one half is in nitrate form and the other half in an ammonium form. It is highly hygroscopic and should be stored in a dry place. Mixing with other fertilizers containing free lime i.e., basic slag or calcium cynamide is not advisable due to loss of ammonia.

b) Ammonium Sulphate Nitrate: It contains 26%N. It has 1/4 of nitrogen in nitrate form and 3/4 in ammonical form. It should not be mixed with fertilizers containing free lime such as basic slag, calcium cynamide etc.

(iv) Amide Fertilizers: These fertilizers contain nitrogen in amide (NH_2 or CN_2) form. Examples are : urea and calcium cynamide which are technically classified as organic compounds. Amide fertilizer are readily soluble in water. Especially urea is suitable for most crops and can be applied to all soils. *Urea* is a concentrated nitrogenous fertilizers and contains 44% N. It is white, crystalline and hygroscopic in nature. It is cheaper than any other nitrogenous fertilizer. It undergoes changes and is converted into ammonium carbonate and then to nitrate due to biological activity in about 7 to 14 days. Urea can also be used as a spray fertilizer. A solution containing urea upto 4% can be used for spraying on many crops such as rice, wheat, potato and fruit crops.

4.4.2. Phosphatic Fertilizers

These are classified as natural phosphates, treated or processed phosphates, by-product phosphates and chemical phosphates. The plant nutrient of all the phosphatic fertilizers is expressed in terms of percentage of phosphorus pentoxide (P_2O_5). The following is an account of the different phosphatic fertilizers.

(i) Rock Phosphate: This occurs as natural deposits of rock in the USA, Morocco, the USSR, Algeria, Brazil, Egypt etc. Rock phosphate contains 25 to 30% as tricalcium phosphate. Very little rock phosphate is used directly as fertilizer. Most of it is used for the manufacture of super phosphate and other phosphatic fertilizers. It can be applied to green manure crops and to the crops grown in acid soils.

(ii) Super Phosphate: Formerly this was produced by treating bones with sulphuric acid. It is now manufactured largely by treating ground rock phosphate with sulphuric acid. Superphosphate is manufactured in three grades: single superphosphate, dicalcium phosphate and triple superphosphate. The phosphoric acid in superphosphate is completely water- soluble. This fertilizer is suitable for all crops and can be applied to all soils. It contains 16% of P_2O_5 and is used all over the world. It is also known as single super phosphate.

(iii) Basic Slag: Basic slag is a by-product of the steel industry. Depending upon the phosphorus content of the iron ore, basic slag contains 6 to 20% P_2O_5. Basic slag is a desirable phosphatic

fertilizer because it is alkaline in reaction and the phosphoric acid is readily available to plants. It is advisable to apply it in heavy doses, a month before the sowing of crops. It has a considerable residual effect.

(iv) Bonemeal: It is available in two forms viz., raw bonemeal and steamed bonemeal. Bonemeal is well suited for acidic soils and for long duration crops. It may be applied to the soil only at the time of sowing or before sowing.

4.4.3. Potassic Fertilizers

Potassic fertilizers are applied to the soils deficient in potash to supply the plants with potassium. Potassium ion (K^+) present in solution is absorbed by the growing plants. Potassic fertilizers in common use are: nitrate of potash (potassium chloride) and sulphate of potash (potassium sulphate).

Nuritate of potash contains 50 to 63% K_2O. It is easily soluble in water and K_2O is readily available to plants. It is not lost from the soils by leaching. Sulphate of potash contains 48 to 52% K_2O and dissolves readily in water and becomes available to plants immediately. Wood ashes containing 5 to 6% K_2O are also applied to crops.

4.4.4. Other Fertilizers

Compound fertilizers are multiple nutrient materials which supply two or three plant nutrients simultaneously. For example, ammosphos provides 16% N and 20% P_2O_5. Most often mixed fertilizers meet nutrient deficiencies in a more balanced way. Complete fertilizers contain a mixture of all the three principal nutrients (N, P and K).

4.4.5. Mode and Time of Fertilizer Application

If the fertilizers are applied at the proper time and at the proper place, then only the crop plants are benefited to the maximum. The nature of the fertilizers, the soil type and the field crops largely influence the time and method of fertilizer application.

When crops are of longer duration, nitrogenous fertilizers should be applied in split doses. Such split application is also desirable in the case of lighter soils for reducing fertilizer losses due to leaching. Phosphatic fertilizers should be applied in one dose before sowing. It is advisable to apply bonemeal or rock phosphate to acid soils a week or fortnight before sowing. At planting time, potassic fertilizer should be applied in one dose.

Fertilizers which are in solid form can be applied in the following ways. S.P 1. *Broadcasting:* The fertilizer is spread evenly and uniformly over the entire field either at planting time or on the crop as top dressing. S.P 2. *Placement:* Fertilizers are placed in the soil before sowing or after sowing the crops. Plough sole placement, deep placement and subsoil placement are different methods of this category. S.P 3. *Localized placement:* In this method, fertilizers are incorporated into the soil close to the seed or plant. Various methods generally followed are contact placement, band placement, pellet application and side-dressing.

When the fertilizer is in liquid form, the following are the four primary methods of application. 1. Starter solutions are applied to young vegetable plants at the time of transplanting, 2. foliar application with suitable fertilizer solutions, 3. direct application of liquid fertilizer to the soil and 4. application of liquid fertilizers through irrigation water.

4.5. BIO-FERTILIZERS

The term biofertilizers denotes all nutrient inputs for plant growth which are of biological origin. These agricultural inputs have manurial value and are aided by microbial processes. Hence, they can be appropriately called 'microbial inoculants'. For example, some bacteria and bluegreen algae fix the atmospheric nitrogen, if they are inoculated into the soil and established in paddy fields. Preparations containing these microorganisms can also be considered as bacterial (microbial) fertilizers.

Of the different bacterial fertilizers, *nitragin* is the most important. It is a peat, lignite or soil based preparation containing effective strains of *Rhizobium* (root nodule bacterium) specific for different leguminous crops in adequate numbers. The other two bacterial fertilizers are azotobacterin and phosphobacterin. Azobacterin is a preparation containing cells of *Azotobacter chroococcum* grown on agar. Phosphobacterin is a kaolin based preparation containing cells of *Bacillus negaterium* var. *phosphaticum.*

A greater understanding of associative symbiosis between grass and *Azospirillum* (a nitrogen fixer) led to its practical application as seed inoculants for cereals in developing countries where fertilizer nitrogen is scarce. The concentrated preparation of dried cells of blue-green algae are also useful for enhancing the nitrogen content of paddy field soil.

Check Your Progress - 3

What is Nitragin?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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4.6. SOIL AMENDMENTS

Soil amendments are materials such as lime, gypsum, saw-dust, sulphur or soil conditioner that are added to the soil to influence plant growth. They change the soil reaction or pH, or improve the physical condition of the soil. The term soil amendment is used most commonly for added materials other than fertilizers. However, agricultural liming materials, for example, also supply calcium and sometimes magnesium as nutrient elements. Soil amendments are of three types. They are: 1. materials for correcting acidic soils, 2. materials for correcting alkaline soils and 3. soil aggregating agents or soil conditioners to stabilize soil aggregates, and to form a granular structure.

Addition of any compound containing calcium alone or both calcium and magnesium, that is capable of reducing the acidity of the soil is generally known as liming. Ground limestone (calcium carbonate), hydrated lime (calcium hydroxide) or burned lime (calcium oxide) are added to acid soils to create soil conditions favourable to the utilization of plant nutrients.

For reclaiming problem soils (saline and alkaline soils) chemical amendments like gypsum ($CaSO_4$ $2H_2O$), sulphur (S), iron sulphate ($FeSO_4$) and limestone ($CaCO_3$) are suitable for different soil conditions.

Chemicals such as polyvinilites, polyacrylates, cellulose, gums, lignin derivatives and silicates are the soil conditioners added to maintain physical condition of the soil.

4.7. SUMMARY

Addition of manures, fertilizers and bio-fertilizers supply the required nutrients to plants for their growth and production. Manures are supplied in the form of bulky organic manures, concentrated organic manures and green manures. Commercial fertilizers are inorganic or organic in nature, improving the nutrient status and uptake by plants. A wide variety of nitrogenous, phosphatic and potassic fertilizers are extensively applied in crop production. Fertilizers are applied to the field either by way of broadcasting or placement. Bio-fertilizers or microbial inoculants enhance the availability of plant nutrients in the soil. Unfavourable soil conditions can be corrected by adding soil amendments.

4.8. CHECK YOUR PROGRESS: MODEL ANSWERS

1. This is a manure obtained from the human excrement by a method known as poudrette system.
2. Blood meal is the dried and powdered blood collected from slaughter houses.
3. Nitragin is the peat, lignite or soil based bacterial fertiliser containing different strains of *Rhizobium*.

4.9. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give an account on the classification of manures.
2. Discuss in detail the use of bulky organic manures.
3. Write about the different types of concentrated organic manures.
4. Write an account on clasification of fertilizers.
5. Give an account on nitrogenous fertilizers.
6. Describe the different types of phosphatic fertilizers.
7. Write about biofertilizers and soil amendments.
8. Discuss briefly the mode and time of fertilizer application.
9. Write the improved methods of preparing F.Y.M. in pit and heap methods.

II. Answer the following questions in about 10 lines each.

1. Write briefly about farmyard manures.
2. Describe the potassic fertilizers.
3. Give an account on the biofertilizers.
4. Give an account on the soil amendments.
5. Which are the ways of application of solid fertilizers?
6. Describe how liquid fertilizers are applied to corps.
7. Write briefly about the time of fertilizer application.
8. Briefly discuss the advantages of green manuring.
9. What are the characteristics of good green manuring crop?

UNIT - 5: TILLAGE AND TILTH

Contents

5.1. OBJECTIVES

By the end of this unit you will able to:

1. define tillage and list out and describe the objectives of tillage,
2. define and differentiate cultivation and intercultivation,
3. list out the types of ploughs and describe each one of them,
4. list out the differences between indigenous plough and mould board plough,
5. describe the Secondary tillage operations and the implements that are used for it, and
6. define tilth and its importance.

5.2. INTRODUCTION

The soil is worked or manipulated by various tillage practices with an objective to prepare a suitable seed bed for better germination of seeds and growth of crops, to remove weeds and improve the soil physical conditions. The purpose of each tillage operation/practice is to achieve either one or all of the above objectives.

5.3. TILLAGE

Tillage is the practice of modifying the state of soil to provide favourable conditions for growing crops.

5.3.1. Development of Tillage

It is believed that the earliest tillage was practiced with a digging stick. In course of time, this digging stick was developed into a manually drawn foot-plough. Later on a bullock drawn plough was evolved.

Greek and Roman farmers believed that loosening and mixing of the soil improves the fertility status of the soil. Hence, the maximum number of tillage operations were practiced. In the recent past, the usefulness of practicing the maximum tillage operations were tested. It was opined that the need for several (maximum) tillage operations in the past, had been grossly exaggerated. Hence, tillage operations required for a specific purpose (good seed bed preparation, removal of weeds and improving soil physical conditions etc are necessary. Extra tillage operations may not be much useful but the cost of cultivation increases.

5.3.2. Objectives of Tillage

The aims of tillage practices are to (i) prepare the seed bed, (ii) control weeds (iii) improve soil structure (iv) improve soil aeration (v) dry the soil (vi) control pests and diseases (vii) improve root penetration (viii) incorporate crop residues and organic manures.

Seed Bed Preparation: A well prepared, weed free seed bed with soft and friable surface soil is necessary for good germination and seedling emergence. ploughing a too dry, too wet, or compacted soil will leave many large and hardclods on the surface. it is a laborious and time consuming process of breaking these clods to prepare a fine seed bed. Excess compaction of the soil impede the seedling emergence. Too loose a soil with many large air spaces may affect the seed germination, when there is no sufficient moisture in the soil. Thus, compacting the soil at seed placement zone and leaving the surface soil in a loose condition is desirable.

Weed Control: This is one of the most beneficial and primary roles of tillage. Weeds compete with crop for moisture, nutrients, light and space. some weeds secrete toxic substances through their roots into the soil recording the growth or killing the crop plants. Weeds at the seedling stage can be controlled efficiently by proper timing, and by using light cultivation implements.

Deep ploughing in dry soil during summer, is the effective means of controlling perennial weeds. It may help to bury weed seeds.

Soil Structure: Tillage improves soil structure (Crumb and granular) under conditions of optimal moisture. Rough surfaces due to tillage, more so in clayey soils, will increase infiltration of water into the soil by reducing run-off. the amount of water stored in the soil increases, because of adequate proportion of micropores.

Soil Aeration: Tillage increases the soil air content. Better aeration hastens the metabolic processes of plants and activity of micro-organisms. Aeration improves decomposition of organic matter and release of plant nutrients.

Soil Drying: Drying the ploughed soil by exposing it to the sun rays in summer increases the availability of some nutrients. Soil drying markedly reduces the total micro-organism population. However, many of the beneficial saprophytes form resistant spores in the dry period and multiply rapidly soon after wetting. The nitrifying bacteria are more resistant to drying.

Pest Control: Ploughing the soil expose the insects (root grubs) and masses to birds or to the sun's heat. The birds would pickup the root grubs. Removing the stubbles by ploughing, reduces the attack of the steam bore on jowar and bollworms on cotton. Many of the pest and disease organisms like maize borer, maize leafblights, ear-rot diseases in maize are destroyed by being buried into the soil.

Root Penetration: Tillage has only limited effect on root penetration, but breaking up of hard pans in the soil, by deep ploughing or sub-soiling is essential not only to improve root penetration but also improve drainage condition of the soil.

Crop Residues and Organic Manures: Making use of proper tillage implements, helps in burying and incorporation of crop residues, and organic manures. These organic materials add more humus and improve the fertility status of the soil.

Check Your Progress - 1

What are the objectives of tillage?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

5.4. TILLAGE OPERATIONS

The various tillage operations based on their timing are broadly grouped as preparatory tillage or cultivation, and inter-tillage or inter-cultivation.

5.4.1. Preparatory Tillage or Cultivation

The tillage operations carried out in the field before the sowing of the crop will go in the name of preparatory cultivation. They aim at the production of a loose, and friable condition of the soil, suitable for crop growth. Preparatory cultivation includes ploughing harrowing, and levelling. The purpose of using different implements, one after another, is to achieve good tilth.

The basic operation performed to break open, and/or invert, the soil mass to prepare a seed bed for growing crops is known as primary tillage, and the implements (mostly plough) used for this purpose are called primary tillage implements.

Tillage operations carried out following the primary tillage are known as secondary tillage. These secondary tillage operations include the tillage practices carried out before the crop sowing, and also soon after sowing (earlier to seedling emergence). The implements employed for this purpose are called secondary tillage implements. These include harrows, cultivators, levellers etc. These operations do not cause much soil inversion.

The secondary tillage aims at soil clod breaking and pulverisation, removal of weeds and incorporation of crop residues with top soil, levelling and compaction of surface soil.

5.4.2. Intercultivation

Intercultivation is carried out in the field after the plants have come up (emerged).

The primary purpose of inter cultivation is to control weeds. Intercultivation also breaks the soil crust, facilitating seedling development and in some cases roughens the soil sufficiently to increase water infiltration. Intercultivation brings about aeration of the soil. the intercultivation operations are carried out for the benefit of the crop after seedling emergence, until the crop makes sufficient growth.

5.4.3. Preparatory Tillage or cultivation Operations

Primary Tillage Operations: Ploughing is the basic tillage operation carried out to break open the soil mass. Ploughing leaves the land cloddy, loose and uneven. Therefore, it is not in proper tilth for sowing of crops. To bring the soil to a good tilth, it is necessary to work the soil with other tillage implements.

Primary tillage implements: ploughs are the most commonly used implements for preparatory tillage. The ploughs are either bullock-drawn or tractor drawn.

5.5. TYPES OF PLOUGHS

The description of different types of ploughs that are used for tillage operatives are given below.

5.5.1. Indigenous or country ploughs:

These are bullock drawn implements made of wood. These are cheap and simple in construction. These can be readily made with locally available wood (Acacia, Neem, Teak etc.) and repaired locally. In addition to ploughing, these can be used to: (i) cover manures (ii) form ridges and furrows (iii) sow and cover seeds like groundnut and bengalgram (iv) intercultivate in chillies, cotton and tobacco etc, (v) earthing up of crops, (vi) harvest crops like sweet potato, onion, turmeric, groundnut etc.

The country plough consists of a wooden body, an iron share, a wooden shaft pole and a wooden handle. (Fig. 5.1).

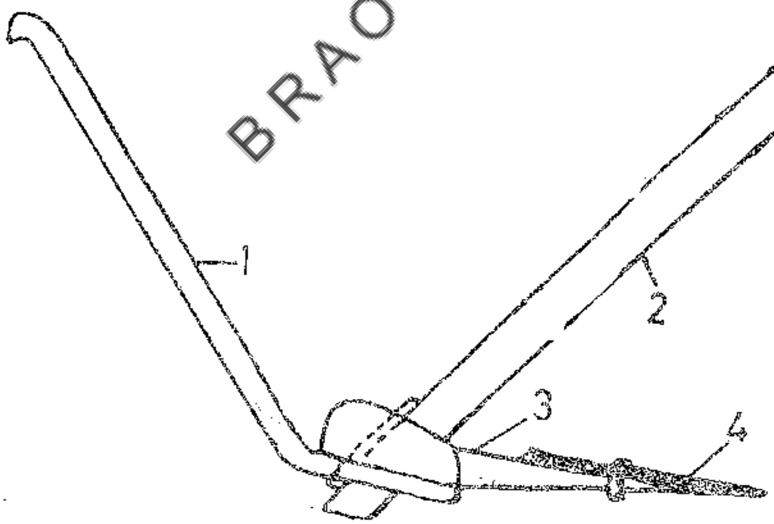

Fig.5.1. Indigenous plough. 1. Handle. 2. Beam. 3. Body shoe. 4. Share.

Body: The body is the vital foundation of the plough, to which are attached all the other parts. The bottom portion is at an angle to the vertical part and is wedge shaped, tapering towards the end for penetration into the soil

Share: The share is 2.5 to 4.0 cm broad, 1.2 to 2.5 cm thick and 30 to 40 cm long. This is fixed upon the top of penetrating end of the body into a groove with 'U' shaped nails. The share is the cutting part of the plough, and requires replacement occasionally on wear off.

Shaft pole: This is about 3 meters long and is driven into the vertical portion of the body. The shaft pole connects the plough to the yoke (Fig. 5.1).

Check Your Progress - 2

What are the important parts of the indigenous plough?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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5.5.2. Wooden Ploughs

a) Peddamadaka: This ploughs to a depth of 15 to 20 cm and is drawn by 2 to 3 pairs of cattle. These are used whenever deep ploughing is needed.

b) Dryland Ploughs: These are smaller, and plough to an average depth of 15 cm. The black soil ploughs are heavier than the ploughs used in red or sandy soils.

c) Wetland Ploughs: These are smallest, and cover about 0.1 to 0.2 hectares a day for the first puddling and about 0.25 to 0.3 hectares at the final puddling.

5.5.3. Mould Board Ploughs

These are made of iron (Fig.5.2) and useful only for ploughing, but not for other operations. These are used in dry and wet land. Usually in wet lands, the ploughs are used for opening soil. However, subsequent ploughings are done with the wooden plough. The different parts of the mould board plough are (i) Share (ii) Mould board or wing (iii) Land slide (iv) Frog or Share (v) Connecting rod (vi) Other accessories.

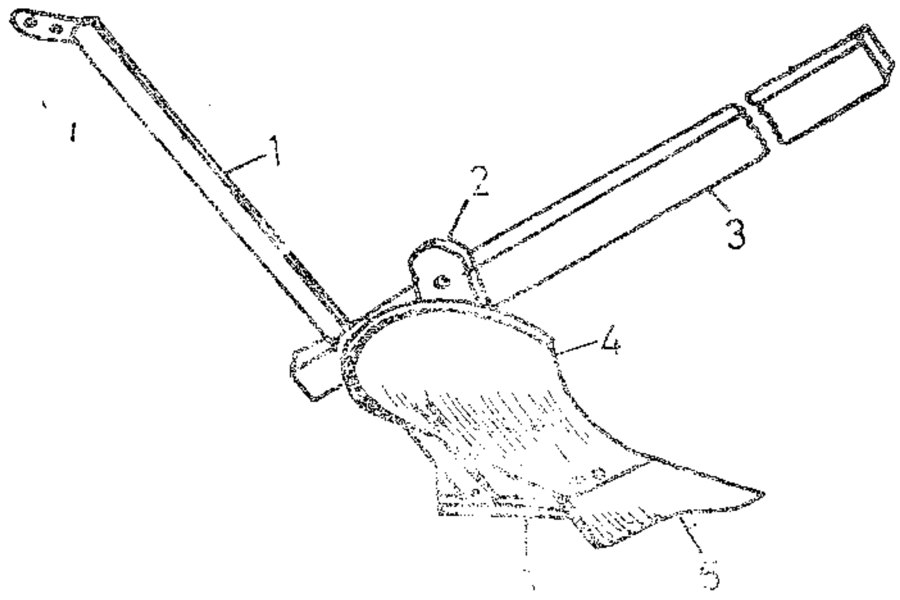

Fig.5.2. Animal mould board plough. 1. Handle. 2. Standard. 3. Beam. 4. Mould Board. 5. Share. 6. Landslide.

Share: The part of the plough bottom that penetrates into the soil and cuts the soil in a horizontal direction below the soil surface. It is a sharp, well polished and pointed component. The share is made up of chilled cast iron or steel.

Mould Board: This is a plate made of steel or cast iron, which receives the furrow slices from the share. It lifts, turns and breaks the furrow slice. to suit different soil conditions and crop requirements, mould board has been designed in different shapes.

Land Slide: This is the part of the plough that slides along the face of the furrow wall. It helps to resist the side pressure exerted by the furrow slice on the mould board.

Frog: This is the part of the plough bottom to which the share, mould board and the land slide are attached rigidly. The ploughing is of two ways. (i) Gathering and (ii) Splitting. The method of covering the plot by turning the plough towards the side of the mould board is called gathering. Ploughing by turning towards the land slide that is opposite to the mould board is called splitting.

Comparative study of the country or indigenous and mould board ploughs.

	Country or indigenous plough		Mould board plough
1.	Only stirs the soil.	1.	Not only stirs but inverts the soil.
2.	Unploughed land is left between successive furrows	2.	No unploughed land is left.
3.	Opens a 'V' shaped furrow	3.	Opens rectangular furrows.
4.	Multipurpose implement.	4.	Not a multipurpose implement.
5.	Can be operated under varying conditions of soil moisture.	5.	Can be operated under the exact moisture conditions only.
6.	Very little scope for adjustment of depth of furrow and no scope for width adjustment.	6.	Perfect adjustments can be made for depth and width of the furrow.
7.	Requires more drought.	7.	Requires less drought.

5.5.4. Other Types of Ploughs

These are some special purpose ploughs. They are (i) Disc plough (ii) Turn-wrest plough (iii) Sub-soil plough (iv) Ridge plough.

Disc Plough: It cuts, turns and in some cases breaks furrow slices by means of separately mounted large steel discs. The usual size of the disc is 60 cm with 7.5 to 12.5 cm concavity, turning a 25 to 30 cm furrow slice. A disc plough is designed with a view to reduce friction by making a rolling plough bottom instead of a sliding plough bottom. More area can be covered with the available power, than with a mould board plough.

Turnwrest or Reversible or One-Way Plough: In this plough, the mould board and the share can be reversed either to the left or to the right side of the beam. This adjustment saves the trouble of turning the plough in hilly tracts, yet facilitates inversion of the furrow slice to one side only.

Sub-Soil Plough: This plough is designed to loosen the sub-soil without inversion. Sub-soiling is probably the most effective method of breaking up compacted of cemented layers for improving root penetration, aeration, and water penetration. To be effective, it must be done in dry soil.

Ridge Plough: This plough has two mould boards with a common share. The ridge plough is used to form ridges and furrows, and for earthing up of crops.

Seed Drill or Gorru: In black soils, where deep ploughing is not required regularly, the seed drill is used for preparatory cultivation. This is used for breaking of clods. Mostly three or six tired drills are used. This covers 0.8 to 1.0 hectare in a single day.

5.6. SECONDARY TILLAGE OPERATIONS

Harrows are used after ploughing to break the clods, pulverise the soil, control the weeds etc. It compacts the subsoil and leaves the surface soil loose and friable. In addition to these, harrows are used for covering seeds after sowing, inter cultivation in linesown crops, harvesting of groundnut etc.

5.6.1. Types of Harrows

Disc harrow: The bullock drawn, disc harrow consists of two sets of discs mounted 15 cm a part on two axles and revolve together with axles. The discs cut through the soil and effectively pulverise the clods. Tractor drawn disc harrows are also commonly used (Fig. 5.3).

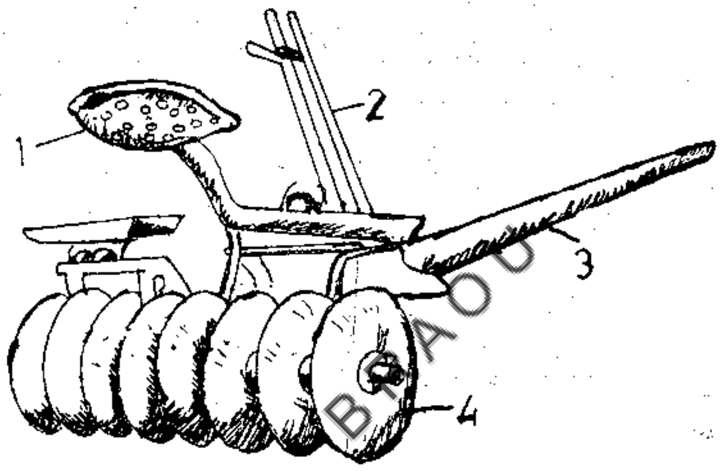

Fig.5.3. Disc harrow (Animal drawn). 1. Seat. 2. Adjusting lever. 3. Beam 4. Disc.

Blade harrows (Guntakas): These blade barrows loosen the surface soil leaving it in the original place. In certain areas, instead of preparing the land by ploughing, harrows are worked,

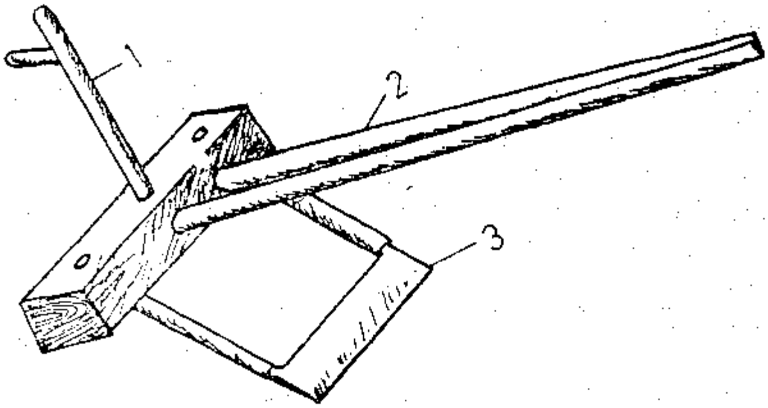

Fig.5.4. Blade harrow. 1. Handle. 2. Beam. 3. Cutting edge.

but to shallow depths only. The guntaka, generally, consists of an Octagonal wooden body to which iron blades of varying lengths are fixed through two shaft poles and a handle. Pedda guntaka. Bara guntaka, and guntaka are commonly used for preparatory cultivation (Fig. 5.4).

Baraguntaka is a light harrow, compared to the peddaguntaka, with a longer blade of 1.5 mt. It is used for soil pulverisation, periodical surface mulching, and weeding etc.

Cultivator: This consists of a number of tynes attached to a frame. The cultivator stirs the soils without inversion and breaks the clods. Destruction of weeds is the primary function of a cultivator. This implement is also used for inter-cultivation. The tynes on the frame can be adjustable to facilitate working between crop rows of varying widths adjustable to facilitate working between crop rows of varying widths (Fig. 5.5).

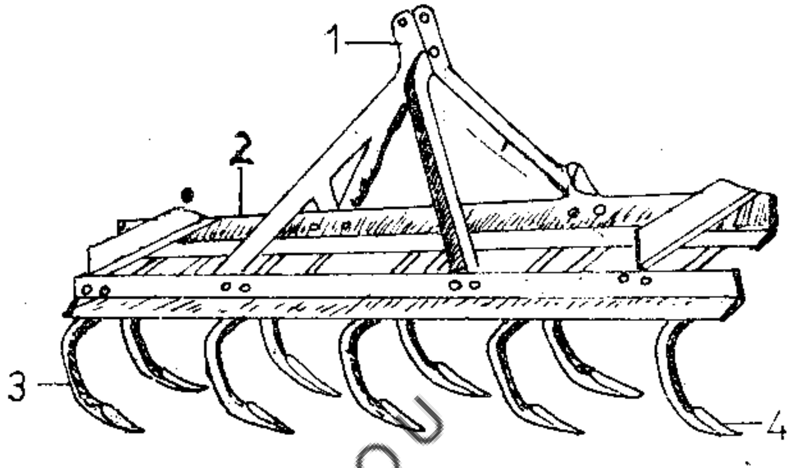

Fig.5.5. Tractor drawn cultivator (Rigid type). 1. Hitch point. 2. Main frame. 3. Tyne. 4. Shovel.

5.6.2. Levellers

Buck scraper or Earth Scoop is a bullock-drawn implement for levelling of fields, by movement of the soil over short distances. The soil should be ploughed and loosened, before working the buck scraper. By slightly raising the handles, the bowl penetrates into the soil and gathers soil. To dump the collected soil, at the lower level, the implement handles are raised and thrown forward. About one cubic metre of soil may be moved per hour over a distance of 33 metres with a bowl capacity of 0.05 cubic metres. The implement consists of a steel bowl or bodv with two handles fitted into two sockets and a drawbar hinged to the bowl.

Wooden planks are the common implements that are used for levelling. These planks may be of round wooden beams of 5 to 15 cm thickness and 2 to 3 metres in length. These implements are passed across the field to level it, and also to cover the seeds after sowing.

In wet lands after puddling. Jumbu (tooth gorru) is used for levelling.

Brush harrow consists of a heavy branch of a tree over which stones or logs of wood are placed. The branch is tied to the yoke with a rope and is drawn across the field. This is used to lightly compact the soil and to cover the seeds after sowing.

5.7. OTHER IMPLEMENTS USED IN PREPARATORY CULTIVATION

Bund Former: This is used to form bunds for, irrigation and conserve soil moisture. The implement which consists of a pair of iron mould boards fixed in opposite directions facing each other, with the front end opening outwards and the rear portion closing into effects the formation of bunds (Fig. 5.6).

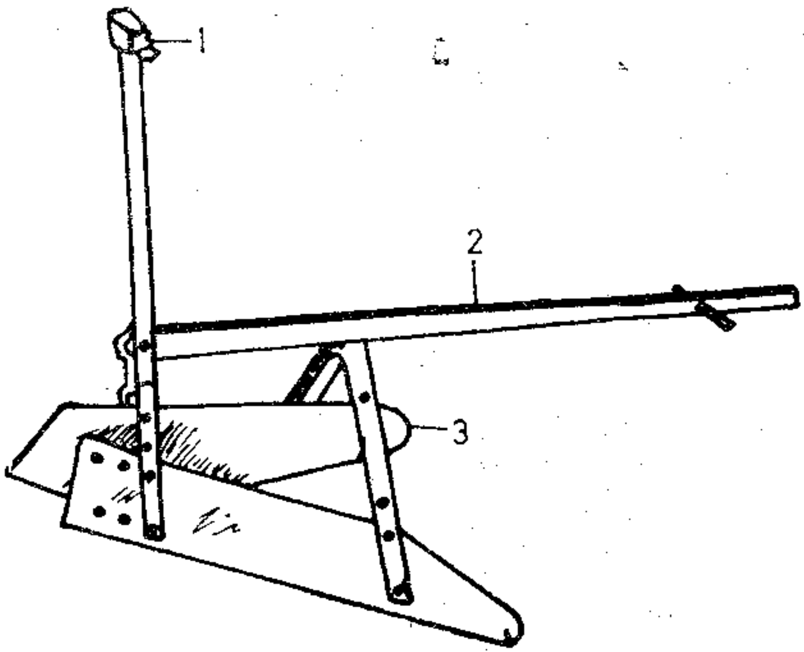

Fig. 5.6. Bund former. 1. Handle. 2. Beam. 3. Forming board.

Wet Land Puddler: This consists of 3 or 4 angular bladed cast iron hubs mounted on a horizontal pipe, rotates when drawn by a pair of bullocks. The puddler churns the soil thoroughly in saturated to submerged condition, for achieving the impervious layer to reduce the water percolation losses. This is used in puddling for wet land rice (Fig. 5.7).

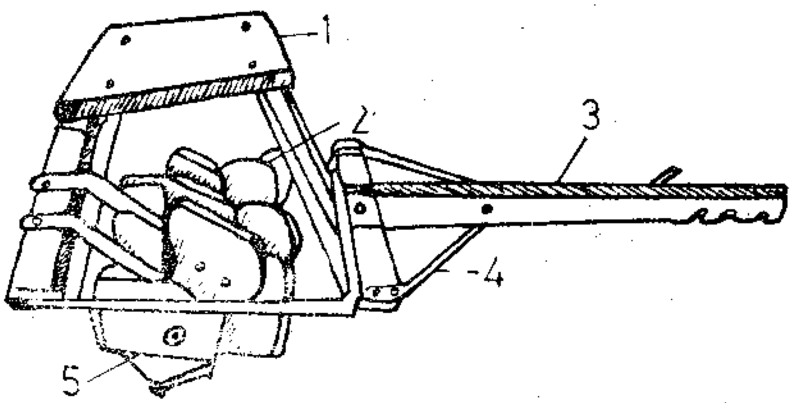

Fig. 5.7. Puddler. 1. Seat. 2. Paddle. 3. Beam. 4. Brace. 5. Axle.

Green Manure Trampler: This is a light implement for effectively incorporating the green manures into a puddle. The implement consists of four 25 cm diameter steel discs with steel horizontal blades interposed between them for efficient trampling. In a day, 1 to 2hectares can be covered.

Check Your Progress - 3

What is the use of Bund former?

Note: (a) Write your answer in the space given below.

(b) compare your answer with the one given at the end.

5.8. HAND OPERATED IMPLEMENTS FOR INTERCULTIVATION.

Hand Hoes: The hand hoes are the tools used in intercultivation of crops by human labour (Fig. 5.8). These are bladed tools with wooden handles and are of different shapes and sizes. Some of them have prongs instead of blades. These tools are (i) Rush type (ii) Pull type (iii) Chisel type (iv) Hand rakes.

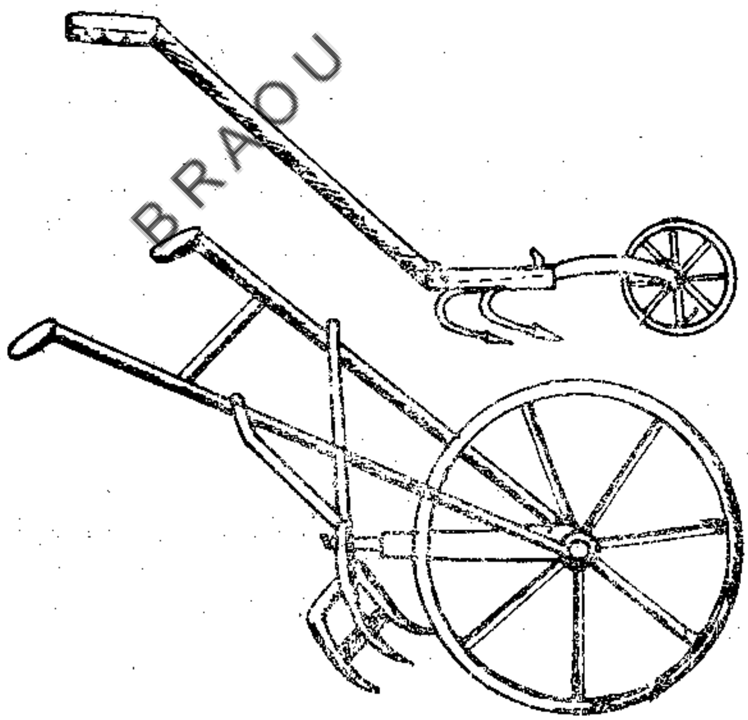

Fig. 5.8. Wheel hand hoe.

Japanese Rotary Weeder: This is a hand operated implement for intercultivation. It consists of two rotary pronged roller fixed on a frame to which a float is attached in the front, and a handle at the back. The float prevents the weeder from getting struck in mud. The prongs or teeth on the roller point towards the handle for better work. The implement worked by two persons can cover 0.1 to 0.2 ha in eight hours (Fig. 5.9).

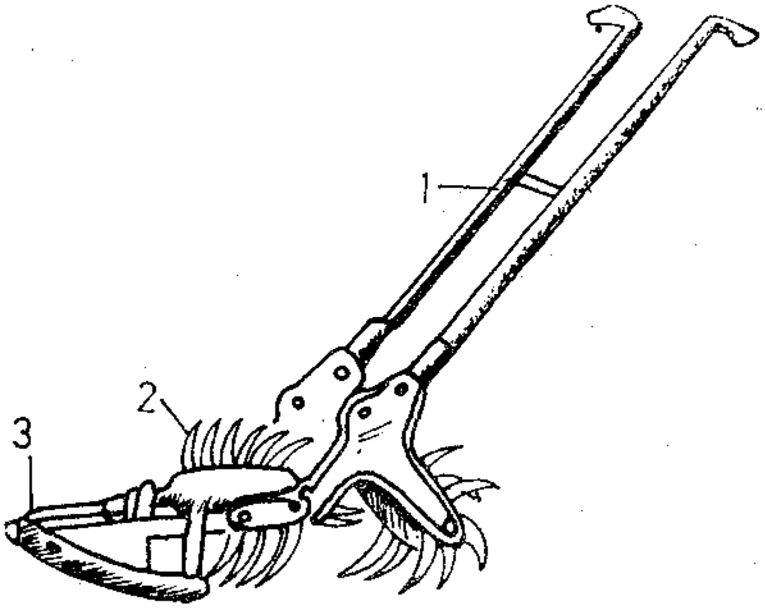

Fig. 5.9. Paddy weeder. 1. Handle. 2. Weeding roll. 3. Float.

Star Weeder: It is operated by a single man. it is useful for intercultivation in row crops for weeding and mulching the top soil in between the crop rows. It consists of two sets of serrated discs of 15 cm diameter mounted on two axles. The front set comprises of four star shaped discs and the rear set of three discs. They are mounted on a 'U' frame. A small cutting blade and a handle are fixed to the frame. It covers about 2.0 acres per day. The star shaped discs loosen the soil and the cutting blade cuts top soil and weeds to about 2-3 cm depth. It saves about 50% labour when compared to hand weeding.

Check Your Progress - 4

List out the hand operated intercultivation implements?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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5.9. BULLOCK DRAWN INTERCULTIVATION IMPLEMENTS

Danti: This is smallest blade harrow and is best suited for intercultivation in between the rows of closely drilled crops. The blade is about 15 cm long. Three to five danties can be worked at a time, by hitching or tying them to yoke.

H.M. Guntaka (Hilson and Munro Guntaka No. O): This is the smallest implement in place of the Danti. This consists of curved arm to one end of which the frame is permanently attached, the other end of the curved arm caries the blade. The depth of penetration can be adjusted.

Metla Guntaka: Three to six small blades like that of danti are fixed to a long wooden body. It is intended to cover three to six inter rows requiring only one person to handle the implement. In case of Danties, each danti needs one person to handle.

Pratti Guntaka: It is intended for widely spaced crops like cotton. The blade is about 30 cm in length suitable for widely spaced corps.

Bode Guntaka: It is mainly intended to form channels across the slope to prevent soil erosion. It is also used in place of pratti guntaka.

Rekkala Guntaka: This covers two wide inter rows at a time. It consists of two blades attached to the beam. Each blade is of the size of 30 cm long.

Meesala Guntaka: This consists of two blades. It is intended only for surface stirring.

5.10. TILTH

Tilth is the physical (Loose, roughly powdery, granular and crumbly) condition of the soil suitable for the production of corps.

This condition facilitates (i) better seed germination and crop growth (ii) free movement of air and moisture in the soil (iii) rapid infiltration of water and (iv) holding maximum amount of available water.

The concept of tilth varies with the type of crop to be grown. Small seeded crops like ragi, onion, lucerne etc., require a fine seed bed. Certain, other crops like sorghum, bengal grams etc come up well even if the seed bed is not thoroughly prepared.

5.11. SUMMARY

The purpose of tillage operations with different implements is to prepare suitable seed bed, to remove weeds and improve the physical conditions of soil for growing of crops. Tillage practices desired for specific objectives are only essential. Extra tillage operations may not be very useful. Soft and friable surface soil is necessary for good germination and seedling emergence. Proper timing of tillage operations with suitable implements will kill the weeds successfully. Adequate pore space helps in increased storage of water, and in release of plant nutrients by increasing the decomposition of organic matter. Deep ploughing is not essential every year. The aim of primary tillage operations is to break open and/or invert the soil mass. Ploughs are most commonly used implements for primary tillage. The country plough only stirs the soil but there is no inversion. Unploughed land is left between furrows. It is a multipurpose implement and can be operated under varying conditions of soil moisture. The aim of secondary tillage operations is to break the soil clods, pulverise the soil, level and compact the soil. Harrows are the most commonly used implements for secondary tillage. Intercultivation is carried out in the field after the emergence of crop plants, mainly for weed control. It also helps in breaking soil encrustation and improving the soil aeration. Small blade harrows are used for intercultivation.

5.12. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The objectives of tillage are: (a) Seed bed preparation, (b) Weed control, (c) Improvement of soil structure, (d) Soil aeration, (e) Soil drying, (f) Pest control, (g) Root penetration, (h) Incorporation of Crop residues and organic manures.
2. The important parts of the indigenous plough are (a) wooden body, (b) iron share, (c) Wooden shaft pole and (d) Wooden handle.
3. Bund former is used for the formation of bunds for the irrigation and moisture conservation
4. The hand operated interculitivation implements are (a) hand hoes, (b) Japanese rotary weeder and (c) star weeder.

5.13. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Discuss, in detail the objectives of various tillage operations?
2. What is primary tillage? Describe the various parts of Mould board plough and label the parts by drawing a neat diagram.
3. What is secondary tillage? Write about the different types of harrows used for secondary tillage operations?
4. What is Intercultivation operation? Write briefly about the various bullock drawn implements used for intercultivation.
5. Discuss the different concepts of tillage?

II. Answer the following questions in about 10 lines each.

1. Define tilth. Mention the usefulness of good tilth.
2. Define tillage. Write briefly about the history of tillage development.
3. Describe the country or indigenous plough with the help of neatly drawn diagram.
4. Compare the working of country or indigenous plough and mould board plough.
5. Describe the buck scraper, and also give the usefulness of this implement.
6. Describe briefly the blade harrow with the help of a neat diagram.

UNIT - 6 : WEEDS AND WEED CONTROL

Contents

6.1. OBJECTIVES

By the end of this unit you will be able to:

1. define weeds and describe the vairous factors that affect the competitive ability of weeds,
2. classify the weeds basing on their life span, angrospermous groups, occurrence, ecological affimities, soil type, origin and special features,
3. describe the vaious control methods such as Mechanical, cropping and competition, biological and chemical.

6.2. INTRODUCTION

Farm activities are designed to favour certain plants and animals that provide us food and fibre. But the same activities may also provide good growing conditions for other plants and animals that harm them. These living things that compete with us for food and fibre or attack us directly are called **pests.**

Pests can be put into Four main groups, namely L (1) insects (plus mites, ticks and spiders), snails and slugs, (2) vertebrates (birds, rodents, etc.), (3) weeds, and (4) plant disease agents. This chapter will deal only with weeds.

Definitions (Concept) of Weed

- any plant or vegetation, excluding fungi, interfering with the objectives, or requirements of people.
- plant growing where it is not desired (wheat in maize field).
- plant out of place.
- plant whose economic value has not been discovered.
- plant that is extremely noxius, useless, unwanted, or poisonous.

The meaning of the term 'Weed' depends on human attitude. It differs from one person to another, from a farmer to an enginer.

Losses Caused by Weeds are: (a) Competition and yield reductions. (b) Added protection costs from other pests. (c) Increased costs of labour and equipments. (d) Poor quality of products. (e) Increased water management problems. (f) Affect human health. (g) Lower land value.

Though losses due to weeds are there, still weeds can also be put to use . The uses are: (1) As forage, e.g., Chicory. (2) As green manure e.g., *Croton sparsiflorus.* (3) For paper and fibre pulp e.g., Aquatic weeds. (4) A source of proteins e.g., *Chlorella pyrenoides.* (5) In crop breeding e.g., *Saccharum spontaneum.* (6) For flavour and medicine e.g., *Cyperus rotundus, Achyranthus aspera.* (7) For thatching and ropes e.g., *Saccharum spontaneum.* (8) Air pollution indicators. e.g., wild mustard (NO_2) Chick weed (SO_2) (9) As vegetables e.g., *Chenopodium album. Digeria arvensis* (10) Weeds some times form canopy over the surface and protect the soil from wind and water erosion. (11) To reclaim alkali soil e.g., *Argemone mexieana.* (12) For beautification (with flowers) e.g., *Chenopodium album, Amaranthus viridis.* (13.) Pot herbs, pot herb sand greens and greens. (14) In irrigation as indicators of soil moisutre status. (15.) Means for evaluations of air pollution damage.

6.3. FACTORS AFFECTING COMPETITIVE ABILITY OF WEEDS

For formulating effective weed control measures, it is important to know about the survival mechanism of weeds that enables them to flourish. The establishment and distribution of weeds depend on their characteristics, cultural operations followed and the agroclimatic conditions. The mechanisms which enable the weeds to survive are given below:

6.3.1. Enormous Seed Production

Most of weed species produce a large number of viable seeds. With the result even if a few weeds are left in the field, they produce enough seed for infesting the area in the coming season.

6.3.2. Vegetative Reproduction

In addition to the reproduction by seeds, perennial weeds like *Cyperus rotundus, Cynodon dactylon, Eichornia crassipes* etc. also multiply by various vegetative means, such as nuts, rhizomes, bulbs, stolons, roots and stems. Reproduction by vegetative means enable them to survice under adverse conditions. These weeds are not controlled by ordinary cultural operations.

6.3.3. Seed Dormancy and Longevity

Seeds of most of the weed species exhibit one or other type of dormancy. Dormancy enables the seeds to survive in the soil for a certain period as they germinate only under favourable conditions. Some of the weed species produce dormant seeds, while, in others, seeds attain dormancy.

Unlike the seeds of the crop plants, weed seeds remain viable for a long time and germinate when they get favourable conditions. Lotus seeds found in a lake in Manchuria were approximately 1000 years old and still viable.

To determine the longevity of seed, certain experiments conducted, have revealed that out of 107 species placed in porous clay pots and buried 8, 22 and 42 inches deep in the soil, it was found that,

(a) after 1 year seeds of 71 species germinated,

(b) after 6 years seeds of 68 species germinated,

(c) after 10 years seeds of 57 species germinated,

(d) after 30 years seeds of 44 species germinated and,

(e) after 38 years seeds of 36 species germinated.

6.3.4. Seed Dispersal

Weeds spread from place to place by means of water, wind, man and animals. Seeds of vairous weed species have one or the other special feature for dissemination. Some are equipped with parachute like structure which makes the seed float in the wind. Some seeds have a special structure to help hem float on water and some are caried in moving water or the bottom of a river. To a long distance, weed seeds are carried inadvertantly along with grain and other materials. Seeds of weeds like cock leber cling to animal hair, or clothing and are carried to other places.

Often new weeds are introduced to the farm with contaminated crop seeds.

6.3.5. Adoptability

Weed plants have a remarkable ability to adopot to the disturbed environment. They can also thrive under adverse conditions due to their morophological and physiological characteristics.

Some of the weed plants have an unpleasant, bad smell. They may also have spines and stiff hairs which protect them from damage by the animals.

The other characteristics which enable the weeds to survive and compete effectively with the crop plants are:

(a) Properly synchronized germination with crop plants.

(b) Rapid establishment and growth of seedlings.

(c) compatible growth habit and life history with crop.

(d) Tolerance to shading effects by the crop at the time of establishment.

(e) Quick response to available soil moisture and nutrients.

(f) Adaptation to the most severe climatic situations of the habitat.

(g) Relative immunity to post-seeding soil-disturbance practices.

(h) Resistance to herbicides that are in use.

The competive ability of crop plants is determined by: (a) variety (b) tillage practices, (c) soil-water relations, (d) soil fertility, (e) soil pH, (f) date of planting and rate of seeding, (g) crop rotation, (h) time of seeding in relation to moisture, temperature, and cultivation.

Check Your Progress - 1

What are the various ways of vegetative reproduction in weeds?

Note: (a) Write your answer in the space given below.

b) Compare youı answer with the one given at the end.

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6.4. CLASSIFICATION OF WEEDS

The classification of weeds is as difficult as defining them. The period of life, or life span, is very often taken as the basis for classification. As per the life-span, the weeds are classified into three categories i.e., (1) Annuals (2) Biennials and (3) Perennials.

6.4.1. Based on Life-Span

1. **Annuals:** These are small herbs with shallow roots and weak stems and propagated by seed, which is produced in abundance. After seeding, the annuals die away and the seeds germinate in the next season. Examples are *Argemone mexicana, Cleome viscosa, portulacca oleracea, Sida glutinosa, Xanthium strumarium. Lagasca mollis, Eclipta alba.*

2. **Biennials:** Biennial weeds are less in number. They generally flower and seed in the second season and then die. Some of them may flower in the first season itself (Alternanthera echinata). They live for more than one year but not more than two years. Examples are *Oldenlandia umbellata, Ipomoea reptans, Merremia emarginata, Achyranthus aspera, Alternanthera echinata.*

3. **Perennials: These are two types: (a)** *Herbs* and *shrubs:* These are well adapted to withstand adverse conditons. These species are propagated by seed and also by underground stems, root suckers etc. The food stored in the underground parts helps to putforth fresh shoots whenever conditons are favourable. Examples are *Cyperus rotundus, Convolvulus arvensis, Aristolochia cristata, Abutilon indicum, Celosia polygonoides, Indigofera enneaphylla, Tephrosia purpurea, Desmodium triflorum, Lantana, Lippia nodiflora.* (b) *Woody plants:* The plants will be usually competing with the more desirable grasses in grazing lands and pasture. This type of plants is common in western U.S., Argetina. Australia, Hawaii etc. These woody plants are frequently members of the native flora of the grazing lands or the peripheries of the grazing land. Example are *prosopis spp.*, Tamarix spp.

6.4.2. Based on Angiospermous Groups

Weeds are also classified in accordance with the two great angiospermous groups. i.e., Monocotyledonous (Narrow leaved) and Dicotyledonous weeds (Broad leaved).

1. **Narrow-leaved weeds:** This term refers to the members of 'grass weeds' which includes the members of 'Graminea', 'Cyperaceae' and 'Juncaceae'. This may also include monocotyledonous plants. These plants are usually low growing and anemophilous. The apical meristem is protected by the sheathing leaf bases, which act as an effective barrier in herbicidal control measures. Annual forms are abundant but they are not as troublesome as the perennial grasses.

Examples for Perennials-*Agropyran repens, Sorghum halepens, Cynodan spp, Inperta cylindrica, Saccharum spontaneum, Panicum repens. Annuals-Echinochloa colonum, Panicum spp., Setaria palidifusca, Arundinella mesophylla, Dactyloctenium aegyptium, Digitaria spp, Avena fatua, Cyperus deformis, Cyperus ratundus, Cyperus bulbosus, Fimbristylis.*

2. **Board leaved weeds:** These are the members of the dicotyledonous group.

Annuals: These are quick growers and complete their life-cycle within a single season. They produce large quantities of seeds in a very short period. Examples are *Amaranthus viridis, Euphorbia hirta, phyllanthus madraspatensis, Celosia argenta.*

Biennials: Require two years from germination to flower and seed production. In the first year the seedling develops with a sturdy root system. Examples are *plantogo spp., Alternanthera echinata, Acanthospermum hispidum.*

Perennials: These plants renew growth year after year from the same root system. Most plants of this group are found in non- cultivated areas or occasionally on cultivated lands (road sides, pastures, waste land etc.) Propagation is by seeds and also by vegetative means. The root or stem portion will be cut and disseminated by modern agricultural implements. Examples are *Convolvulus arvensis, Cirsium arvense, Abutilon indicum, Tephrosia spp. Lantana spp. Phaseolus trilobus, Celosia polygonoides, Digera arvensis, Aristolochia bracteata.*

Check Your Progress - 2

What are Bienniels? Give two examples?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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6.4.3. Based on Special Features

The weeds are classified into 1. Poisonous 2. Parasitic and 3. Aquatic.

1. Poisonous Weeds: These plants are responsible for the death of cattle every year to some extent, besides, causing harm to children. As these plants grow along with fodder or grasses, they will be cut and fed to cattle unintentionally. Even if these plants are eaten by cattle in small quantities the animals become weak and unfit for work. The yield of milch cattle will be reduced. These weeds may also cause abortion in cattle. Children are also poisoned by eating the fruits.

(a) *Datura fastuosa:* The species of *Datura* are poisonous to both man and animals. All parts of the plant are toxic but the seeds are more toxic. The alkoloids, *atropine* and *hyoscyamine* have poisonous effects.

(b) *Soalanum nigrum:* The fruits may cause harm to children rarely.

(c) *Withamniya somnifera:* The seeds contain an alkaloid called somniferine which is poisonous.

(d) *Lochnera pusilla:* This is poisonous to cattle.

2. Parasitic Weeds: Parasitic weeds are degenerating species and many of them are devoid of green matter of leaves. They have efficient means of propagation and seed dispersal. The seeds will remain viable for a number of years. These weeds are distributed in about 10 families, out of which, 6 families contain more troublesome weeds. So far about 2,500 species of parasitic seed plants are recognised. Physiologically these are divided into two groups (1) Autotrophic (*Orobanche*) and (2) Heterotrophic (*Cuscuta*). Autotrophic groups can have independent growth upto some extent. *Lxamples* are *Loranthus* spp; whereas heterotrophic are complete parasites depending for nutrients and, water from the host plant eg., *Cascutta.* Parasitic weeds are also classified as (1) Stem parasites and (2) Root parasites.

The stem parasites are:

(a) *Cuscuta campestris* (dodder weed):This parasitises the weeds and small annual and perennial herbs.

(b) *Cassytha filiformis:* This contains more chlorophyll than cuscuta, leaves are reducea to scales and attacks orange trees.

(c) *Loranthus spp:* This occurs on various deciduous trees. These are semiparasites, depending on the host for nutrients and water only. This also attacks rose wood, sandalwood, teak, babul etc.

(d) *Viscum spp:* These are also parasitic on various cultivated plants such as *Pomegranate, Pongamia* and *Albizzia*. This establishes connections with the host at one place unlike *Loranthus*.

The root parasites are:

(a) *Orobanche ssp:* This occurs in tropical and sub-tropical areas.

(b) *Striga asiatica:* Root parasite on sorghum and also sugarcane.

3. Pond Weeds or Aquatic Weeds: These plants grow in tanks and ponds and have common characters, eventhough they belong to various families. This is because of the environment. The plants are adapted to thrive under aquatic conditions. The transpiration mechanism is absent and the water conducting tissues and root system are poorly developed. They have special tissues for storage of air, commonly propagated by vegetative means.

The damage done by these weeds to crops is considerably less when compared to the damage caused by weeds of aerable lands. But these weeds may cause considerable inconvenience (1) Drainage and irrigation channels may be blocked, (2) Lifting of water may be difficult, (3) Drinking water may be polluted with decaying material of weeds (4) Fishing may be difficult. The examples for this type of weeds are *Nymphaea stellata, Typha spp, Pistia stratiotes, Nelumbo nucifera, Marsilea minuta, Ipomoea aquatica, Potamogeton pectinatus, Hydrilla verticillata, Eichornia crassipes, Salvinia auriculata,*

Check Your Progress - 3

Give two examples each for poisonous and parasitic weeds.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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6.5. WEED CONTROL METHODS

The common saying 'An ounce of prevention is worth a pound of cure' is also true of weed control. As such prevention of the entry of weeds into a country of individual fields will be the first step in weed control. The following are the common preventive methods of weed control.

1. Use of clean seed.
2. Do not feed cattle anything having viable weed seeds.
3. Manure having viable weed seeds should not be used.
4. The cattle should not be permitted to move directly from weed infested fields to clean areas.

5. Clean the implements such asharvesters, cleaners, tractor wheels etc. before taking them to other areas from weed infested fields.
6. Avoid use of gravel, sand, soil etc. from weed infested areas.
7. Clean the nurseries and keep them free from weeds.
8. Banks of irrigation and drainage ditches must be kept free from weeds.
9. Keep corners of fields, fence lines, road sides, rail roads etc. free of weeds.
10. Prevent the production of wind-borne seeds in any area.

The weed control methods may be grouped as follows: (1) Mechanical Method (2) Cropping and competition method, (3) Biological Method and (4) Chemical Method.

6.5.1.Mechanical Methods

Hand Pulling: This method can be used to control annuals and biennials which do not have underground parts for propagation. If adapted in perennials this has to be repeated. This is best done when the soils have sufficient moisture.

Hand hoeing: This is generally used in gardens, fields, lawns etc. Even perennial weeds such as bind weed can be controlled by hand hoeing.

Tillage : This is useful in controlling annuals, biennials, and perennials. Tillage reduces the weed seed population of the soil. This prevents the weed seedlings from producing seeds and also encourages the germination of weed seeds which will be destroyed later. Deep ploughing helps to bury the weed seeds.

Mowing: This helps to prevent the weed seed production. This may also weaken the food reserves of perennials.

Heat : Heat kills living cells due to the coagulation of protoplasm and inactivating enzymes. The thermal death point for most plant cells lies between 45^{0} and $55^{0}C$ (113 to $131^{0}F$).

Smothering with non-living material: The weeds may be controlled by mulches such as soil, manure, paper, plastic film, rice hulls etc. This excludes light and hence prevents top growth. This is a common practice in the pine-apple plantations of Hawaii. The mulches will also help (1) to conserve moisture (2) to maintain a higher temperature and (3) rapid and early growth.

Black sheet plastic materials are better for this purpose which control weeds well and are also economical.

6.5.2. Cropping and Competition

Continuous cropping with small cereals invariably results in an increase in the annual weed population. Continuous cropping with the same crop encourages pests and diseases. The areas where crop plants were damaged by insects etc. will be invaded by weeds. Weeds also can be controlled by raising smothering crops such as, millets, sudan grass, buck wheat, sweet clover, rape, barley, sorghum, alfalfa, cowpea, clovers, hemp etc. A combination of tillage and competitive crops gives encouraging results.

The crop rotations and fallowing reduces the weed growth than taking the same crop.

6.5.3. Biological Control of Weeds

It employs natural enemies of weeds such as insects, plant pathogens and animals.

1. *Basic Principles:*

- basic objective is not eradication but reduction of weeds density to non-economic levels.

- biological control is never the solution to every weed problem, since there are no effective agents for every problem.
- introduced weeds are the best targets of biological control programmes.
- unspecialised feeders are not used in biological control because of the danger that they attack closely related plants.

2. *Requirements and qualities of a predator/parasite/pathogen for biological control*

  - specificity - the organism must feed on or affect only one host (the weed species) even if it starves to death when this species is unavailable.
  - free of enemies - must be free of its own predators and parasites and be resistant to those found in the new areas.
  - adaptability - must be adapted to the climate/environmental conditions over a maximum part of the terrain infested by the weed.
  - Aggressiveness - must be capable of seeking out the host in its environment, dispersing successfully to locate the host plant.
  - effectiveness - must be able to kill the weed or at least prevent its reproduction in a direct or indirect way.
  - reproductivity - must have a reproductive capacity sufficient to overtake the increase of its host species without too much delay when for any reason control is temporarily halted, as by occurrence of unfavourable weather conditions.

3. *Procedures involved in introducing a biological control agent.*

  - foreign exploration - search for the control agents in foreign countries, usually, where the weed species came from.
  - test on host specificity - determine the host range and select only those that are specific to one host.
  - shipment and handling of biological agent through quarantine-any biological agent must be carefully sorted out and examined in quarantine to make sure it is free of its predators and parasites, etc.
  - local test - must evaluate the culture and multiplication techniques, and then its effectiveness against the host on a small and then on a larger scale.
  - release of the agent, followed by further evaluation of results.

Specific Weeds and Biological Control

In Australia the *Lantana* sp. was controlled with two beetles, namely *Octotoma scabripennis* and *Uroplata girardi*. In addition *Lantana* bug (*Teleonemia scrupulosa*) was found effective in controlling this weed.

Prickly pear weed (*Opuntia spp*) was controlled by *Cactoblastis cactorum* (moth borer) in Australia.

Opuntia dillenii was controlled by *Dactylopius tomentosus* cochneal scale insect in India. St. Johnswort weed (*Hypercuum perforatum*) was controlled by *Crysolina quadrigemina* in U.S.A. (leaf eating beetles). Alligator weed (*Alternanthera philo-xeroides*) an aquantic weed was controlled by *Agasicles hygrophyla flea beetless*).

Certain fresh water carp fish consume large quantities of aquatic weeds as their food e.g., Common carp (*Cyprinus capio*) and chinese grass carp eat weeds more than its body weight and grow at a rate 5 kg/year and can attain a body weight of 50 kg.

Marisa sp. and other fresh water snails feed on submerged aquatic weeds - e.g., *Coontail elodea* and certain algae.

A spider mite (*Tetrancchus sp.*) is found to be useful in controlling the prickly pear.

Certain fungi also control weeds. *Acacia glauca* weed is controlled by *Cephalosporium sp.* and Cliandrilla juncia weed is controlled by *Puccinia chondrillina.*

6.5.4. Chemical Methods (Herbicides)

Herbicides are a relatively new tool in man's effort to control weeds. Their use has increased rapidly since 1944 when 2,4-D was first used as a herbicide. Since that time the area treated with chemical has increased dramatically.

Research during the past 3 decades has increased our knowledge about weeds and their control. At the same time, many new chemicals have become available for use in weed control. At present, there are few weed problems in which chemicals cannot help and the feasibility of their use is dependent upon the cost- benefit ratio. In many instances herbicides offer the most practical, effective and economical means of reducing weed competition, croplosses and production costs. Throughout Asia, however, chemicals have had difficulty in gaining acceptance probably because of the high cost-off herbicides, the supposed availability of cheap labour and problems associated with herbicide application. The following are some of the advantages of herbicide usage.

Advantage of Herbicides

1. Can be applied in any season.
2. Control at early stage.
3. Kill all weeds - mimicry wild oat in Wheat, barn yard grass in Rice.
4. Effective in row spacing as well as broad-cast.
5. Control lasts for a longer time.
6. Convenient to use on spiny weeds.
7. Safe on erodoble land where tillage may accelerate soil and water erosion.
8. Kills the weeds *in situ* with-out helping dissemination of seeds. Physical methods on the other hand fragment the weeds and drag them to new sites.
9. Can be sprayed easily, and reach the weeds growing in obstructed situations.
10. Lower cost of production of crops.
11. Greater yield per unit area.
12. Few labour problems.
13. Greater possibility of farm mechanization.
14. Easy crop harvesting.
15. Lower cost of processing of Farm produce.
16. Lesser health problems, due to allergies caused by weeds.
17. Less crop failure due to drought.

Limitation of Herbicide Use

1. There is no automatic signal to stop a farmer who may be applying the chemical inaccurately till he sees the result in crop sprayed, or the crop that follows in rotation.
2. Correct dosage may interact with environment to produce unintended results-Drifts, wash off, run off.
3. Depending upon diversity in farming, a variety of herbicides must be stocked on the farm to control weeds; whereas in physical, one or two implements are enough.

4. Requires considerable skill on the part of the user in the identification of weeds and crop, proper dosage and time etc.
5. Selection or replacement of crop must be based on its tolerance to herbicides present in the soil.
6. Herbicides research and development requires very extensive testing which require large expenditure.
7. Herbicides have been misused in chemical warfare for destroying enemy crop.

Classification of Herbicides

I Classification according to the type of formulation with examples.

A Liquids.

1. Water soluble chemicals - solution concentrate.

acerolein	MSMA
amitrol-T	paraquat
dicamba	picloram
dinoseb	sulphuric acid
diquat	2,3,6 TBA
DSMA	2,4-D and 2,4,5-T
fenac	water soluble amines.

2. Non-water soluble chemicals-emulsifiable formulations.

alachlor	nitrofen
barban	pebulate
benefin	PCP
bromoxynil	propanil
butylate	propham
CDEC	triallate
Chlorpropham	trifluralin
diallate	2,4-D 2,4,5-T
erbon	oil sol. amines, acids, esters
molinate	vernolate.

B. Dry Solids

1. Water-soluble chemicals - soluble powder formulations.

amitrole (various)	endothall, Na, K salts
AMS	sodium chlorate
borates	TCA (Sodium TCA inhibited)
copper sulphate	grass KILLER
dalapon	2,4-D (sodium salt)

2. Non-water soluble chemicals - wettable powder, or liquid supension formulations.

<u>Wettable Powder</u>	
atrazine	linuron
benefin	chloroxuron
bromacil	cynazine
diphenamide	nitrofen
diuron	prometryne
fenuron	propazine
fluometuron	pyrazon
	siduron

metrobromuron	simazine
metribuzin	terbacil
monuron	
nitralin	terbutryn

<u>Granular</u>

alachlor	karbutilate
atrazine	molinate
CDAA	picloram
chloramben	propham
chlorproham	2,4-D
Dacthal	
diallate	
EPTC (EPTAM)	

Detailed Classification with Examples

A. Selective Herbicides

1. Foliage applied herbicides.

(a) Contact type

Bromoxyril		propanil
dinoseb		nitrofen
diquat	paraquat	sulphuric acid
endothall		

(b) Translocated type

barban	MCPA	2,4-D
dalapon		2,4-DB
dicamba	MSMA	2,4,5-T
dichlorprop	picloram	
	DSMA	

2. Soil-applied herbicides

alachlor	dinoseb	propachlor
atrazine	diphenamic	propham
benefin	diuron	pyrazone
bensulide	endothall	sesone
bromacil	fluometuron	siduron
CDAA	linuron	simazine
CDEC	molinate	TCA
chloramben	monuron	terbacil
cyanizine	napthalam	terbutryn
cycloate	nitralin	trallate
cyprazine	nitrofen	trifluralin
DCPA	norea	vernolate,
dichlobenil	bepulate	
	prometryne	

B. Nonselective herbicides.

1. Foliage-applied.

(a) Contact herbicides

AMS	dinoseb	paraquat
cacodylic	diquat	PCP
acid		weed oil

(b) Translocated herbicides

amitrole	DMSA	silver
dalapon	erbon	2,4-D
dicamba	MSMA	2,4,5-T

2. Soil-applied herbicides

(a) Soil fumigants

Carbon bisulfide		methyl bromide
methem	metyle bromide + cloropicrin	

b) Residual soil herbides

atrazine	erbon	picloram
borates	fenac	prometone
bromacin	karbutilate	simazine
dicamba	monuron	TCA
Chlorates	linuron	2,3,6-TBA
diuron		

c) Aquatic applications

acrolein	endothall
copper sulphate	fenac 2,4-D
diquat	

Practical Application Technique of Herbicides

Modern chemical methods of weed control with herbicides offer the most practical, effective, and economical means of reducing weed competition, crop losses and production costs. In the past, herbicides other than 2,4-D and MCPA have been regarded as too costly in many countries. This situation has been changed due to introduction of new formulation of herbicides. Herbicides are presently available as granular materials ready for direct use, or as emulsifiable concentrates (EC), wettable powders (WP) and water soluble powders (WSP). However, to use these inexpensive chemicals to eliminate weeds in rice or other crop effectively, one must understand the following three general precautions.

1. Apply herbicides at the right time. The performance and selective control of weeds (without injuring the crop) of most herbicides depend upon their application at the correct stage of growth of the weeds or the crop. For example, many herbicides are safe to apply to transplanted rice, but only a few will be suitable for direct seeded rice. Similarly, pre-emergence herbicides, such as Eptam and Trifluralin/MCPA must be applied before or during germination of weed seeds because they are less effective after the weed seedlings have emerged from the soil. Post-emergence herbicides such as Propanil must be applied at the later stages of weed growth because they may injure the rice if applied too early.

2. Apply herbicides at the right rates.

3. Apply herbicides accurately because inadequate amounts give unsatisfactory weed control and excessive rates may injure the crop.

Measure the exact amount of herbicide formulation and the area to be treated. Never rely on mere estimates. When spraying herbicide, calibrate properly. This takes a little effort and time, but it is worthwhile in terms of satisfactory results, economy, and safety. Follow carefully the manufacturer's instructions for each herbicide.

Read the label on each herbicide container to find out the correct time and rate of application and other directions of precautions to be observed.

6.6. SUMMARY

Definition of weed depends upon human attitude. A plant out of place is the best definition. Weeds cause many losses *viz.*,reduction in yield, uptake of plant nutrients, harbour pests and disease, reduces quality, weeds are also useful as indicator plants, for medicinal purpose and also to prevent erosion.

Weeds can be classified, based on several factors like life span, angiospermous group, occurrence, ecological affinity, soil type and on special features like parasitic, aquatic etc. The best way of classifying them is on the basis of Angiospermous group. Weeds must be controlled at the appropriate time by adopting effective and economical measures.

Broadly there are three control methods: 1. Physical 2.Biological and 3. Chemical. Physical methods are better but non- availability of labour and high cost makes this method prohibitive. Biological method is not practical. Chemical method is the best and it has more advantages than disadvantages.

Herbicides-usage on large scale was started in 1944. Presently it is always advantageous to use the herbicide for control of weeds in crops. Practical application technique indicates errors commonly made while spraying the herbicides. Herbicide to be effective, the speed while spraying, the pressure of the sprayer, and doses should be followed strictly. Calibration must be made before taking actual spraying of herbicide.

6.7. CHECK YOUR PROGRESS: MODEL ANSWERS

1. The weeds reproduce vegetatively by means of nuts, rhizomes, bulbs, stolons, roots and stems.
2. The plants which live for two seasons are called Bienniels. The examples are *Oldenlandia umbellata* and *Ipomoea reptans*.
3. *Datura fastuosa* and *Solanum nigrum* are the examples for prisonous weeds and *Cuscata carmpestris* and *Orobanche* sp are the examples for parasitic weeds (any other).

6.8. MODEL EXAMINATION QUESTIONS

I. Answer the following question in about 30 lines each.

1. Write the classification of weeds based on several factors with two examples of weeds under each.
2. Write the different methods of weed control along with principles involved in it.
3. Give the classification of herbicides based on chemical nature with two examples under each.
4. Write the advantages and limitations of herbicide use.

II. Answer the following question in about 10 lines each.

1. Discuss the significance of seed viability, longevity and dormancy to weed management technique.
2. Write the different methods of weed control.
3. Define weed and write the principles of weed control management.

4. Write the principles involved in biological control of weeds with two outstanding examples under this.
5. Write the requirement and qualities of predator/parasite/pathogens for biological control of weed.
6. What is meant by cropping and competition. How are they effective in controlling the weeds?
7. List out the characters, which enable the weeds to survive and compete effectively with the crop plants.
8. What are the advantages of using herbicides over mechanical methods?
9. What are the three precautions that are to be understood before undertaking chemical weed control?

UNIT-7: CROPPING SYSTEMS

Contents

7.1. OBJECTIVES

By the end of this unit you will be able to:

1. familiarise yourself with the terminology used in cropping systems.
2. describe intercropping and list out the advantages of it,
3. describe the multiple cropping in rain fed and irrigated areas and its effect on soil properties,
4. define relay cropping and explain its advantages and disadvantages,
5. define sequential cropping and list out some of the sequences in Andhra Pradesh,
6. describe crop rotation and explain the limitations of monoculture,
7. describe the cropping patterns in the black and red soils of semiarid tropics of India.

7.2. INTRODUCTION

The food production has to be increased so as to keep pace with the demand of the ever increasing population. There is little likelihood of extending the areas under cultivation. But there is a possibility of raising two or more crops per year through multiple relay and intercropping systems and the utilising of the available resources more efficiently than before.

Growing more than one crop in sequence or simultaneously as mixed crop is an ancient practice. Indeed, the Indiam Epics mention double cropping. In the early periods, the objective of adopting such a cropping practice was to reduce the risk of total crop failure due to uncertain monsoons and to have a variety of products for meeting the food requirement of the farmer's family, feeding his animals and for meeting his financial requirements. Other benefits such as yield increase due to complementary effect of the component crops, improvement of soil fertility, the spreading of the use of labour over a period of time, and the minimising of the damage caused by weeds. Insect pests and diseases were only incidental. These practices were till recent times thought to have been adopted for subsistance agriculture.

With the avilability of high yielding crop varieties and improved management techniques, the emphasis has been shifted from yield stability of crop mixtures to the achievement of yield advantage, maintenance of soil fertility, the increasing of farm income and efficient utilization of resources through intensive cropping by exploiting the space more effectively through the planting of crops of varying architecture within a specified time span.

The Terminology used in Cropping Systems is given below.

Cropping System: The cropping patterns used on a farm and their interaction with farm resources, and available technology which determine their make-up.

Cropping pattern: The yearly sequence and spatial arrangement of crops or of crops and fallow on a given area.

Farming System: The entire complex of development, management and allocation of resources as well as decisions and activities which, within an operational farm unit or combination of units, results in agricultural production, and the processing and marketing of the products.

Sole Cropping: One crop variety grown alone stands at normal density synonymous with solid planting, and opposite of intercropping.

Monoculture: Continuous growing of the same crop on the land.

Rotation: Continuous cultivation f crops (or crops and fallow) one after another on the same land. One cycle may take one or more years to complete.

Multiple Cropping: Growing two or more crops on the same field in a year.

Cropping index (Cropping intensity): The number of crops grown per year on a given area of land, multiplied by 100.

Intercropping: Growing two or more crops simultaneously in separate rows on the same field. Crop intensification is in terms of both time and space. There is intercrop competition during the entire growth period or part of crop growth period.

Mixed cropping: Growing two or more crops simultaneously with resousing of any separate row arrangement.

Strip intercropping: Growing two or more crops simultaneously in strips wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically.

Relay intercropping: Growing two or more crops simultaneously during the part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage for growth but before it is ready for harvest, often simply referred to as relay cropping.

Sequential cropping: Growing two or more crops in sequence on the same field in a farming year. The succeeding crop is planted after the preceding crop has been harvested. Crop intensification is only in time dimension. There is no intercrop competition.

Ratoon cropping: The cultivation of crop regrowth after harvest, although not necessarily for grain.

Component Crop: This is used to refer to either of the individual crops making up the intercropping situations.

Main or Base Crop: This is the one which is planted at its optimum sole crop population in an intercropping situation and the second crop (intercrop) is planted in between rows of the main or base crop with a view to obtain some extra intercrop yield without sacrificing the main or base crop yield.

Check Your Progress - 1

What is meant by Multiple Cropping?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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The cropping intensification techniques include intercropping, multiple cropping, relay cropping, sequential cropping and crop rotation.

7.3. INTERCROPPING

In dryland agriculture, cropping pattern should be adjusted in accordance with the available resources to utilize the scarce rainfall efficiently. This needs to increase the cropping intensity per unit area per unit time.

As the moisture is available only for a limited period in a year, there is no scope for growing a second crop in sequence. Under such conditions, its adoption of intercropping system as a whole has proved to be more profitable than its growing of one or two crops in sequence. Hence, intercropping make it possible for utilising the growing season fully and other growth resources like light, water and plant nutrients. Light is more fully utilized by extending the time of leaf cover and by a fuller use of the solar energy reaching the field at any given point of time due to the variation in the height of the crops.

The use of nutrients and moisture is likely to be all the more complete because different crops in intercropping use the moisture and nutrients from different depths and layers of soil and because there is less run-off and leaching.

The Advantages of Intercropping are given below.

1. Maximum utilization of resources like sunlight, moisture and nutrients.
2. Production can be increased per unit area per unit time.
3. Greater stability of production over a period can be achieved.
4. The risks due to diseases, pests and weeds are minimised.
5. Soil fertility can be built up with the inclusion of legumes in intercropping systems.
6. Labour peaks can be distributed over the entire crop growing period.
7. Intercropping system provides the farmer with balanced food and meets his domestic needs.

7.4. MULTIPLE CROPPING

The main objectives of multiple cropping is to intensify cropping with the available resources in a given environment.

For the success of the multiple cropping programme from the productivity point of view, proper choice of crop varieties is essential. Crops should be arranged in such a way that temporary immobilization of plant nutrients and depletion of nutrients from the same layer of the soil do not occur. Similarly, crops which add larger quantities of easily decomposable residues and which benefit the succeeding crop with available nutrients should be included. Legumes are suitable for any cropping system because of their limited demand on resources like water, nutrients and light, their adaptability to varying environmental conditions and capacity to fix atmospheric nitrogen in their root nodules. Vegetable crops are also suitable for multiple cropping programmes because they have monetary and nutritional values. Most of the vegetable crops can be raised as seedlings and planted, thus reducing main field duration. The vegetables can be grown in interspaces in orchards and plantations and can be inter-relay cropped on fields of cereal base crops.

The photoinsensitive varieties of different crops of short duration, introduced recently are best suited for multiple cropping.

7.4.1. Rainfed Areas

The selection of crops and varieties by farmers in rainfed areas mainly depend on the amount of rainfall received, the length of the rainy season and the type of soil. In general, millets are preferred for light and shallow soils, sorghum for heavy soils and castor and redgram for soils with compact sub-soil. Higher yield is obtained in *Kharif* than in *rabi* season on heavy soils with good drainage. Safflower grows well in rabi in heavy black soils. Barley, mustard or bengalgram is preferable to wheat in rabi in the Deccan plateau region.

The cropping intensity varies as follows with the amount of rainfall received:

500-625mm with 100mm soil storage capacity-single monsoon crop.

625-750mm Intercropping with crops of different maturity periods.

750-900mm with 150mm soil storage capacity - Relay cropping e.g., Safflower relayed with sorghum.

900mm with 200mm soil storage capacity - Double cropping: e.g., Rice Bengalgram in Indo-Gangetic alluvium, pearl millet - barley/mustard in Central U.P.

The improved cropping pattern suggested for rainfed black and red soils by Krantz (1975) is given below:

Monsoon	Post Monsoon
Sorghum	Rotoon
Sorghum	Relay Bengalgram/Safflower
Maize	Relay Bengalgram/Safflower
Setaria	Sunflower/Sorghum

7.4.2. Irrigated Areas

In irrigated areas the growing of a second or third crop depends not only on the availability of irrigation water but also on the soil type and climatic conditions. Systematic research has been initiated on multiple cropping to find out a suitable potential cropping pattern in irrigated areas. In delta areas rice-rice- pulse is the traditional cropping pattern. Here the short duration pulse (green-gram or blackgram) seeds are broadcasted in the standing rice crop of rice 10 to 15 days before harvest. The pulse seeds germinate with the available soil moisture and establish themselves even before the rice crop is harvested.

7.4.3. Effect on Soil Properties

Physical properties: Keeping a continuous cover through the major part of the year reduces the direct impact of rain drops, soil dispersion, surface sealing and crust formation. This helps in easy establishment of the crops planted. Soil erosion due to run-off water and wind is minimised and helps in maintaining the fertility of soils. The presence of crop stubbles and residues in the soil improves the structure of the soil and keeps the soil in an ariable condition, reducing tillage requirements. Raising crops of different rooting depths helps to explore the soil effectively for moisture and nutrients and prevents the formation of compact sub-soil layers which often happens in monoculture and in the case of repeated cultivation.

Chemical properties: Intensive cropping without adequate manuring and fertilizers may deplete the soil in course of time and decrease its productivity substantially. Even the crop residues are returned to soil and legumes included in the system add nitrogen through root nodules; an intensive cropping without adequate fertilization will not last long. The extent of nutrient of the soil varies with the type of crop included in the multiple cropping programme.

7.5. RELAY CROPPING

It refers to interplanting or sowing of a second crop before the harvesting of the first crop. It is like a relay race, in which a crop hands over the land to the next crop in quick succession. The purpose of this technique is to plant the next crop well within time to realize its potential yield. It has been practiced under irrigated conditions and occasionally in humid climates as a means of maximising the use of resources like land, water and time. Early observations on relay planting at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics, Hyderabad) indicate encouraging potentialities on scope for effective soil and water resources utilisation and increased yield.

7.5.1. Advantages

1. The efficiency of use of water and fertilizers is increased (residual moisture and nutrients).
2. The growth of weeds is kept under control.
3. Owing to the inclusion of deep and shallow rooted crops, proper use of soil moisture and plant nutrients is obtained.
4. Inclusion of legume crops in rotation helps in the restoration of nitrogen status of the soil.
5. Foliage drop and left over stubbles in the field add a considerable amount of organic matter to the soil.
6. The farm labour and cattle could be efficiently used.
7. No preparatory cultivation for the second crop is needed.

7.5.2. Disadvantages

1. As the seed bed is not prepared for the relay crop, the weeds present a magnified problem.
2. This system is legally limited to irrigated areas.

Although relay cropping is normally not practised in the rainfed semi-arid tropics, the development of high yielding short season varieties has given scope for relay cropping in such areas also, particularly in black soils which have high water holding capacity. Since many of the monsoon crops mature during the period when the monsoon rainfall is waning, relay planting of the post-monsoon crops 1-3 weeks before the harvest show the way to reduce the risk of failure in establishing the second crop. Hence, timeliness is important in relay planting operation.

Selection of varieties in relay cropping system should be based on the following considerations:

1. Evolving suitable short duration varieties.
2. Evolving varieties with high yield potential.
3. According to the depletion pattern of nutrients in the soil by the individual crops.
4. Water requirements of crops in the system.

The following are some of the relay cropping systems followed.

Rice-Greengram
Rice-Blackgram
Rice-Linseed.

Check Your Progress - 2

What is relay cropping?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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7.6. SEQUENTIAL CROPPING

Sequence cropping or double cropping is the practice of sowing a crop immediately after the harvest of the first crop. This practice is also adopted in assured irrigated conditions and also in sub-humid areas with heavy rainfall. Double cropping like relay cropping has rarely been practised in rainfed, seasonally dry, semiarid tropics.

Double cropping in a sequence is preferred under the following conditions.

1. In areas with pronounced weed intensity.
2. In areas where the post-monsoon crops require adequate seed bed preparation.
3. Conditions where a crop can be grown with the residual moisture. For example, Sowing Horsegram after groundnut or Bajra.

Under dry farming conditions the sequential cropping mainly depends on

1. Average annual rainfall of the area;
2. Crop suitability to the tract;
3. Prevalent systems of agriculture.

7.6.1. Some Sequences in A.P.

a) Dryland or rainfed conditions:

1. Groundnut - Jowar
2. Ragi - Horsegram
3. Bajra - Horsegram or Jowar or Chillies (Under wells)
4. Kharif: Pulse - Jowar

In upland conditions in intensive pockets under wells vegetables and chillies are under continuous cultivation and at times Ragi or Maize for table purpose will also find a place in the crop sequences.

b) Sequences in Assured Irrigated conditions:

1. Paddy - Pulses - Mesta or Groundnut
2. Green manure - Paddy - Pulses - Fallow
3. Paddy - Groundnut - Paddy.

In deciding the crop sequences it is advisable to select crops with different morphological behaviour, i.e., deep and shallow rooting, etc., and also the nutritional requirements of the crops.

Swaminathan et.al (1970) pointed out that certain basic rules should be taken as guide-lines in formulating and introducing sequential cropping patterns.

Some of the basic rules are:

1. No two crops sharing in common the same pests and diseases should be grown in sequences.
2. One should be deep rooted and another with shallow roots.
3. Attention to restoration of soil fertility by including one legume in the sequence.
4. The fitting of the crops in rotation should be based on an understanding of their production physiology in relation to the environment.

7.6.2. Advantages of Sequence Cropping

1. Better seasonal distribution of labour.
2. Less erosion.
3. Better weed control.
4. Less insect and disease problem.
5. Less seasonal and weather risk.
6. Crops yield more in rotation.

Sequential cropping is also resorted to for the use of available land through the year or for most of the days in the year. Care should be taken in choosing the crops in sequences to see that the preceding crop does not leave any toxic effect. The residual moisture and fertilizers applied to preceding crops will have a definite bearing on the yields of the succeeding crop, specially in dry farming areas and micro water shed development areas, where fertilizer application to the succeeding crop may not be possible.

A grain crop succeeded by a pulse crop or any legume is a good sequence. Continuous cultivation of a single crop should preferably be avoided at the time of deciding the crop sequences.

7.7. CROP ROTATION

The importance of crop rotation was realised a long time ago in view of the need for the soil fertility maintenance, prevention of the spreading of soil borne diseases, pests and weeds, control of soil erosion and insurance of the balanced programme of work throughout the year. Selection of crops in a given rotation primarily depends on the type of farming in question i.e., rainfed farming and irrigated farming. Intensive research work has been undertaken to identify suitable crops for crop rotations under various conditions. A well planned crop rotation has the following advantages over monoculture (growing the same crop continuously on the same land):

1. Soil fertility is maintained:
2. The build up of pests weeds and soil-borne diseases is prevented;
3. Soil erosion is controlled;
4. Prevent or the limiting of the peak period of irrigation water requirements of crops;
5. Provision of a balanced programme of work throughout the year.

7.7.1. Principles

1. Growing of crops with differential depths of rooting systems alternately to absorb nutrients from different soil layers.
2. Alternating crops susceptible to certain diseases with those that are resistant.
3. Selection of crops in rotation with due consideration of detrimental or beneficial effects of one crop on the succeeding crop. These effects may be due to the presence of toxic substances that affects the nutrient supply, the build up of organic matter, soil structure, soil micro-organisms or residual soil moisture.
4. Alternating the crops of soil exhaustion with those contributing to the soil fertility improvement.
5. Alternating the crops with different peak requirements of water, labour etc.,
6. Alternating with soil conserving crops in the rotation to prevent erosion.

As the main objective of crop rotation is to maintain soil rertility and the raising of productivity, it is necessary to include legume crops either of pulse or fodder crops in the rotation. Legumes are known to build up the fertility through their atmospheric nitrogen fixation capacity. Hence, the inclusion of pulses in the rotation provides protein food for man and feed for cattle.

7.7.2. Limitations of Mono-Culture

1. Soil moisture limits the application of chemical fertilizers:

Under semi-arid conditions, deficient soil moisture limits the amount of chemical fertilizers that can be applied and specially for nitrogen, may even make their use impracticable. Low yield levels also make the use of heavy fertilizer doses protective. The rotation including legumes is still frequently the most economical solution to this problem.

2. Monoculture tends to upset the nutrients balance in soils:

Fertilizers are not cheap or easily available everywhere and are costly in the less developed semi-arid regions. A leguminous crop supplying grains and nitrogen to the soil may be able to justify itself economically. Monoculture also tends to upset the nutrient balance in soils by drawing heavily on certain nutrients and leaving behind excessive amounts of other nutrients unused.

In conclusion it can be stated that the former is no longer as dependent on crop rotation for maintaining high levels of production as he was in the past. However, a well planned crop rotation in the context of multiple and relay cropping helps in securing profit, soil sanitation and fertility, weed control, regulation of labour and the use of water and the ensuring of the stability and security of income.

Soil toxin theory: Plant roots produce phyto toxic substance leading to so-called soil sickness. The phytotoxic substances are secreted by the roots and underground systems of certain plants, or produced during the decomposition of their residues. Certain crops such as flax (*Linum sp.*) guayle (*Parthenim argentatum*) and bromegrass (*Brames ineruidus*) are particularly subject to soil sickness. Stands became sparse and yields decline when the crop is grown continuously on the same soil. The conditions are usually species-specific and other crops grow well in the same soil.

As per the experimental evidence available, a group of endogenous substances called Kaolines are excreted or diffused by plant roots that have inhibitory influence on other plants. The effect is called allelopathy. Kaolines are variedly identified as lactones, aminoacids, peptides and even simple carbohydrates.

Check Your Progress - 3

Explain the term monoculture?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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7.8. CROPPING PATTERNS IN SEMI-ARID TROPICS OF INDIA

Black cotton soils are with high water holding capacity. They are rich in potassium, calcium and magnesium. However, these soils are low in O.M. (0.4 to 0.8%) and are usually deficient in N, P and sometimes Zn.

The cropping patterns followed in various black and soils regions may be grouped as follows.

7.8.1. Black Soils

The cropping patterns followed in various black soils in the semi-arid tropics of India are given below.

a) Cropping in Monsoon season only: In soils of shallow and medium textured, moderately deep blacks, crops are grown by utilizing the available water in the rainy season.

Sorghum + Pigeonpea + Sesamum (Intercrop)

Pearlmillet + Pigeonpea + Sesamum (Intercrop)

Sorghum + Pigeonpea - fallow (2 year rotation)

Sorghum + Pigeonpea - Groundnut (2 year rotation)

Soya bean + Pigeonpea - Cotton (2 year rotation)

Cotton-Sorghum + Pigeonpea - Groundnut (3 year rotation)

b) Cropping in post monsoon season only: This system is used in deep or moderately deep black soils by utilising the residual moisture following monsoon season fallow. About 50% of the cultivated black soil is fallowed during monsoon and then cropped during the post monsoon season. There is possibility to increase the cropping intensity in this region if suitable soil, water and crop management practices are used by growing crops during monsoon season and by growing short season crops as relay or double cropping in the medium to high rainfall area (750mm).

Fallow - Sorghum + Oilseed mixture (Intercrop)

Fallow - Chickpea (Continuous)

Fallow - Wheat (Continuous)

Fallow - Wheat - fallow - gram (2 year rotation)

Fallow - Wheat - fallow - linseed (2 year rotation)

c) Cropping during both monsoon and post-monsoon season: In some deep black soils, a monsoon crop is grown during the rainy season followed by catch crops of pulses or oilseeds grown on residual moisture.

60mm on sequences followed

Monsoon crop	Post monsoon crop
Sorghum	Pulse
Sorghum	Safflower
Groundnut	Safflower
Pulses	Wheat
Pearlmillet	Wheat
Cotton	Sorghum + Safflower

7.8.2. Red Soils

These soils are low in N, P and Zinc. Potassium is present at medium to high. Leval Red soils range from shallow to medium in depth and have a relatively low water-holding capacity. Crops are grown only during the monsoon season.

Cotton + *Setaria* (Intercrop)
Sorghum + Pearlmillet + Pigeonpea (Intercrop)
Fingermillet - Groundnut or Horsegram (2 year)
Sorghum - Pulses (2 year)
Finger millet - Pulses (2 year)
Sorghum - Groundnut - Cotton - Setaria (4 year)

In seasons with late rains in september, crops like horsegram, Sesamum and safflower are grown following early maturing monsoon crops.

Alluvial soils: Water holding capacity is relatively low compared to black clay soils. These soils are usually low in organic matter, deficient in N, P and Zn.

Fallow - Wheat (One year)
Fallow - Barley (One year)
Pearlmillet - Chickpea (One year)
Pearlmillet - Barley (One year)
Monsoon fallow - Chickpea - monsoon fallow - Sorghum + Sesamum (2 year)

7.9. SUMMARY

Monocropping, intercropping, sequence cropping, multiple cropping are commonly followed in cropping systems. Intercropping is a common practice adopted under rainfed conditions as an insurance against complete crop failure. Multiple cropping can be adopted to make the best possible use of resources like land, water, labour etc. Relay planting refers to interplanting or sowing of a second crop before the harvesting of the first crop to fully utilize the available moisture. Sequence cropping is the practice of growing a second crop immediately after the harvesting of the first crop which is followed in the case of moisture retentive soils or under irrigated conditions. Crop rotation is mainly useful in maintaining soil fertility and avoiding recurrance of pests and diseases. Monoculture upsets the nutrient balance in the soil by extracting certain nutrients and leaving the other nutrients meagerly utilized.

7.10. CHECK YOUR PRROGRESS: MODEL ANSWERS

1. The growing of 2 or more than two crops on the same field in an year is called multiple Cropping.
2. The interplanting or sowing of a second Crop before the harvesting of the first crop is called relay cropping.
3. Growing of the same crop continuously on the same land is called Monoculture.

7.11. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Briefly discuss the effect of multiple cropping on physical and chemical soil properties.
2. Discuss the advantages and disadvantages of relay cropping.
3. Discuss the advantages and disadvantages of sequence cropping.

II. Answer the following questions in about 10 lines each.

1. What are the advantages of inter cropping?
2. Write about the multiple cropping systems in rainfed areas.
3. Write about the sequence cropping and some sequences followed in A.P.
4. What are the principles of crop rotation.

UNIT - 8: DRY LAND FARMING

Contents

8.1. OBJECTIVES

By the end of this unit you will be able to:

1. classify the regions based on precipitation and evapotranspiration of the crop,
2. list out the principles of dry farming and describe them separately,
3. explain the practice of water harvesting in life saving irrigation, run off farming and microwater sheds.

8.2. INTRODUCTION

Of the 140 million hectares of net cultivable land in India, 105 million hectares (75%) are rainfed and if all available irrigation resources are utilized, still 55 to 60 per cent of cultivable area will continue to be rainfed. Rainfall is the only source of soil moisture to crop plants in rainfed agriculture. In areas, where the annual rainfall is less than 1000mm, with erratic and uneven distribution, a partial or complete failure of crops may occur. Areas receiving less than 1000, constitute 36 percent of net area sown in the country covering nearly 47 million hectares. There are about 84 districts in India coming under this category spread all over the states except Assam, West Bengal, Kerala and Orissa. The major dry farming areas are situated in Punjab, Haryana, Rajasthan Maharashtra, Sourashtra, and Kutch in Gujarat, Rayalaseema, and Telangana regions except Adilabad, Nizamabad, Karimnagar and Warangal districts in Andhra Pradesh, interior north Karnataka, the greater parts of M.P. and some pockets in Tamilnadu and U.P. Agriculture in these parts of India is still a gamble with the monsoon.

8.3. CLASSIFICATION OF REGIONS

Many approaches were proposed to classify the regions based on precipitation and evapotranspiration of the crop. Out of those, Troll's classification based on the period of rainfall and Thornthwaite's classification based on moisture index (MI) are commonly used to classify the regions.

Table-8.1. Troll's classification of regions

Period of precipitation equal or greater than PET *P ** PET	Region
1. Less than 2 months	Arid
2. 2 to 7 months	Semi arid
3. More than 7 months	Humid

* P = Precipitation

** PET = Potential evapotranspiration.

In Thornthwaite classification, Moisture Index (MI) is calculated by using the following formula.

$$\text{Moisture Index} = \frac{P - PET}{PET} \times 100$$

where P = Precipitation

PET = Potential Evapotranspiration

It is evapotranspiration that occurs when the ground is completely covered by actively growing vegetation and there is no limitation of moisture.

Crop production in India is greatly influenced by the South West monsoon (June-September) since 70 percent of the annual rainfall is received during this monsoon period. The distribution of rainfall varies widely, being as high as 4000mm over Khasi hills and as low as 200mm in West Rajasthan. The amount and distribution of rainfall received of depressions and cyclonic storms that move inland from the Bay of Bengal and the Arabian sea coasts and their track and extent of travel over the land. The South-West monsoon is followed by the North-East monsoon from October to December which is known as the *Retreating monsoon* and in some places it is the main source of rainfall.

Soil moisture is the most limiting factor in dryland farming and the crop experiences drought (moisture stress) frequently. According to Thornthwaite, 'drought' is a condition in which the amount of water needed for evapotranspiration exceeds the amount of available moisture in the soil.

Check Your Progress - 1

What is the formula for Moisture Index?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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8.4. PRINCIPLES OF DRY FARMING

The various practices in dry farming regions are in accordance with one or more principles given below to achieve maximum moisture use efficiency.

1. Conservation of moisture by controlling run off and increasing the infiltration.
2. Reduction of evaporation losses from soil and transpiration losses from the plant.
3. Judicious utilization of conserved moisture by adopting appropriate crop management practices and cropping systems.
4. Evolving contingency plans to meet seasonal aberrations

8.4.1. Moisture Conservation Practices

The amount of precipitation stored in the soil depends upon the control of run off and increase in the infiltration rate of the soil.

The lands having different sloped can be better utilized for growing crops by adopting different soil and moisture conservation practices like bund former bunding, contour bunding, contour trenching, bench terracing, depending upon the slope of the land. Other practices like levelling, tillage practices, contour cultivation, strip cropping can also be adopted to obtain optimum production. Soil structure improvement also reduces the run-off water and increases the infiltration rate of rain water.

1. Bund former bunding: It consists of forming temporary bunds with a bund former across the slope at regular intervals dividing the land into compartments of 5 to 10 cents. The size of the bund ranges from 30 to 50 cm in width at the base with 20 to 30cm height. The experiments conducted at Hagari and Sholapur indicated that bunding increased the yields of crops by 15 to 40 per cent compared to unbunded plots.

2. Contour bunding: Permanent earthen bunds along the contour line are put up at every 90 metre distance or a drop in level of 90cm. These are quite big size bunds having a height of 75cm width at the base 3.3 metres and at the top 60cm. The earth required for forming bunds, is taken from the upper sides of bunds by digging to a maximum depth of 15cm, all along the bunds. The experimental results at Hagari and Bellary indicated that the yields of crops increased ranging from 16 to 62 per cent in different crops due to contour bunds when compared to unbunded plots.

3. Bench terracing: In extremely slopy lands where soil depth permits levelling, terracing is adopted. It is transforming relatively steep land into a series of level strips or platforms across the slope of the land, one over the other, which looks like the steps of a staircase from a distance. These steps are separated by risers, or vertical drops of earth or stones protected by a heavy growth of grass.

4. Contour trenching: It consists of small trenches or channels constructed across the slope

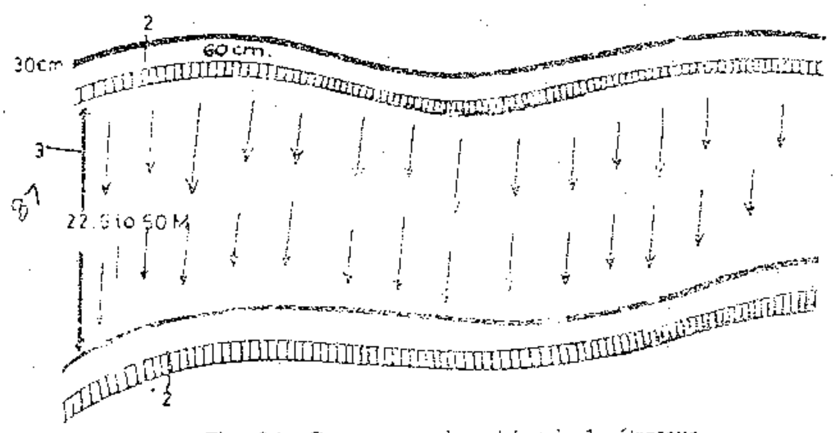

Fig. 8.1. Contour trench and bund. 1. Contour trench. 2. Bund. 3. Distance between two trenches.

to catch the run-off which later percolate into lower layers of soil. The size of contour trench should be 60cm wide 30cm deep of a convenient length spaced at 22.5 to 60 metre distance depending upon the slope of land for hill sides and pasture lands. For cultivated fields the contour furrows of 10cm wide and 10cm deep, spaced at 90 to 105cm, may be formed to capture the run-off water.

5. *Levelling:* Levelling of the land reduces the velocity of run off water and gives more opportunity for the infiltration of water into lower layers of the soil. Levelling of the land is advisable in fields having mild slopes. Levelling in more slopy lands leads to the removal of fertile top soil in the upper strip which becomes less productive.

6. *Protection of surface soil with vegetative cover:* Covering most of the surface soil by quick growing crops or with any vegetation or with dried plant materials, moderates the direct impact of rain drop, to prevent the breaking of aggregates and consequent sealing of pores. Under such conditions the infiltration rate is high and it is continued for longer time. This is very clear from soil moisture studies in a grassed plot compared to a cultivated plot at Hastings, Nebraska.

In a cultivated plot, only half the rainfall is infiltrated as against 85 to 90 per cent infiltration in fields having grass cover. In another experiment in straw mulched plots the infiltration rate was 3 cm/hour compared to 1.2cm in plots without straw mulch.

Contour Cultivation.

Contour cultivation is the practice of conducting field operations such as ploughing, sowing, intercultivation across the slope and along the contour line to conserve moisture in slopy lands. This practice reduces the velocity of run-off water and gives more time for rain water to enter into the soil. Experimental results at Bellary indicated that contour cultivation alone gave 10 per cent more yield than cultivation along the slopes. At ICRISAT in red soils graded ridges of 150cm apart increased the infiltration by 25 per cent over flat land. In black soils the infiltration rate was 6mm/hour in cropped land with ridges and furrows system, whereas in flat cropped land the infiltration rate was 3 mm/hour.

Tillage Practices

Crop response to different tillage practices depends upon the amount and distribution of rainfall in a season. In seasons during which precipitation provides adequate water to the crop throughout the growing period, differences in soil moisture regime due to tillage have little or no effect on yields. Conversely tillage methods like deep ploughing or listing increased the available moisture in the soil which benefited the crop in the year of a rainfall less than normal. Deep ploughing is suggested when hard pans are formed in the sub soil to facilitate easy root penetration, aeration and infiltration of rain water. Deep ploughing carried out in summer months is most effective means of controlling perennial and problematic weeds like *Cynodon dactylon and Cyprus rotundus.* It exposes the clods to high temperatures which is beneficial for improving the soil structure by increasing the percentage of water stable aggregates. The experiments conducted at IARI, New Delhi, with different depths of ploughings from 10 to 45cm showed that moisture percentage in the soil at the end of the Kharif season increased with increase in the depth of ploughing. Deep ploughing of 45cm depth resulted in higher percentage of moisture both at the surface and sub-soil layers. The grain and straw yields of Kharif maize were maximum with deep ploughing.

Frequent tillage operations under tropical conditions reduces the organic matter content, resulting in poor soil aggregation and also leads to greater soil compaction. The modern concept of minimum tillage or zero tillage not only conserves organic matter but leaves a rough surface on the soil which can store considerable quantities of water in micro depressions (detention storage). Minimum tillage can be practised by combining the work of ploughing and sowing in one operation and controlling weeds effectively by herbicide. Bains et al, (1970) observed maximum infiltration (4.39 cm/hour) in plots receiving zero tillage, having 80 per cent crop residue as against 1.8 cm/hour infiltration in the ploughed soil.

Strip Cropping

It consists of growing erosion resisting and erosion permitting crops in strips at right angles to the natural slope. The ratio of erosion permitting to erosion resisting crops ranges from 4:1 to 8:1. The strips of erosion resisting crops reduces the speed of run off water coming from erosion permitting crops. It enables water to remain longer in the field and more water is infiltrated. Moreover, it serves the objectives of crop rotation and mixed cropping.

Check Your Progress - 2

What is meant by strip cropping?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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8.4.2. Reduction in Evapotraspiration Losses

It is estimated that about 70% of water is lost through evaporation and transpiration (Charless Bradley). It is therefore necessary that every effort should be made to minimise this big portion of water loss. Evaporation is a very complex energy- controlled process which is influenced by micro-meteorological conditions above the soil surface as well as soil properties. There are three stages of evaporation in the soil.

1. Rapid and steady loss of water which is dependent on transmission rate through the soil depending on the above ground conditions such as wind speed, temperature, radiant energy and relative humidity.
2. Rapid decline in the rate of loss which is governed by moisture flow to the surface being influenced by soil factors.
3. Extreme slow loss which is dependent on absorptive force of solid liquid interface.

The methods to reduce evaporation losses include:

1. Decreasing the turbulent transfer of water vapour to atmosphere by mulches and wind breaks.
2. Decreasing capillary continuity by tillage methods or rapid drying of surface soil by chemicals.

Mulches

The practice of applying mulches to the soil to control evaporation is an age old practice. Mulch may be defined as any material like plant residue, straw, saw dust, paddy husk, gravel, polythene sheet etc. which covers the surface soil.

Vegetative mulches are effective in reducing evaporation losses as long as the surface soil is wet. When the surface soil dries, the effect of mulch decreases and cumulative evaporation from straw mulched plot and bare soil is equal after prolonged drying. This means that straw mulch can conserve water in periods of frequent rains but are of little value during extended dry period.

Vegetative mulches reduce the evaporation losses in the following way.

i) Reduction in the supply of solar energy: Stubble mulch reflects incoming solar radiation. Bright straw reflects 80 percent solar radiation than bare dark soil.

ii) Reduction in wind velocity: With increasing depth of stubble mulch, wind velocity progressively decreases.

iii) Reduction in the liquid water flow to the site of evaporation: Stubble mulch creates a micro-climate in which evaporation demand of atmosphere is decreased and the water flow from layers to the site of evaporation decreases.

Soil Mulch

Keeping the surface soil loose and dusty upto 5 to 8cm deep with repeated surface stirrings is known as 'soil mulch' or 'dust mulch' or 'natural mulch'. This effectively blocks the capillary pores and prevents the rise of water to the surface. After rainfall, the surface stirred 5 to 8cm soil gets dried up rapidly but below this layer, moisture loss by evaporation from soil becomes minimum.

Drying of surface soil by spraying chemicals like fatty alcohols or non ionic surfactants reduces the evaporation losses by reducing capillary flow to the surface.

Wind breaks were found to be effective in reducing the wind velocity by 20 to 63 per cent which in turn reduced the evaporation losses ranging from 10 to 30 per cent.

Anti-Tranpirants

Various methods of controlling transpiration losses are based on (i) increasing leaf resistance to water vapour loss (ii) modifying the net energy balance at leaf surface (iii) reducing the crop growth and (iv) reducing the effect of the wind by wind breaks.

Anti transpirants are those materials which are sprayed on leaf surfaces to reduce transpiration losses. There are 4 types of anti-transpirants.

(a) Stomata closing type (Fungicides like PMA and Weedicides like atrazine).

(b) Film forming type (Silicones and emulsion).

(c) Reflective type (Kaolin).

(d) Growth retardants (Cycocel).

(a) Stomata closing antitranspirants: These are also called metabolic antitranspirants which induce stomatal closure partially and reduce transportation losses but reduced availability of CO_2 may affect the photosynthetic rate. The antitranspirants are most effective when water losses from plants are not restricted by natural stomatal closure in response to leaf water deficits. Under such conditions 30 to 40 per cent transpiration losses are reduced by spraying phenyl mercuric acetate (PMA) at concentration of 15 mg/litre of water or spraying weedicide like alachlor at a rate of 20 mg/litre of water.

(b) Film forming antitranspirants: Coating leaves with inert material to form an impermeable layer on the leaf surface reduces transpiration losses. These will not inhibit the passage of CO_2. Diesel oil at 1.25 per cent emulsion or emulsifiable wax at a rate of 2 litre/ha can be sprayed to

form a thin coating on both sides of the leaf surface. Emulsifiable wax (mobileaf) and water in proportion of 1:8 can be used for dipping the leaves of tobacco seedlings before transplanting to reduce the transpiration losses of tobacco.

(c) Leaf Albedo: Leaf albedo is considered to be one of the most important factors in reducing the transpiration losses. The percentage of incoming radiation that is reflected back to the atmosphere is called albedo. The materials that can be used on leaf surfaces for the reflection of solar radiation are Kaolinite clay, hydrated lime, zinc sulphate, magnesium carbonate and calcium carbonate. It was found that by spraying Kaolinite clay (Kaoline) at six per cent concentration reduced the transpiration losses by 22-28 per cent with a reduction in leaf temperature by 3-4^{o}C.

(d) Growth retardants: Certain growth retardants have been found to reduce the plant susceptability to water stress. CCC (2- chloroethyl trimethyl ammonium chloride) is one of the most important growth retarders. Plants treated with CCC at the rate of 1 to 15 litres/ha remained turgid and survived longer under moisture stress conditions. Growth retardants usually decrease the top-root ratio thereby reducing the loss of water by transpiration. They proved effective in increasing the yields under drought conditions. However, there is not much evidence to show that the growth retardants reduce the transpiration rate.

8.4.3. Judicious Utilization of Conserved Moisture

It is not enough to store more moisture in the soil but it has to be utilized more effectively by adopting suitable management practices. They include selection of suitable crop variety, efficient cropping system, proper land preparation, best time of sowing, method of planting, fertilizer application, weed control etc.

Choice of crop: In dry land areas, certain crops are grown by convention. Some of these crops can be replaced with efficient crops (Table 8.2).

Table 8.2. Efficient Crops

Region	Traditional crop		Efficient crop	
	Crops	Yield (q/ha)	Crop	Yield (q/ha)
1. Black soils of Kurnool and Anantapur	Cotton	2.0	Sorghum or Safflower	25.0 12.0
2. Red soils of Anantapur and Mahaboobnagar	Groundnut	5.3	Sunflower	9.1

Choice of varieties: The crops and varieties possessing the following characteristics are generally found suitable for dry land agriculture.

(i) Short duration: Short duration varieties, for eg., 100-105 days of sorghum are found to escape drought than long duration varieties of sorghum.

(ii) Early seedling vigour: Crop varieties possessing early vigour withstand weed competition and moisture stress better.

(iii) Deep root system: Plants with deep root system withstand moisture stress by utilising the moisture from deeper layers.

Photoinsentivity: The varieties that can come to harvest within the prescribed period irrespective of photoperiod will give flexibility to the time of sowing depending upon the receipt of rainfall.

The hybrids and other high yielding varieties released in different crops under intensive management with irrigation facilities were found to possess the above characteristics. They also performed well under dry land conditions and gave 50 to 100 per cent increased yields over local varieties at zero level of nitrogen.

This clearly shows that improvement in yields can be made by replacement of local varieties with high yielding varieties of crops.

Land Preparation and Seeding

Moisture depletion in the upper layers of sandy soils is quite fast due to high temperatures and windmovement in between the rains. In such soils the minimum time should be taken for preparation and seeding so that the seed can be placed in the moist zone. Under existing conditions, with the available bullock power at the disposal of the farmer, only 1/10 to 1/15 of his holding can be covered at each interval. This often leads to seeding in a dry soil which has an adverse effect on germination. The poor stand is the main reason for low yields in dry land agriculture. Custom service to provide tractors for ploughing (initial land preparation) before the monsoon season and using improved seeddrills like Rayalagorru of Ananthpur or Pora Plough to place the seed in the moist zone after receipt of rains, would increase the yields of crops.

Planting Time

Early sowing has several advantages like:

1. better moisture availability,
2. seedling vigour,
3. larger growing period,
4. Avoidance of pests and diseases for example, shoot fly in sorghum, downy mildew in pearl millet,
5. Early sowing of Kharif crops facilitates double cropping in black soils.

It may not be practically possible to sow all crops early. The relative losses suffered by different crops due to delayed sowings, should form the basis. A crop, which gives comparatively less yields, under delayed conditions, needs to be sown first. Another approach is to increase the efficiency of sowing by off season tillage practice and increase the efficiency of sowing by widening the row width and reducing the intra-row spacing (spacing within a row). The row width can be doubled, without significant reduction in yield.

Cropping Systems Based on Rainfall and Moisture Storage in Soil

The amount of rainfall and the soil characteristics to store the moisture will determine the

Table 8.3. Suitable efficient crops for soils of different moisture storage capacity under different rainfall conditions in Andhra Pradesh

Rainfall (mm)	Soil type	Amount of available water held in soils profile (mm)	Crop system	Most efficient crops
375-625	Red	50	Single crop	Castor or pearl millet grasses and forages.
670-750	Red	100	Inter crop	-do-
600-900	Deep red	150	-do-	Pigeopea, Castor, *Setaria*, Sorghum and groundnut.
600-900	Medium black	150	-do-	-do-
900	Deep black	300 and above	Sequence Cropping	Pigeonpea, maize, Sorghum

duration of the cropping season. The weekly rainfall data of the last 70 years of Hyderabad region was analysed by Virmani (1976) and he suggested that the successful cropping season is 17 weeks in shallow red soils, 21 weeks in medium soils and 25 weeks in deep soils. The effective crops for different soil types based on rainfall and moisture storage are given in table 8.3.

a) Inter cropping: In dry farming areas intercropping is a common practice. It consists of growing two or more crops in set rows simultaneously on the same piece of land. The crops need not necessarily be sown at the same time, and their harvest time is quite different but they are simultaneously grown for the significant part of the growing season. It is not only a device for risk covering but ensures more production per unit area than the sole cropping by utilizing the soil moisture and nutrients effectively. Besides, it helps in stabilising the yields of crops under dry land conditions.

Sorghum + Pigeonpea: Growing two rows of sorghum alternated with one row of red gram (Pigeonpea) with full population of both the crops is found to be more remunerative than sole sorghum of pigeonpea.

Groundnut + Red gram: In Anantapur groundnut is grown extensively as a sole crop or intercropped with red gram or castor after every 11 or 15 rows (11 to15:1). Intercrop yields of groundnut and red gram were increased considerably by narrowing down the groundnut and redgram ratio to 7:1 to 5:1.

Other intercropping systems which were found to be advantageous are pearl milet + Pigeonpea (2:1), sorghum + green gram (1:1) and maize + Pigeonpea (1:1).

Sequence Cropping

Sequence cropping is possible in the higher rainfall regions and in soils having better moisture holding capacity. Sequence cropping of sorghum followed by safflower in the deep black soils of Adilabad and ragi followed by redgram or ragi followed by horse-gram in the deep red soils of Srikakulam and Vishakapatnam districts would be a profitable proposition.

Fertilizer Application

The main reason for low fertilizer use in the un-irrigated crops is the uncertainty in the minds of farmers, about the returns, from its application. The gradual and continuous removal of nutrients by dry land crops and loss of nutrients due to erosion and disappearance of organic nitrogen due to frequent cultivation, depleted the soils of semi-arid region which necessitated the use of fertilizers in dry lands. Further, improved moisture conservation practices and better weed control practices helped in getting response to fertilizer application in drylands. Experiments conducted by All India Co-ordinated Projects have shown that fertilizer application to rainfed crops is profitable and it should be applied based on normal yields and rainfall as criteria (Table 8.4).

Table 8.4. Doses of Nitrogen application based on rainfall and normal yields of crops.

Rainfall (mm)	Yield (Kg/ha)	Recommended nitrogen dose (Kg/ha)
500-700	750	40
700-1000	1000	60
1000	1500	80

Under conditions of low rainfall or low soil moisture regions, the rate of fertilizer application has to be limited to the extent which will not promote more growth than the available soil moisture can sustain, until the harvest. It is, therefore, necessary that the quantity of fertilizer application should be based on the moisture holding capacity of the soil.

Recent studies have shown that fertilized crops withstand drought better than the un-fertilized crops. The vigourous growing crops resulting from fertilizer application penetrates into the deeper layers of soils and extract more moisture from the soil.

Phosphorus: Semi-arid soils are deficient in phosphorus. To meet the phosphorus requirement of crops, the available P_2O_5 content in the soil should be between 30-35 Kg/ha. To bring the soil to this level, application of 60 and 40 Kg/ha in the first year and at the rate of 45 and 30 Kg. P_2O_5/ha in subsequent years for heavy and light soils respectively is recommended.

Potassium: It was observed that low concentration of potassium in the soil solution resulted in higher transpiration losses of wheat and peas. Adding potassium chloride to potassium deficient wheat plants decreased the transpiration rate by 50 per cent within two hours. This effect was mainly due to changes in the stomatal aperture.

Method of Fertilizer Application

For increasing the fertilizer use efficiency, it is always advisable to apply fertilizers, particularly phosphorus, by band placement for Kharif and rabi crops.

Zinc application: In areas wherever zinc deficiency was noticed, application of $ZnSO_4$ at a rate of 50 Kg/ha increased the yields of rainfed crops substantially.

Weeding

Weeds cause considerable damage to dry land crops. Weeds take away not only moisture but also nutrients from the soil. Weed control is of greater significance under dry land conditions because there will be severe competition between weeds and crops for moisture which is the most limiting factor.

8.4.4. Seasonal Aberrations

There could be three important variations in the rainfall from normal rainfall pattern. These are:

(a) long gaps in the rainfall.

(b) delayed onset of the monsoon.

(c) early stoppage of the rains.

Cropping strategies suitable for Hyderabad and Anantapur region under the above aberrant rainfall conditions is given below.

Hyderabad Region

This region includes entire Ranga Reddy, Nalgonda districts parts of Medak, Karimnagar, Mahboobnagar and Warangal districts.

Characteristics

Red sandy soils (Chalka or dubba); mean annual rainfall 750mm with minor peak in July and high peak in September - only Kharif crops are possible. The following cropping pattern is adopted under different weather conditions.

Normal Onset of Monsoon

From the first week to the 3rd week of JUNE, sole crop of sorghum or bajra or Inter crop of sorghum + Pigeonpea or Bajra + Pigeonpea can be grown. Later on, castor sowings can be continued upto 4 to 6 weeks.

(a) Normal Onset of the Monsoon Followed by Long Gaps in the Rainfall

1. Weeding early and creating soil mulch by repeated intercultures helps in tiding over the moisture stress for a short period.
2. When sorghum crop fails due to serve moisture stress, it can be cut and fed to the cattle. If rains are received subsequently, ratooning of the crop with application of 20 Kg/ha is suggested.

Delayed Onset of the Monsoon

1. Late sowing (Mid July - Mid August) sowing of Ragi (Godavari variety) is suggested.
2. Very late sowing (Mid August to early September): The following crops can be sown.

Crop	Variety
1. Cowpea	C-152 or EC 4216
2. Setaria	Ise 701
3. Sunflower	EC 68414 or Morden
4. Safflower	A-300 (very deep soils only)
5. Horse gram	Local

Early stoppage of rains at the end of growing season

1. Spraying of antitranspirants on crop and
2. Creating soil mulch to reduce evaporation losses will minimise the risk of crop failure.
3. In regions where frequency of early stoppage of rain is more, growing of short duration crops will provide an insurance against such contingency.

Anantapur Region

This region comprises of Anantapur, parts of Kurnool and Chittoor districts.

Characteristics

Shallow red soils: The mean rain fall is 560mm and 40 per cent is received during September-October. It is the most difficult region due to the shallow depth of soils and the most unpredictable rainfall. Cropping patterns to suit aberrant weather conditions are given in the Table 8.5.

Table 8.5. Alternate crops for Anantapur region.

	Season	Crops and varieties
1.	Normal (July)	Groundnut, pigeonpea, Castor and mesta.
2.	Early (last week of May of first fortnight of June)	Fodder, sorghum, pigeonpea, castor and mesta
3.	Late (August)	Bajra (HB-3), Setaria (H-1), Sunflower (EC 68415).
4.	Very late (early September)	Bajra (HB-3), Sunflower (EC 68145), Black gram (T_9, Cowpea and horse gram.

Inter cropping systems such as groundnut + pigeonpea, bajra + pigeonpea, sorghum + pigeonpea are recommended upto the end of July.

Black Soils:

Important crops are taken up in the rabi season. Sowing of the rabi crops in September instead of the traditional October plantings, is suggested. Sorghum should be sown the earliest, the next, safflower and the last, Bengalgram.

Check Your Progress - 3

List out three important variations in the rain fall from the normal pattern.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

8.5. WATER HARVESTING

It is a practice of collection and using of water derived from an area that has been treated to increase the run off of rain water. Water harvesting is adopted under three different situations.

8.5.1. Life Saving Irrigation

In areas of moderate rainfall, whenever there is excess rain which can not be conserved within the soil profile is collected at the down side by digging a small pond. The water thus collected is reused in the event of long drought spells as life saving irrigation in the donor area or other adjacent lower elevation areas. Experimental results clearly indicated that giving a three centimeter depth of irrigation at the most critical stage of moisture stress increased the yields of crops by 600 kg/ha. For adopting this method in the farmer's fields, needs collective action and developing the most economical water- storage ponds and efficient irrigation delivery system for supplying water in the upper reaches.

Broad bed-and-furrow system developed by ICRISAT can be adopted to collect the excess rainfall. It consists of forming broad beds of 90-100 cm width having 10-15cm height alternated with furrows of 50-60 cm wide by specially developed implement known as 'tropiculture'. It is one of the efficient methods of water-shed management. It is an effective method in improving the drainage in black soils and also facilitates collection of excess water in black and red soils which can be reused.

8.5.2. Run off Farming

In areas where the rainfall is extremely low, the moisture that can be stored in the soil is not in any case sufficient for successful crop production. Under such situations the upper reaches of field are treated to increase run-off in order to supplement the soil moisture in the adjacent lower portion for sustained crop production. This is known as run-off farming. The ratio between donor and recipient area ranges from 25:1 to 30:1.

The same concept can be used in high rainfall regions. In the upper reaches, crops requiring less water can be sown and rice can be successfully grown by diverting water to the lower reaches.

8.5.3. Micro Water Sheds

This is another method of water harvesting deficit rain fall areas. This consists of growing of crops in narrow strips, between wide intervals that are ridged as artificial miniature water sheds either with one side or two sides sloping. The relative width of water shed strip to crop producing strip is in the ratio of 2:1 to 4:1 depending upon the rainfall, this is more efficient than fallowing.

8.6. SUMMARY

Crop failures are very common in the areas even if the annual rainfall received is 1000mm if its distribution is uneven and erratic. There are about 84 districts receiving less than 1000mm which are spread all over India except states of Assam, West Bengal, Kerala and Orissa. Principles of dry farming practices consist of (a) Conservation of moisture by controlling run off, and simultaneously increasing the infiltration. (b) Reduction of evapo-transpiration losses. (c) Judicious utilization of conserved moisture by adopting suitable cropping systems. Run-off control and increased infiltration in the soil can be achieved by adopting any one or two or more moisture conservation practices like bund former bunding, contour bunding, contour trenching, bench terracing, levelling, contour cultivation, tillage practices and strip cropping etc. Evaporation losses can be minimised by creating soil mulch or covering surface soil with vegetative mulch or polythene mulch or providing wind break to reduce the wind velocity. In the event of moisture stress, anti- transpirants can be used to minimise the transpiration losses. Efficient use of limited moisture can be achieved by selecting the most efficient crop and variety. Preparation of land in a short time for placing the seed in the moist zone facilitates in getting optimum stand of the crop. Early planting results in better seedling vigour, and free from pests and diseases. Inter-cropping is the most common practice in dry farming regions not only to safeguard against complete failure of one single crop, by to ensure more production per unit area by effective utilization of resources. Sequence cropping is possible in high rainfall regions and in soils having better moisture holding capacity. Fertilizer application helps the crops to withstand drought better than unfertilized crop. The amount of fertilizer application should be based on the amount of rainfall and moisture storage capacity of the soil during cropping season. Application of fertilizers through band placement increases the fertilizer use efficiency. Control of weeds is of greater significance in dry land agriculture, as there will be severe competition between weeds and crop, for the limited moisture supply. Alternate crop planning needs to be formulated under aberrant weather conditions in relation to soil characteristics of the region.

8.7. CHECK YOUR PROGRESS: MODEL ANSWERS

1. $$\text{Moisture} = \frac{\text{Precipitation-Potential Evapotranspiration}}{\text{Potential Evapotranspiration}} \times 100$$

2. The growing of erosion resisting and erosion permitting crops in strips at right angles to the natural slope is known as strip cropping.

3. The important variations in the rainfall from the normal pattern are: (a) long gaps in the rainfall, (b) delayed onset of the monsoon and (c) early stoppage of rains.

8.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the moisture conservation practices which reduce the run off water in slopy lands.
2. How are different mulches effective in reducing the evaporation and conserving soil moisture? Give brief account about some of the materials used for mulches.
3. Give the cropping systems under different rainfall and soil types.
4. How is fertilizers application important in dryland agriculture? What aspects should be considered in recommending the doses of nitrogen, phosphorus and potassium?

II. Answer the following questions in about 10 lines each.

1. What is dry farming? What are the principles of dry farming?
2. Discuss the role of tillage practices on moisture conservation.
3. Describe the different ways of reducing the transpiration losses with examples.
4. Give the characteristics of crops and varieties suitable for dry farming tracts.
5. What measures do you suggest at various stages.
   i) In case of prolonged dry spells during crop growth.
   ii) In case of early withdrawl of monsoons.

UNIT-9: PLANT NUTRIENTS

Contents

9.1. OBJECTIVES

By the end of this unit you will be able to;

1. list out the essential elements for the growth and development of higher plants,
2. distinguish between the micronutrients and macronutrients,
3. describe the physiological role of essential nutrients,
4. describe the deficiency symptoms of essential elements in plants,
5. explain the symptoms of toxicity of essential elements.

9.2. INTRODUCTION

All the living organisms are capable of taking up substances from the environment. These substances are used by plants for the synthesis of their own cellular components or as an energy. The supply and absorption of chemical compounds needed for growth and metabolism may be defined as nutrition. The chemical compounds required by an organism are called nutrients. Green plants obtain the essential nutrients exclusively in inorganic form, which are usually referred to as essential elements.

A strict definition of essentiality is not simple, though attempts have been made to develop a definition of essentiality by several workers; as the requirements for essentiality imposed by these definitions have frequently been found to be too rigid, more useful definition of 'essentiality' proposed by D.J. Nicholas is employed. Nicholas has suggested the term 'functional or metabolism nutrient' be used to include any mineral element that functions in plant metabolism whether or not its action is specific. This definition avoids confusion that some times occurs where rigid criteria of essentiality are imposed, which say, that one element is essentiality and symptoms of its deficiency can be prevented by supplying that particular element.

9.3. ESSENTIAL CRITERIA

1. Not all elements are required for all plants but all elements have been found to be essential for some plants.

2. An element is considered essential for a plant if the plant fails to grow to complete its life cycle.
3. An element is considered essential for a plant if it is shown to be a constituent of a molecule which is known as an essential metabolite, whether or not its action is specific.
4. When a certain nutrient is deficient the plant produces acute deficiency symptoms which can be corrected by the supply of particular elements or a substitute.

Twenty chemical elements are known to be essential for the growth and development of higher plants. They are: Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Boron (b), Zinc (Zn), Copper (Cu), Molybdenum (Mo) and Chlorine (Cl). In addition, other elements such as Sodium (Na), Cobalt (Co), Silicon (S) and Vanadium (Va) have been shown to be essential to certain higher plants. Most of the essential elements are called mineral elements as they are derived in the form of inorganic ions from mineral constituents of the soil. Thus, all the above elements except Carbon, hydrogen and oxygen are mineral elements.

Carbon and water (in the combined form of oxygen and hydrogen) constitute about 93% or more of the weight of a plant. The plant obtains carbon and oxygen from the atmosphere. Hydrogen is derived, either directly or indirectly, from the soil water. The remaining mineral nutrients are absorbed by plants from the soil. However, leguminous plants can fix and utilize nitrogen from the atmosphere through root nodule bacteria.

9.4. MACRONUTRIENTS

Six mineral nutrients out of the 20 essential plant nutrients, viz., N, P, S, K, Ca and Mg are needed by plants in relatively large amounts. Thus, the essential amounts required by plants in relatively higher amounts are called microelements. Potassium, calcium and magnesium are present in soils as cations (K^+, Ca^{++}, Mg^{++}) and nitrogen, phosphorus and sulphur are normally present as anions (NO_3^-, $H_2PO_4^-$, $SO_4^=$). Sometimes, the term macronutrient refers to the chemical form in which a macroelement is available to plants. Nitrogen, Phosphorus and Potassium are known as primary or major plant nutrients. Calcium, magnesium and sulphur are the secondary nutrients. This division is mainly based on their abundance. The major nutrients are utilized by plants in considerable quantities.

Check Your Progress - 1

Give the list of macronutrients in plants.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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9.5. MICRONUTRIENTS

The other essential elements, boron, chlorine, copper, iron, manganese, molybdenum and zinc are utilized by plants in very small quantities. Hence, the elements that are required in relatively small amounts are called micronutrients. These are sometimes known as 'minor' or 'trace' elements. Microelements are available to plants in different chemical forms, usually referred to as micronutrients. They are available to plants either as inorganic ions or undissociated molecules or organic complexes. The different undissociated molecules or ions are H_3BO_3 (boric acid), Cl^- (chloride), Cu^{++} (cupric), Fe^{++} (ferrous) or Fe^{+++} (ferric), Mn^{++} (Manganese), MoO_4^- (molybdate), and Zn^{++} (zinc).

Considering the role played by various essential elements they can be grouped as follows.

A. Main structural elements of plant tissues.	(1) Carbon (2) Hydrogen (3) Oxygen.
B. Accessory structural elements of plant tissues.	(4) Nitrogen (5) Phosporus (6) Sulphur.
C. Regulators and carriers of plant food elements.	(7) Potassium (8) Calcium (9) Magnesium.
D. Catalysts and activators.	(10) Iron (11) Manganese (12) Zinc (13) Copper (14) Boron (15) Molybdenum (16) Chlorine (17) Cobalt (18) Sodium (19) Silicon (20) Vanadium.

9.6. PHYSIOLOGICAL ROLE OF ESSENTIAL NUTRIENTS

Nitrogen

1. It is an essential constituent of chlorophyll, proteins, aminoacids, alkaloids and protoplasm.
2. It promotes vegetative growth.
3. It imparts a dark green colour and the plant becomes a succulent.

Phosphorus

1. It is a constituent of nucleic acid, phytin and phospholipids and enzymes.
2. It stimulates root development, increases the tiller number and gives strength to straw and prevents lodging of the crop.
3. It hastens ripening and counters the effect of excess nitrogen.
4. It improves the quality and yield of grain.
5. It increases disease-and pest-resistance.
6. It enhances the activity of Rhizobia bacterium and increases the formation of root nodules in Legumes.

Potassium

1. It is not a form of any plant constituent but its presence in cell sap imparts vigour and disease resistance to plants.
2. It helps to reduce in cereals by producing stiff straw.
3. It is essential for potato and sugar beet crops as it increases the efficiency of manufacturing sugars and starch.
4. It is an activator of many enzymes in protein synthesis and carbohydrate and nucleic acid metabolism.
5. It is involved in adjustment of stomatal movement and water relations in plants.

Calcium

1. It is a constituent of Cell wall, and hence it is responsible for inducing stiffness in straw and early root development and growth.
2. It provides the basic material for neutralization of organic acid.
3. It encourages seed production.
4. Calcium prevents luxury consumption of potassium.

Magnesium

1. It is a constituent of chlorophyll.
2. It aids in the uptake of phosphorus and regulates the uptake of other nutrients.
3. It helps in carbohydrate translocation.

Sulphur

1. It helps in chlorophyll formation even though it is not a constituent of chlorophyll.
2. It is an essential constituent for many proteins, enzymes and certain other volatile compounds.
3. It stimulates root growth, seed and nodule formation.

Iron

It is not a constituent of chlorophyll, but is essential for its formation and also for synthesis of proteins and several metabolic reactions.

Manganese

This acts as a catalyst, and helps in chlorophyll formation. It is an activator of many enzymes.

Zinc

It is a constituent of many enzymes. Hence, it is essential for a number of enzymic reactions.

It also helps in the formation of growth hormones and chlorophyll.

Copper

It is a constituent of certain proteins and it activates a group of oxidizing enzymes. It is known to act as an 'electron carrier' in enzymes.

Boron

It acts as a regulator of K/Ca ratio. It is intimately related to the absorption of nitrogen and is necessary for cell division. It is involved in the uptake of calcium and its efficient use by plants.

Molybdenum

It is intimately related to nitrogen metabolism of plants. It acts in the enzyme system which is responsible for reducing nitrate to ammonia prior to amino acid and protein synthesis. It is also essential for nitrogen fixing organisms.

Chlorine

It is considered essential for photosynthetic process. Plants require one Kg of chlorine for every 4 tons of dry matter.

Sodium

It has been known for years that it can stimulate growth or increase the yield of several crops like, sugarbeets, table beets and turnips. It is reported to influence water relations in sugar beets and to increase their resistance to drought.

Silicon

It is required for rice, and other crops like cucumbers, barley etc. Silicon is reported to increase the length, number of stems and fresh and dry weight of rice when they are grown in nutrient cultures.

By application of calcium silicate sludge, significant increase in the growth of sugarcane has been reported on highly weathered tropical soils, containing small amounts of silicons, minerals, and large amounts of iron oxides.

Cobalt

Responses of non-leguminous crops to application of this element have been reported by several workers. Cobalt is required by Rhizobia for the fixation of elemental nitrogen.

Recent work reported by Russian workers indicate that cotton, beans and mustard will respond to the applications of cobalt. It is said to improve the growth of plants. In cotton, decrease in number of fallen squares, and increase in boll number, were attributed to the addition of cobalt.

Vanadium

It is considered an essential element for green algae. Some workers reported increased plant growth in higher plants *viz.* asparagus, rice, lettuce, barley and corn-which is attributed to Vanadium.

Though crops differ in their nutrient requirements they need all the 17 nutrients from the soil. If any nutrients in short supply the growth and yield of the crop is limited by the essential element present in the least amount as shown in the diagram.

Check Your Progress - 2

Explain the importance of iron in the physiology of plants.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

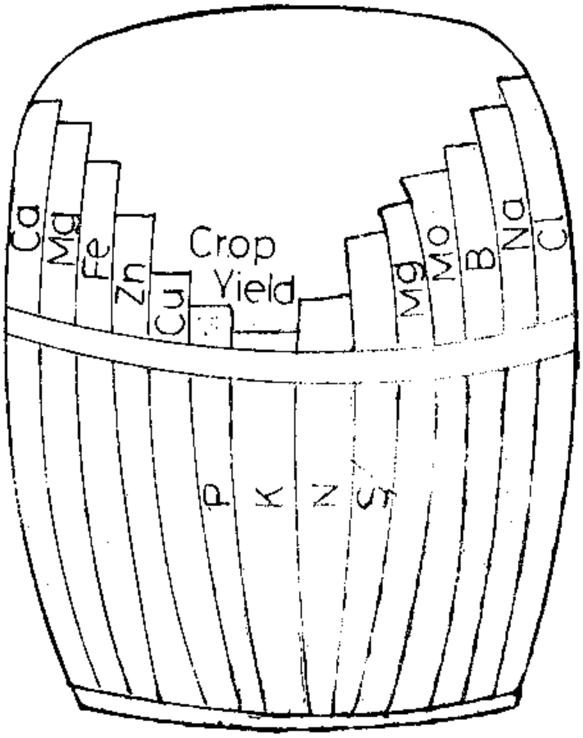

Fig.9.1. Diagram showing the crop yild limited by some deficient nutrient. No nutrient should be limiting to get highest possible yield. In this example if nitrogen, phosphorus and potassium are supplied, copper and zinc will be the next limiting nutrients.

9.7. SYMPTOMS OF DEFICIENCY

Severe deficiencies of individual essential elements produce a set of characteristic effects in the external appearance of leaves, stems, roots, blossoms and fruits. Visual symptoms of nutritional deficiency include stunted growth, chlorosis, mottling of leaves, abnormal curling of leaves, leaf discoloration, necrosis, premature senescence of leaves and blossoms. The following is an account of visual symptoms of deficiency of individual essential elements.

Nitrogen

When plants are deficient in nitrogen they become stunted and yellow in appearance. This yellowing usually appears first on the lower leaves, the upper leaves remaining green. The mature parts of the plant are first affected because nitrogen is translocated from the older to the younger actively growing regions. Flowering is reduced.

Sulphur

Deficiency symptoms of sulphur resemble those of nitrogen deficiencies. However, unlike nitrogen, sulphur does not appear to be easily translocated. The leaves are light green to yellow, appearing first along the veins of the young leaves. The stems are slender.

Phosphorus

Particularly in cereals, the shortage of phosphorus will cause marked reduction in plant growth. Young plants are stunted under severe deficiency of phosphorus. Dark green or blue-green foliage is one of the first symptoms of phosphorus deficiency in many species. Often, anthocyanins develop along the veins. Fruits ripen slowly.

Potassium

The deficiency symptoms usually appear first on the lower leaves of annual plants and progress towards the top. The leaves are dark blue-green to pale green with marginal chlorosis and under necrosis appearing first on old leaves. Growth is subnormal and under severe conditions, terminal and lateral buds may die. Potassium deficiency is associated with a decrease in resistance to pests and diseases.

Magnesium

Magnesium deficiency symptoms first appear on the lower leaves and in many species of plants it results in interveinal chlorosis of the leaf in which only the veins remain green. Severely affected leaves may wilt and shed or abscise without the wilting stage. Brittleness of the leaves is common and necrosis often occurs.

Calcium

The deficiency of calcium stops the development of terminal bud; plant growth ceases in the absence of adequate supply of calcium. Leaves are chlorotic, rolled and curled. Plants fail to develop due to failure of terminal buds. Roots are poorly developed and they are prone to infection by bacteria and fungi. In corn, deficiency of calcium prevents the emergence and unfolding of the new leaves.

Iron

A deficiency of iron appears on the young leaves of plants. It is most frequently seen in crops growing on calcarious or alkaline soils. Many crops exhibiting deficiency of this element are blue berries, sorghum, soyabeans, straw berries, vegetable crops and ornamentals. The young leaves develop an interveinal chlorosis which progresses rapidly over the entire leaf. In severe cases the leaves turn completely white. Interveinal chlorosis appearing first on young leaves is the most striking symptom of iron deficiency. All aerial parts become chlorotic and often necrotic. The leaves may be completely bleached, the margins and the tips are scorched.

Manganese

The leaves often show an interveinal chlorosis, with veins green and leaf web tissue yellow or white, appearing first on young leaves. This mottled chlorosis may spread to the old leaves. The stems are yellowish green which are often hard and woody. Carotenes are reduced. Plants are badly stunted in severe cases of deficiency.

Zinc

Deficiency of zinc was observed in corn, sorghum, rice, cotton, vegetables, legumes, and citrus. Zinc deficiency leads to "little leaf" and 'rosette' in fruit trees. Leaves are chlorotic and necrotic, sometimes with premature shedding of leaves. Flowering and fruiting are much reduced under conditions of severe zinc deficiency.

Copper

Copper deficiency was retorted on crops growing on peat and muck soils. Wilting of terminal shoots takes place, frequently followed by death. The leaf colour is often faded due to the reduction of carotene and other pigments. Flowering and fruiting are curtailed. Copper deficiency causes iron accumulation in the nodes of corn plants.

Molybdenum

Interveinal chlorosis and mottled appearance are the major symptoms with molybdenum deficiency. Leaf blades become necrotic and disintegrate, leaving only a much reduced strip along the midrib resulting in the symptom known as 'whiptail'.

Boron

Deficiency of Boron is reported in citrus fruit. Terminal leaves are necrotic and shed prematurely. Tissues of plants with this deficiency appear hard, dry and brittle. Roots are short and stubby. Plants are dwarfed and stunted. Flowering and seed production are severally affected, or lacking. In citrus, the peel is uneven in thickness, the fruit is lumpy, and gummy deposits can be seen on the fruit.

Chlorine

In the heat of the day, the tips of the young leaves wilt and dangle down, Wilting is followed by chlorosis, bronzing and necrosis. Under severe conditions of deficiency, plants are spindly and stunted.

Check Your Progress - 3

What are the deficiency symptoms of Zinc in Plants.

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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9.8. MANAGEMENT OF DEFICIENCY SYMPTOMS

Different diagnostic techniques along with soil-test results are useful in identifying and correcting the factors that limit yield and quality. In general, deficiencies associated with plant nutrients can be remarkably alleviated by maintaining soil fertility in the following two principal methods (a) Addition of organic matter to the soil, so that through decay, it may furnish a more or less continuous supply of nutrients for crops and (b) Restoring or increasing the amount of deficient nutrients by the application of fertilizers. Once the deficiency symptoms are recognized, the microelements are usually applied in the form of commercial fertilizers. On the other hand, micronutrients could be applied to the soils or directly to the crops in various ways. Three methods, *viz.*, soil application of materials containing micronutrients, spraying of nutrients on plant foliage and addition of micronutrients through mixed fertilizers, have been more often used in the field crops due to their simplicity and ease in the application of desired amounts in one or two applications. In the other methods, such as seed soaking and seed coating, the amounts of micronutrients applied, usually are too small to suffice the needs of the growing plants throughout the season.

9.9. SYMPTOMS OF TOXICITY OF ESSENTIAL ELEMENTS

Several characteristic symptoms associated with toxicity of mineral elements are expressed in the external morphology of plants. The tolerance capacity of a plant species to an element and the toxic effects are determined in solution culture studies.

In saline soils where $SO_4^{=}$ concentration is about 50 ppm, plant growth is adversely affected, with the leaves, dark green in colour. Extremely high phosphate levels in the root medium can depress growth. The reduced growth effects may well be dependent on phosphate retarding the uptake, the translocation of some of the micronutrients including Zn, Fe and Cu. Manganese toxicity symptoms are generally characterized by brown spots in older organs and by an uneven distribution of chlorophyll. The toxicity is often accompanied by Fe deficiency symptoms.

Zinc toxicity results in a reduction in root growth and leaf expansion which is followed by chlorosis. High levels of Zn depresses the uptake of P and Fe. Chlorosis is the commonly observed symptom of Cu toxicity resembling Fe deficiency. This may be due to the displacement of Fe from physiologically important centres. Toxic effects of boron results in leaf tip yellowing, followed by progressive necrosis. The leaves are scorched in appearance and drop prematurely. The symptoms of chlorine toxicity include burning of leaf tips or margins, bronzing, premature yellowing and abscission of leaves.

Manganese toxicity is reported in Cotton, crinkle leaf in tobacco growing on extremely acid soils. The condition can be corrected by applying lime to the soil to bring the soil pH upto 5.5 or more.

9.10. SUMMARY

Twenty elements are known to be involved in plant nutrition. Plant nutrients can be divided into two groups - macro and micro nutrients. Plant nutrients can also be classified according to role played by various essential elements. Plant nutrients can also be divided into groups based on their similarities in biochemical behaviors. All elements absorbed by the plants are not necessarily essential to plant growth. The term functional or metabolism nutrient was introduced for including any element that functions in plant nutrition, regardless whether its action is specific or not. Depending on the availability of nutrients, plants develop either deficiency or toxic symptoms. By adding bulky organic manures the deficiency of micro-nutrients can be avoided. By supplementing the fertilizers containing the deficient element, either by application to the soil or by foliar spray, the nutrient deficiency in plants can be corrected.

9.11. CHECK YOUR PROGRESS - MODEL ANSWERS

1. The macronutrients are (1) Nitrogen, (2) Phosphorus (3) Sulphur (4) Potassium (5) Calcium and (6) Magnesium

2. Iron is essential for the synthesis of Chlorophyll and proteins and also in several metabolic reactions.

3. The deficiency of Zinc leads to little leaf and rosette in fruit trees, chlorotic and necrotic symptoms on leaves which leads some times to their premature shedding. Under severe deficiency conditions flowering and fruiting are very much reduced.

9.12. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write a brief account on classification of plant nutrients.
2. Describe the symptoms of deficiency of essential elements.
3. Describe the symptoms of toxicity of essential elements.
4. Write an account on the management of deficiency symptoms.
5. Write an account on the physiological role of macro-essential elements.

II. Answer the following questions in about 10 lines each.

1. Write briefly about the macronutrients.
2. Write briefly about the micronutrients.
3. Describe the deficiency symptoms of nitrogen, phosphorus and potassium.
4. Write briefly the elemental toxic symptoms in plants.
5. Comment on the management of elemental deficiency in plants.
6. Describe briefly the physiological role played by nitrogen on phosphorus
7. Describe briefly the physiological role played by potassium and calcium.

9.13. GLOSSARY

Antagonistic	:	When two herbicides are mixed together or applied one after another, will show a negative resultant effect, than when they are applied alone.
Chlorosis	:	Loss of chlorophyll from the leaf.
Defoliant	:	That chemical which makies the plant drop leaves.
Deflocculation Agent	:	Chemical which prevents settling of herbicide at the bottom of sprayer (on container).
Dessicant	:	A compound that promoter dehydration of plant tissues.
EC (Emulsifiable Concentrate)	:	When a toxicant is dissolved in an organic solvent and an emulsifying agent is used the resultant product which can be sprayed with water or with oil for dilution purpose. It is called emusifiable concentrate.
Epinasty	:	Curling or twisting of leaves.
Formulation	:	Commercial product in which the basic chemicals are present, that can be used for direct use.
Inverse emulsion	:	If wateris dispersed in oil itis called inverse emulsion.
Persistence	:	The residual effect of applied chemical in the soil even after the crop is harvested.
Soil sterilant	:	A chemical that prevent the growth of vegetation on the soil to which it is applied. It may be temporary or permanent.
Synergistic	:	When two herbicides are mixed or sprayed one after another, gives the resultant effect, that when they are sprayed alone, is called synergistic effect.

Swath	:	The width of the area that can be covered by the chemical when the tigger of the sprayer is pressed.
Toxicity	:	Degree at which something is poisonous.
Vapour drift	:	The chemical will be carried away from the point of application due to high wind, high pressure etc. This is called drift.

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BLOCK - II
CROP PRODUCTION

UNIT - 10 RICE (*ORYZA SATIVA*)

Contents

10.1. OBJECTIVES

By the end of this unit you will be able to :

1. describe the climatic conditions necessary for rice cultivation,
2. list out the rice zones of Andhra Pradesh,
3. describe the method of sowing of rice seeds,
4. describe the method of preparation of main field and transplanting of rice seedlings,
5. explain the water and nutrient requirement of rice,
6. describe the three important groups of rice varieties.
7. List out the recommended rice varieties for different zones of Andhra Pradesh,
8. describe the symptoms caused by different pests and diseases and suggest the control measures.

10.2. INTRODUCTION

Rice is the principal staple food of nearly half of the world's population. It is predominantly an Asian crop as 95 percent of it is being produced and consumed in South East countries extending from Indo-Pakistan Sub-continent to Japan.

Rice is one of the most important food crops of India covering nearly 3% of the total annual cultivated area in the country. Rice is grown in almost all the states in India but its cultivation is mainly concentrated in the river valleys, deltas and low lying coastal areas of North-Eastern and Southern India, in the states of Assam, West Bengal, Bihar, Orissa, Andhra Pradesh, Kerala, Tamil Nadu, Karnataka, Madhya Pradesh, Uttar Pradesh, which together, contribute 97 per cent of the country's rice production. In Andhra Pradesh it is being grown in 3.89 million hectares producing 6.45 million tonnes. Rice is uniquely adapted itself to growing even in submerged conditions as it possesses air tubes in the leaves, stems and roots that permit air to move from the leaves to the root system, thus supplying sufficient oxygen required for the submerged roots for normal respiration.

This semi-aquatic of the plant allows it to be grown in many river basins and deltas of tropical and sub-tropical Asia. These areas would undoubtedly be unable to support even one quarter of their present population if rice is not cultivated in these areas.

Highest yields of rice can be obtained with controlled water management to a depth of less than 10 cm. However, rice is being grown under upland conditions without flooding the fields and in Kolleru lake it is being grown in deep water conditions. No other leading or major food crop, except rice, is adaptable itself to such a wide range of climatic and soil conditions.

10.3. CLIMATIC CONDITIONS

Climatic factors that influence or affect rice production are 1. Altitude, 2. Latitude, 3. Temperature, 4. Rainfall, 5. Daylength or photo-period, 6. Wind, 7. Humidity.

10.3.1. Altitude

Rice can be grown from mean sea level in river valleys as in parts of Kerala state. It can also be grown in Kashmir and Himalayan slopes. It has been observed that at higher altitudes the average rice yields are higher than those obtained in the plains. However, rice grown at 1000 meters elevation will take two weeks longer to mature, and yield 10% more than the crop planted at sea level.

10.3.2. Latitude

Evidence indicates that although rice is primarily a tropical and subtropical crop, best yields are obtained in temperate regions only such as Italy (45^{o} N), Northern Japan (38^{o} N) or Australia (38^{o} S). In these temperate regions rice is entirely grown under assured irrigated conditions only.

Rice can be grown from tropics to sub-tropical warm temperate regions upto 40^{o} North latitude and between 70^{o} to 140^{o} East longitude. Highest rice yields are obtained between 30^{o} to 45^{o} North of equator. The evidence indicates that the average rice yields per hectare generally increase as the countries are situated further away the equator.

10.3.3. Temperature

Temperature is one of the limiting factors in rice cultivation in temperate regions of the world. The temperature generally influences not only the growth duration but also the growth pattern of the rice plants. The average temperature required throughout the life period of the crop ranges from 21 to 35 ^{0} C.

10.3.4. Rainfall

The practice of rice cultivation is greatly influenced by the pattern of rainfall distribution. The distribution pattern of the rainfall and the onset and withdrawal of the monsoon and distribution, the extent of irrigation facilities available in different regions are the main factors governing the extent of productivity and potentiality of the crop. Water is frequently stated to be the most important single factor in rice production.

10.3.5. Day length

Photoperiodically rice is a short day plant. Based on the response to day length, rice varieties can be classified into photosensitive and photoperiod non-sensitive varieties. From the experience it has been found that all the long duration varieties are photo-sensitive and can be grown only during the specific season. While short duration varieties are non-sensitive to photoperiod and can be grown in any part of the year.

10.3.6. Wind

Gentle winds are considered beneficial to rice production as CO_2 is replenished with new-breeze. Heavy winds are detrimental especially at heading time.

10.3.7. Humidity

The most favourable humidity for flowering is 70 to 80% and flowering is inhibited at humidity below 40% or above 90%.

Check Your Progress - 1

What is the average temperature required for rice crop?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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10.4. RICE ZONES OF ANDHRA PRADESH

Rice is cultivated throughout Andhra Pradesh state under diverse, agro-climatic conditions varying from completely rainfed to continuously irrigated or flooded. Based on these conditions the state can be grouned into seven distint zones.

Zone -1 : This zone includes Coastal alluvial heavy soils represented by parts of East and West Godavari, Krishna and Guntur districts. Rainfall is received in this zone both in South West and North -East monsoon periods. The region is highly productive and is assured of irrigation.

The medium duration varieties of 135 days are best suited for Kharif and for uplands a short to medium duration are suitable.

Zone-2 (Srikakulam and Vishakapatnam Dist.) :Soils are light and the rice crop is irrigated by river diversion channels and large number of tanks. During both the seasons a medium duration variety of 130 days duration can be grown in this zone.

Zone-3 (Prakasham Dist.) : Soils are light, irrigation resources are extremely precarious. A short duration variety of 130 days is quite suitable. Rains are received mainly during North-East monsoon period.

Zone-4 (Cuddapah, Ananthapur, Kurnool and NSP Areas of Guntur) : Rainfall is very precarious during South-West mansoon and hardly there is any rainfall during North-East monsoon. Short to Medium duration varieties are best suited.

Zone-5 (Chittore Dist.) :Rice is cultivated round the year making use of well irrigation. Soils are light and water supply is from the wells. Rice blast is a problem whenever the rice plantings are delayed i.e, when sown between October and December. Short duration varieties are suitable as they reduce pumping costs of irrigation water.

Zone-6 (Nellore Dist.) :This zone is predominantly North-East monsoon area. Hence the seasons for the rice culture are also different from other areas of Andhra Pradesh. Blast (*Pyricularia oryzae*) is endemic problem in areas where particularly rice is planted late and applied high doses of nitrogenous fertilizers. Blast appears on foliage, upto grand growth stage and the necks of the panicles are infected at flowering time, which normally syncronises with high humidity and low temperatures. Varieties resistant to blast can help to increase the production. Predominantly rice is grown under tanks and reservoirs.

Zone-7 (Telangana) :This zone represents an admixture of areas like Nalgonda with assured irrigation and other areas depending upon minor irrigation.

10.5. SEASONS

There are three main seasons for growing rice and these are named according to the time of the harvest of the crop. The most important is the Kharif crop sown in June-July and harvested in November and December (Winter rice).

	1 st crop	2 nd Crop	3 rd crop
Coastal Andhra	Sarva (June-Nov.)	dalva (Nov-March)	Summer (March-July)
Telangana	Abi (June-Nov.)	Tabi (Dec-April)	Kathera (March-July)
Rayalaseema	Vanakaru (June-Dec)	Edakaru (April-May)	

10.6. SOILS

Rice can be grown under fairly wide range of soil conditions. For successful rice culture, the most important soil property is its ability to hold water on the surface of the soil. Rice can tolerate a fairly wide range of soil pH from 4.0 to 8.5 but is best grown within the limit of pH 5.0 to 6.5. Most of the World's rice is mainly grown on alluvial soils.

The soils most suited for the cultivation of rice crop are heavy neutral soils like clay, clay loams and loamy soils as these soils are capable of holding water for longer period for sustained good growth of rice crop. The most important soil groups under which rice can be successfully grown in India are alluvial, black, red, literate and lateritic, peaty and marshy soils.

10.7. RICE CULTURE

The method of rice cultivation can be grouped into

1. Upland or dry cultivation
2. Low land or wet cultivation

Upland rice refers to the rice crop grown on higher land, hill sides or areas where neigher irrigation nor any water retaining device is available. It grows and matures just like any other dryland crop.

In general lowland rice refers to at the rice grown on low lying areas where water can be controlled and retained to keep the soil constantly sumberged either by artificial irrigation or by rainfall.

10.7.1. Methods of Sowing

The common methods of sowing of rice are: 1. Broadcasting, 2. Dibbling, 3. Drilling

Broadcasting : In areas, where rains set in early, the soil is ploughed to pulverise the soil and to supress the weeds. The clods are crushed with the help of balde harrows or wooden beams. When the monsoon sets in, the seed is broadcast and covered in the soil to a depth of 5 to 10 cm. It was found to be advantageous if the seeds are soaked for six to eight hours prior to sowing as the germination will be hastened.

Dibbling : The practice of dibbling the seed behind the plough at regular intervals is in vogue in parts of Tamil Nadu and Maharastra. The sprouted seeds can also be dibbled in lines when the soil is puddled and levelled. The yield obtained by the dibbled crop is better than that of a broadcasted one. Another advantage of dibbling is the uniform germination, resulting in an even stand. In a dibbled crop the interculturing operations and rouging of wild rices can be carried out with ease. It has been observed that a crop dibbled in lines is able to resist drought better than broadcast crop.

Drilling : Drilling rice is the most common method of sowing in certain parts of Karnataka, Maharastra and Andhra Pradesh. This method enable the cultivator to cover larger area with a pair of bullocks within the limited sowing period. Drilling as the same advantages as that of dibbling.

Direct seedling:

There are two methods of direct seeding of rice (i) Direct seeding under dryland conditions. (ii) Direct seeding in wet land. In both the cases line sowing and broadcasting are practiced.

Dryfield Direct Seeding

Seeds of rice are sown directly in the field either by broadcasting or by seed drill. In case of broadcasting the gorru (the seed drill without hopper) or guntaka (balde harrow) will be worked to cover the seed properly. When the crop is sown by using the seed drill, the spacing between the rows will be 15 to 20 cm. The depth of sowing can be adjusted and will be sown at 3 to 5 cm depth. Seed rate used is 80 to 90 kg/ha.

Wet Field Direct Seeding

After flooding the field, it is thoroughly puddled either with country plough or by using tractor drawn implements. The field is levelled by working with 'manu' the toothed harrows. Then either dry seed or sprouted seed is broadcast on the top of soil by keeping thin film of water. On the next day morning the water is drained from the field completely. Irrigation is withheld till the soil becomes dry. After developing fine cracks in the field thin film of water is let in and drained until the crop attains 10 to 15 cm height. Then onwards thin film of water is maintained continuously and the field is not allowed to become dry.

Advantages of Direct Seeding

a) Saving of expenditure on seed bed preparation, plant protection of nursery, pulling, transport and trasplanting.

b) Direct seeded crop matures 7 to 10 days earlier than trasplanted crop.

Disadvantages

a) Higher quantity of irrigation water is required.

b) Weed control becomes a problem in some fields where copious water is not available.

c) The seed is exposed to bird and rat damage resulting in poor stand and lower yields.

d) There is greater tendency for the crop to lodge because the base of the plants are not so deeply set into the soil.

e) It is impossible to maintain a good stand in low lands particularly during monsoon as there is no control on water and its management.

f) Proper care is needed in adopting optimum seed rate, timely weed control, rational fertilizer application and effective control on water management.

Conditions Favourable for Direct Seeding

1) Direct seeding can be adopted profitably in wetland rice where the size of the plots for rice cultivation is small and perfectly levelled ensuring good control of irrigation water.

2) When the labour is in acute shortage during transplanting period, it cuts labour costs and reduces the demand for labour during transplanting season.

3) Fecilitates raising of crop in time.

4) It comes to maturity a week earlier than trasplanted crop. Under lift irrigation system the cost of oil for pumping water is reduced.

5) Direct seeding can be practiced when there is no serious weed problem.

6) The expenditure on raising nursery, pulling, transport and trasplanting is saved.

Dry Nurseries

In some places penning cattle or sheep or carting F.Y.M. during the summer is in vogue. After preparation of the land, the seed is sown by broadcast. Heavy seed rate of 10 to 12 kg per 100 square meters is used. The nursery raised in 300 to 400 sq.m. is quite sufficient to transplant in one hectare of land. To utilize the meagre source of water, the dry nursery is raised by using heavy seed rate in minimum area. Dry nurseries are raised usually under wells and watering is done only when it is absolutely necessary. The seedlings are much harder and the growth can be manipulated by cutting out the entire water supply.

Advantages of Dry Nursery

1. Planting can be done at the right time for better yield.
2. Can be grown even under limited water supply.
3. Nursery bed preparation is easy.
4. It requires little space.
5. Pulling is easy and the seedlings do not adhere to each other. This facilitates even planting of single seedling when it is desired.
6. Seedlings get better established soon after planting.
7. These seedlings are harder and can resist the adverse conditions to some extent.
8. The growth of the seedlings in the nursery can be regulated according to the time of planting.

Disadvantages

1. The seedlings cannot withstand salinity and may result in severe chlorosis.
2. Not suitable for all types of soils - poor, hard and problematic soils.
3. They require ample time for field preparation.
4. Higher seed rate is to be used.
5. Seedlings are usually thin and pale.

The Wet Nursery

In the case of trasplanted rice, the seeds are first sown in the nursery. When the seedlings are about 22 cm height or 5 to 6 leaf stage it is ready for transplanting. In some areas topping of the seedling is in practice. After cutting the tops the seedlings are trasplanted in the puddled field. Topping of seedlings not only helps to eliminate egg masses of many pests but also reduces the traspiration rate through the leaves. Moreover it prevents young trasplants being blown away by high winds before striking new roots.

Preparation of Seedbed

In order to raise good and healty seedlings of rice, seed beds are carefully prepared with dimensions of 1 to 1.2 meters wide and of any convenient length. The mud available in the 30 to 40 cm channel provided around the bed can be used for raising the level of seed beds. These channels which are depended between the two beds can be utilized for draining water from beds after sowing. The seed beds have to be manured heavily. Normally 5 to 10 cart loads of farm yard manure or compost is spread over 1/25th of a hectare quite sufficient to trasplant one hectare.

Seed Rate and Seed Treatment

For transplanting one hectare of land nearly 60 kg of seed is required. Before soaking the seeds they have to be kept in a bucket of salt water (salt and water is in the ratio of 1:40) and stirred well. All the sound and heavy seeds will go down and the cafe and half filled grains will float. Thus the chaff and half filled grains can be separated and removed. Then the heavy seeds in the bottom of the bucket are thoroughly washed with water to remove traces of salt.

These seeds have to be treated with thiram or ceresan at the rate of 2.5 grams per kg of seed. The treated seed is kept overnight in a gunny bag in a dark place. By next day evening the seed will sprout and then seeds are broadcast in the nursery bed keeping thin film of water. The next day the seed beds are drained completely and the beds are irrigated when ever the fields develop air cracks. A thin film of water is applied wherever it is necessary and immediately drained.

After growing to a height of 8 to 10 cm, a thin film of water is maintained throughout the nursery period. Fertilizers at the rate of 1 to 1 1/2 kg P_2O_5 and 1/2 kg K_2O to be applied for every 1000 sq. meters of seed bed. A top dressing with 10 to 20 kg N/ha can be given if the growth of the seedlings is not satisfactory.

Recommended Seed Rates

a) Transplanting, 50 to 60 kg/ha.

b) Broadcasting, 80to 100 kg/ha.

c) Dibbling/Drilling, 80 to 90 kg/ha.

Advantages of Wet Nursery

1. Any type of soil is suitable.
2. Can be prepared in much less time.
3. Can be located any where in the field.
4. There is saving in quantity of seed.
5. Growth of the seedlings is quick. Strong and sturdy seedlings can be raised.
6. Can withstand slight salinity.
7. Suitable for first and second crops.

Advantages of Transplanting

1. Immediate establishment of the seedlings in the puddled soil.
2. This system permits raising of healty and robust seedlings separately.
3. Permits weeding with ease, particularly wen planted in rows.
4. Permits optimum plant spacing.
5. Permits efficient use of valuable irrigation water particularly during Rabi season and particularly where the rice is grown under wells by lift irrigation under limited water supply.

Disadvantages of Transplanting

It involves extra cost on seed bed preparation, plant protection, pulling, transport and trasplanting. It needs higher amount of labour for the above operations when the labour is in short supply.

Conditions Congenial for Transplanting

1. Where adequate supply of irrigation water throughout the crop period is available.
2. In soft puddled soil.
3. Where the weed problem is severe.
4. Where plant population cannot be maintained uniformly.
5. Where community nurseries are available for timely planting
6. Where it is not possible to take up plant protection measures to control pests and diseases and nutrient deficiencies in the mainfield, the seedlings can be treated with less cost to present pests and diseases and nutrient deficiencies.

Check Your Progress - 2

What are the recommended seed rates of rice per hectare?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

Age of Seeedlings

For short duration varieties - 3 to 4 weeks.

Medium to long duration varieties - 5 to 6 weeks.

Spacing

Season	Duration of the variety	Spacing
Kharif 1st crop	Medium duration	20 x 15 cm
	Short duration	15 x 10 cm
Rabi 2nd crop	Medium duration	20 x 10 cm
	Short duration	15 x 10 cm
Summer 3rd crop	Medium duration	20 x 10 cm
	Short duration	15 x 10 cm

10.7.2. Preparation of the Main Field

In sandy soils the field has to be ploughed to incorporate weeds and other stubbles into the soil. Trimming bunds and plugging holes after cutting the grass on the field bunds is essential. The field has to be levelled and water is let into the field. If green manure or green leaf manure is applied, it is better to incorporate by using green manure trampler or APAU Puddler. For proper decomposition of the green manure it has to be incorporated into the soil, for at least 10 to 15 days before trasplanting. For other type of soils, the field is flooded and puddled thoroughly either with the help of country plough or by using tractor drawn cage weels and then the field is levelled with the help of toothed harrow. As usual the bunds have to be trimmed and crab and rat holes have to be plugged before puddling the field.

10.7.3. Pulling and Transplanting

When the seedlings are 15 to 20 cm in height they will be in the sixth leaf stage. This is the proper stage to pull the seedlings. At the time of pulling the seedlings, great care has to be taken to see that least injury is caused to the root system. After pulling the seedlings it is always better to transplant them within 24 hours after pulling. Normally the seedlings that are pulled in the previous evening are utilized for trasplanting on the next day morning. In any circumstances the pulled seedlings should not be kept more than three days as the mortality of the seedlings will be high and yield potential will be considerably reduced. Two to three seedlings per hill have to be plantd adopting the recommended spacing as per the variety and season of planting to accomodate the required number of hills per unit area.

10.7.4. Gapfilling

Gapfilling has to be attended to one week after transplanting. It is always better to use the same age of seedlings for gapfilling. In a corner of the field it is always better to plant the seedling in bunches adopting very close spacing. For gapfilling some of the seedlings can be pulled out and utilized. Normally if the portion of the nursery is available after planting the field, the seedlings from this nursery can also be utilized for gapfilling.

10.7.5. Weeding

Weeds are one of the major causes of low rice yields throughout the world. First weeding is to be carried out 20-25 days after planting. Normally this period synchronises with the first top dressing of fertilizer Nitrogen. After draining the water a thin film of water is allowed before application of fertilizer. Soon after the application of fertilizer it is always better to take up weeding. In the process of weeding at least some nitrogen fertilizer which was applied as top dressing can be incorporated by the women who are going round the field.

Chemical Weed Control

For paddy Nursery : Spray butachlor at the rate of 1.85 to 2.0 kg a.i. /ha, 2-8 days after sowing.

For Direct Sown Rice

1. Pre-emergence application of butachlor, thiobencarb and Pendimethalin at 2.0 kg a.i/ha, combined with a manual weeding 6 weeks after sowing.
2. Post emergence application of propanil at 2 to 3 kg a.i/ha, 20 days after seeding.
3. A combination of pre-emergence application of either oxadiazon or nitrofen or molinate or thiobencarb at 1.0 kg a.i/ha with post emergence application of propanil at 0.75 to 1.5 kg a.i/ha.

For Transplanted Rice

1) Pre-emergence application of butachlor (Granules or E.C.) at 1.25 to 1.50 kg a.i/ha.
2) Thiobencarb (Granules or E.C.) and pendimethalin (E.C.) at 1.5 to 2.0 kg a.i/ha as pre-emergence to weeds.
3) 2,4 - DEE (Granules) or 2,4-D Na (W.P) at 0.8 kg a.i/ha as pre and post emergence respectively.
4) Anilopos 30% EC or 2% Granules at 0.3 to 0.4 kg a.i/ha applied at 4-6 days after transplanting.

10.7.6. Nutrient Requirement

The data obtained by several workers indicate that large amounts of nutrients are needed by a crop of low land rice.

The nutrient ratio in the plant is not a good index of the fertilizers required by the crop. The amount of nutrient absorbed by the plants is governed by many factors such as variety, season, soil conditions and chemical behavior of the soil nutrients. Hence, the only sure method of determining the amount and kind of fertilizers needed by a particular soil is by a combination of actual field tests, soil analysis and uptake studies and experience on the farm.

Organic Manures

Organic manures include plant and animal wastes which have low content of plant nutrients. They must first undergo decomposition before the nutrients become available to the plants.

Organic nitrogen from green manure, however, is released faster and is effective as the inorganic fertilizer. Rice straw and other organic wastes liberate nitrogen gradually throughout the season. Besides the major nutrients , these materials also contain trace elements.

Crop Residues

Rice straw, maize stalks and other similar organic materials are good sources of plant nutrients. For example, one tone of paddy straw in the form of stubbles gives about 5 to 9 kg Nitrogen/ha and 40 to 45 kg of potassium besides other nutrients in minor quantities. However the available nitrogen is released from paddy straw or from any other bulky organic manure or crop residues only a few days before transplanting, the establishment of rice seedlings is greatly retarded as the residues contain high carbon in relation to their nitrogen content. Hence during decomposition some of the available nitrogen in the soils utilized by the micro-organisms and hence the young seedlings are at disadvantage in respect of nitrogen availability.

The following ways may be adopted to prevent this competition :

a) Plough the organic manure under the soil and allow enough time to pass i.e., 2 to 4 weeks before transplanting rice.

b) Apply readily available inorganic form of nitrogen (commercial fertilizer) at traspianting to ensure adequate nitrogen supply for the establishment of seedlings.

c) Compost these materials before applying them to the field.

Relative Efficiency of Forms of Nitrogenous Fertilizers

Rice can use both nitrate (NO_3^-) and ammonium (NH_4^+) forms of nitrogen efficiently. However, in the early stages of the plant growth rice prefers ammonical form-under anaerobic conditions because the NO_3^- forms are decomposed and lost by denitrification in the reduced zone of the soil or lost by deep percolation. Thus under submerged conditions ammonium containting or ammonium producing fertilizer is a good source of nitrogen. There was no significant difference among different ammonium containing nitrogen sources on equal nitrogen basis. Ammonium sulphate and urea are of equal value because both supply nitrogen to the rice plant in the same form, NH_4^+.

Method of Application

The efficiency of applied nitrogen in flooded soil is considerably improved if the nitrogen fertilizer is placed in the reduced zone. Surface applications of ammonium fertilizers results in rapid nitrification in the surface oxidised layer due to presence of abundant oxygen.

Once ammonical nitrogen is converted into nitrate nitrogen, it slowly percolates into the reduced layer. Some quantity of nitrate nitrogen is utilized by the paddy roots that come across and a portion of the nitrate nitrogen is leached down beyond the root zone. Major quantity of nitrate nitrogen that reaches the reduced layer will under denitrification changes on account of the anerobic bacteria and looses as elemental nitrogen to the atmosphere.

If ammonical nitrogen is placed in the reduced layer i.e., 5 to 10 cm depth of the soil, the ammonical nitrogen will be slowly available to the crop for a longer period as the nitrogen will not be changed to nitrate nitrogen and hence it will remain readily available to the plant. Nitrate sources are particularly unsatisfactory for preplant application because of an almost complete loss of nitrogen through denitrification and leaching. however they can be used for late top dressing when the root system is well developed.

Time of Application

The recommended dose of fertilizer nitrogen is to be applied in 2-3 split doses depending upon the duration of the variety and type of soil. For medium to long duration varieties nitrogen is to be applied in three equal splits. The first 1/3rd dose of nitrogen is to be applied in the last puddling so as to incorporate it thoroughly into the reduced zone. This dose of fertilizer is necessary for establishment of the seedlings very quickly and for initial tillering. The second 1/3rd dose of nitrogen is to be applied 20-25 days after planting to produce optimum number of tillers per unit area. The final 1/3rd dose of nitrogen is to be applied just before the primordia initiation stage which helps to increase the number of grains per panicle and longer and heavier panicles.

Depth of Application

Depth of placement of nitrogen fertilizer makes all the difference between efficient use or wastage. Ammonium sources of fertilizer nitrogen are more stable and effectively utilized by rice plant in flooded soil when placed in the reduced zone 4 to 5 cm below the soil surface. Nitrate nitrogen is stable only in the oxidised zone and hence should not be applied in the reduced zone as it will be denitrified and lost.

Phosphorus

Many investigators around the world reported that lowland rice crop fails to respond to phosphate fertilization eventhough upland crops grown on the same soil show positive response. The problem of posphorus nutrition is three-fold :

(a) It is present in the soil relatively in small quantity.

(b) major part of phosphorus present in the soil is not readily available to the crop as it gets bound to the soil complex.

(c) even plant available forms get reverted back to less available forms of phosphate soon after application. Moreover only 25 to 26% of applied phosphorus is recovered by paddy crop. Phosphorus is required for rice plant in the initial stages for root development and hence it is increasingly absorbed by rice from planting to flowering. Greater portion is utilized for tillering and elongation stages.

Adequate phosphorus in the soil is essential for nitrogen uptake and if phosphate is limiting, plants do not grow normally and yields are depressed. When phosphate is deficient, hardly any benefit can be derived by adding other two nutrients, nitrogen and potassium.

Source of phosphorus

Of the inorganic sources, superphosphate and rock phosphate are most popular and bone meal is also widely used in many countries. In low land rice soil there is relatively little difference among phosphate sources, except in extremely acid or extremely alkaline soils. Super phosphate is good source in all types of soils except those extremely acid. On acid soils rock phosphate or bone meal is good. Bone meal and Rock phosphate are preferable in lateritic soils where fixation of P is very high. In alkaline soils rock phosphate is inferior to other forms.

Method of Application

(a) Broadcasting before last puddling before planting.

(b) Drilling into the soil.

(c) Dipping the seedlings in slurry of mud with phosphorus.

(d) Application in a pellet form.

Time of Application

Phosphorus should be applied early enough to ensure the development of good root system. It is usually broadcast with or without mixing with surface soil. In some places soon after broadcasting it is incorporated by wetland puddler before transplanting. As the rice plant takes up the bulk of the phosphate during early stages at tillering and elongation stages.

Rate of Application

Increase in yield due to phosphate application upto 30 kg P_2O_5 /ha was generally found, where native phosphorus was low.

In dwarf Indica varieties, phosphorus application was found to increase the grain yield significantly in medium black, alluvial and hill soils in different tracts in India.

Potassium

The requirement of rice plant for potassium is much higher than for either nitrogen or phosphorus. About 80 to 90% of Potassium absorbed by the plant is found in the straw. If the stubbles are properly incorporated there is no necessity to apply any potassium.

The greatest need for potassium is most likely to occur in sandy soils. Research data obtained by several workers show little effect of potassium on low land clay soils.

Source

Potassium fertilizers such as potassium sulphate or muriate of potash or potassium magnesium sulphate (scheonote) are all satisfactory sources of potassium.

Zinc Deficiency

Soil application of zinc sulphate before planting at the rate of 50 kg/ha in every season or in atternate years will prevent the zinc deficiency.

When zinc deficiency is observed in the standing crop spraying of zinc sulphate of the rate of 2 gm in a litre of water corrects the zinc deficiency. Two to three sprays are needed at 5 day intervals.

10.7.7. Water Requirements

The water requirement varies according to the growing season, duration of the variety, type of soil, preparation of the manifold and method of irrigation. The water requirement for rice crop ranged from 750 mm to 1250 mm for a medium duration variety of 130 days duration. About 86 per cent of irrigation water in Andhra Pradesh is used for production of rice. About 40 to 70% of water diverted to irrigation of rice is lost by deep percolation. Water is very inefficiently used in rice production. Then production of grain (Kg/ha per mm of water) is only 3.7 in rice as against 13.4 in finger millet, 12.6 in wheat, 9.0 in sorghum 8.0 in pearl millet and maize and 9.2 in groundnut.

Studies all over the world indicated that soil saturation appeared to be sufficient for good yield under low atmospheric evaporative demand and or at higher water tables. Submergence of rice crops not exceeding to 5 cm seems to be essential under high atmosphheric evaporative demands. However continuous submergence has some advantages such as less weed problem, fixation of atmospheric nitrogen due to blue green algae, the lower leaves get benefited to the reflections of light in water, increased availability of plant nutrients like phosphorus, iron, manganese, sulphur, etc., regulation of soil temperature and reduction of labour costs for weeding. The main disadvantages are deep percolation losses, surface run-off, sulphide injury, iron toxicity under reduced water logged conditions.

Rice can be grown successfully if the soils are saturated with water or with thinfilm of water retained on the surface soil. Shallow depth of water leads to considerable saving of water which can be used for cultivating more land. More than 5 cm depth of submergence has been found to be a waste. But to follow this system of keeping shallow depth of water, land is to be properly levelled and weeds are to be effectively controlled either by spraying herbicides or by hand weeding particularly in the early stages of crop growth where the weeds may reduce the yield by competing with rice plants for nutrients, space and solar energy.

Depth of Submergence

It is not necessary to submerge the land continuously to a depth of 5 cm throughout the crop growth as different growth stages react differently. The following schedule can be followed for obtaining optimum yield.

Stage of the crop growth	**Depth of submergence in cm.**
At transplanting	2 + 1 cm
2 days after planting to 7 days after planting	5 + 1 cm
7 days after transplanting to panicle initiation stage	2 + 1 cm
panicle initiation to 21 days after flowering.	5 + 1 cm
21 days after flowering to harvest	Drain the water gradually from the field.

In heavy soils after puddling and levelling it is better to leave the field for two days and transplant rice by which time the soil will settle down and shallow planting encourages optimum tillering. After transplanting immediate flooding is not advocated so as to allow the transplanted seedlings to settle down in the puddled soil. Hence, only two days after planting 5 + 1 cm of water is given for creating congenial micro-climate for early establishment of young transplants.

The moisture sensitive period for rice are initial seedling, panicle initiation, heading and flowering. During these periods it is essential to have land submergence upto 5 + 1 cm. The water requirement for different field operations and growth stages of rice of a medium duration variety are as follows:

Stage of growth	Water require ment in mm	% of total water requirement.
Nursery	40	3.22
Mainfield preparation	200	16.12
Planting to panicle initiation	458	37.00
Panicle initiation to flowering	417	33.66
Flowering to maturity.	125	10.00
Total	1240	100.00

10.7.8. Drainage

Though rice is grown under submerged conditions it responds well to adequate drainage. Due to continuous growing of rice under submerged conditions the soil develops ill-drained conditions. Rice grown in ill-drined soil is subjected to toxic effects of the reduced products such as sulfides and methane. Further, the problem is more acute wen organic matter content of the soil is high. The benefits of drainage is attributed to better aeration and removal of toxic substances. Drainage is essential in heavy clay soils. Drainage in sandy soils leads to leaching of nutrients. The best time for drainage in all drained soils is at late tillering stage. Drainage exerts beneficial effects on the soils which produce abundant toxic substances and in the fields where large quantities of green manures or green leaf manures are applied.

Mid Season Drainage

In fertile soils receiving very heavy doses of nitrogenous fertilisers annually or the fields which have very high natural fertility status, the water is drained from the field at a maximum tillering stage for 3 to 5 days. It is known as mid season drainage. By following this method of drainage the roots are kept physiologically active. It also stimulates extensive root system penetrating down to the lower layers. It checks excess vegetative growth and development of unproductive tillers by removing all available nitrogen in the soil.

This midseason drainage is not usually recommended to be followed in average Indian soils as the Indian farmer cannot afford to loose much on applied fertilizer.

However it can be recomended in special cases like heavy fertile soils where there is a problem of lodging and in problematic soils where drainage is essential to save the crop from toxic substance like sulphide. Soon after drainage the field is reflooded and last dose of fertilizer is applied, and thereafter the field is never allowed to get dry.

10.7.9. Harvesting

The crop is to be harvested in the right stage at optimum moisture content (18%). If the harvesting is delayed till the crop is dead ripe, much grain is lost due to shedding.

The milling quality of the grain will be very badly affected and the result is broken rice. Rice is always harvested by employing women labour. After cutting the crop it is allowed to dry on the field for three to four days and there it is bundled and carried to the threshing yard. Threshing is done by beating the bundles of sheaves against the hard floor or plank. Tractor threshing is becoming very common in delta areas and this practice is slowly spreading to upland areas also.

After threshing, the paddy is winnowed, cleaned, and dried to a moisture level of 12 to 14 per cent. Well dried seed will be stored in moisture free containers or in gunny bags.

Details of various paddy based cropping systems followed in Andhra Pradesh.

Various rice based cropping systems followed in Andhra Pradesh are as follows:

1. **Srikakulam District**

   Rice - Pulse.

2. **Vijayanagaram District**

   Rice - Sugarcane

   Rice - Pulses

3. **Vizag District**

   Rice - Sugarcane

   Rice - Pulses

4. **East and West Godavari Districts**

   Rice - Rice

   Rice - Green gram or Black gram

   Rice - Rice -Green gram or Black gram

5. **Krishna and Guntur Districts**

   Rice - Rice

   Rice - Sun hemp or Pillipesara (*Phaseolus trilolus*)

   Rice - Pulses

   Rice - Sugarcane

   Rice - Gingelly

6. **Prakasam and Nellore Districts**

   Rice - Rice

   Rice - Fodder

   Rice - Pulses

   Rice - Groundnut

7. **Rayalaseema (Kurnool, Cuddapah, Ananthapur and Chittoor Districts) and Mahaboobnagar District**

   Rice - Groundnut

   Rice - Sugarcane

   Rice - Rice

   Rice - Pulses

8. **Nizamabad and Medak Districts**

   Rice - Rice

   Rice - Sugarcane

9. **Warangal and Karimnagar**

   Rice - Rice

   Rice - Pulses

   Rice - Groundnut

10.8. RICE VARIETIES

Rice belongs to the genus *Oryza* and family Graminae. The genus *Oryza* includes 27 accepted species of which two species of *Oryza sativa* and *Oryza glaberrima* are cultivated. All cultivated varieties of rice in Asia, Europe and the Americas belong to the species *Oryza sativa* while many of the cultivated varieties of the West Africa belong to the species *Oryza glaberrima*.

There are nearly 8000 botanically different rice types that are recognized in the world of which 4000 types are being maintained as genetic stock in Central Rice Research Institute, Cuttack.

Oryza sativa can be divided into three geographical groups. *Oryza sativa* var. *Indica* is grown all over tropical regions. *Oryza sativa* var. *Japonica* is grown only in sub-tropics and warm temperate regions such as Spain, Japan, Italy, and West of USA. *Oryza sativa* var. Javanicas are grown both in tropics and warm temperate regions of the world.

10.8.1. Indicas

Mainly grown in tropics. They are generally tall (more than 150 cm), vigorus growing, leafy, profuse tillering, late maturing, photosensitive and susceptible to lodging. They are not responsive to higher doses of nitrogenous fertilizers. They are low yielding and cannot stand heavy fertilization. They have persisted for centuries in Tropical Asia because of their ability to produce moderate but stable yield even under adverse conditions such as deep water and intense weed competition. They develop and adopt themselves to conditions of low fertility and most of them have grain dormancy. Several of them have genes of resistance to some of the major pests and diseases.

10.8.2. Japonicas

Japonicas are mainly grown in sub-tropical and warm temperate regions of the world. They are relatively short with sturdy straw (resistant to loading), narrow, erect, dark green leaves with persistant leaf sheath, medium tillering ability, photoperiod insensitive and can be grown throughout the year regardless of planting season. They are highly thermo-sensitive, put forth poor growth in tropics, respond to added doses of nitrogen with additional grain. No grain dormancy and relatively difficult to trash with conventional methods. Susceptible to number of virus diseases prevalent in tropics. Cooking and eating qualities are poor due to low amylase kernals.

The plant characteristics permit light to penetrate into lower regions of the plant which results in more efficient light utilization, especially at higher levels of nitrogen.

The lack of photosensitivity and lack of grain dormancy in Japanica strains make multiple cropping feasible on a commercial basis.

10.8.3. Javanicas

These are intermediate types and mostly confined to the equatorial countries like Indonesia. These are photoperiod insensitive or low photosensitive varieties have, very thick culm, non-lodging, poor tillering. These are intermediate types to Indicas and Japonicas. These are mainly cultivated in tropics and warm temperate regions. These varieties have morphological resemblance to indicas but freely cross with Japonicas.

Check Your Progress - 3

Oryza sativa is divided into 3 geographical varieties. What are they ?

Note :(a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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10.9. BREEDING FOR HIGH RESPONSE TO HEAVY MANURING

The task of finding ways and means to increase rice production per unit area was taken up by Indian scientists. In this direction Japanese method of rice cultivation was practiced in India to improve the yield without much success as the traditional varieties used to lodge prior to flowering causing heavy losses in grain yield whenever higher doses of nitrogen is applied.

The Japonica varieties when introduced in India proved futile because these varieties failed to grow and tiller normally. They produced only one or two small earheads. The Japonicas have thus been found to be unsuitable for direct introduction. It was thought that it might be possible to utilize them as parents for incorporating their valuable characteristics into the indicas and develop strains which would combine the high-yield and responsiveness to heavy manuring, characteristic of Japonicas with the hardiness and adaptability to tropical conditions. With this objective in view, intensive programme of projects sponsored at CRRI, Cuttack, by the Indian Council of Agricultural Research and the Food and Agricultural Organisation of the United Nations for the benefit of the states in India and several other South and South-East Asian countries.

In these two projects 710 Japonica, Indica cross combinations were made with 192 selected Indicas from India and several other Asian countries. Out of these projects ADT 27 and IJ-52 were released and tried in several places in Andhra Pradesh and found that these varieties also are susceptible to lodging under high fertility conditions and the farmers have not accepted these varieties due to their poor quality.

The first break through came with the introduction of Taichung (Native) -1. The yield potential of rice varieties of dwarf statured, erect leaved, non-lodging, nitrogen responsive varieties are quite spectacularly demonstrated by Taichung (Native) -1. Large quantities of poonali varieties, Chinan-2, Tainan-3 and Taichung - 65 were obtained and tried at several places. These poonali varieties are Japonicas acclamatized in tropical countries with fertilizer responsive, fairly non-lodging but poor tillering with poor grain quality. Hence, most of these varieties were not accepted by the farming community and hence release of varieties by hybridization work was initiated in all the research stations with Taichung (Native)-1 and other dwarf varieties like Deo-Geo-Woo-Gen and Iteodge. In the mean while IR -8 was developed and released by the Scientists working at IRRI, Manila. Once again this strain gave the evidence of the high potentiality of the need plant type. With the release of IR-8 the tropical farmer has a sturdy fertilizer responsive rice with high potential for yield. Several crosses were made with indigenous Indica varieties and many cultivars were developed. The varieties thus containing dwarf genes which are nitrogen responsive desirable plant type were released from many research stations and they have replaced almost all the traditional varieties throughout rice growing regions of India. The nitrogen responsive plant type varieties have early vegetative vigour, relatively high tillering ability with short sturdy stems that resist lodging when high rates of nitrogenous fertilizers are applied. They are not sensitive to photoperiod.

There are many traits which must be incorporated with the nitrogen responsive plant type to meet the demands of the farmers and consumers of tropical Asia. They include:

1. Variations in growth duration to suit various conditions of the tropics.
2. Varieties that can produce optimum grain yield under low light intensities.
3. Tolerance to cold weather.
4. Resistance to leaf damage during typhoons.
5. Slow leaf senescence.
6. Resistance to diseases and insect pests.
7. Tolerance to deep water.
8. Grain dormancy.
9. Improved milling and cooking qualities.

Due to higher amount of Nitrogen fertilizers use, to get the maximum production, many pests and diseases which were unknown or which were considered as minor pests and diseases came into existance.

For example, (a) Rice tungro virus in deltaic tracts.

(b) Brown plant hopper in Godavari and Krishna delta.

(c) Sheath blight in Godavari and Krishna delta.

(d) Bacterial left blight in all the rice growing tracts.

Research work is in progress to develop resistant varieties for all the major pests and diseases in all the rice research stations of Andhra Pradesh the research work done at Agricultural Research Station, Maruteru yielded some varieties which are quite resistant to brown plant hopper and these varieties which are under adaptive trails are quickly spreading in Krishna - Godavari delta areas.

10.10. RECOMMENDED RICE VARIETIES FOR ANDHRA PRADESH

Andhra Region

Mashuri, BPT 3301, BPT 3291, IET 5854, IET 6314, NLR 9672, NLR 9674, Jagannath, Goutam, Vasista, Vijaya Mashuri, MTU 6024, MTU- 5656, MTU- 6280, MTU- 9416, MTU 3626, Jaya, PLA- 1100, Dhanya Lakshmi, IR-20, IR-50.

Rayalaseema

Tellahamsa, IR-20, Jaya, IET 2508, Rajendra, Prakash, RP 143-4, IR -8, RNR 29692, Raasi, Ratna, NLR 9672, NLR 9674.

Telangana (excluding Warangal)

Tella Hamsa, Rajendra, Prakash, Rasi, Ratna, Surekha, Jaya, IET 6717, IET 2881, RP 79-14 IET 143-4.

Warangal

IET 5656, MTU- 4407, Goutam, Vasista, IET 5854, WGL 20506, RNR 29692, Kakatiya, Surekha.

Varieties Suitable for Upland Areas

Tella Hamsa, Rasi, Surekha, Jaya, Prakash, RP 79-23, IET 2508.

10.11. IMPORTANT PESTS AND DISEASES

A. PESTS

1. Brown plant Hopper (BPH) *(Nilaparvata lugens)*

Nature of damage :BHP is brownish to black in colour and both adults and nymphs suck the sap from the base of the plant. The population starts increasing from tillering to flowering. The plants show orange yellowish colour and slowly turns to yellow and finally dry up. In the field drying of he plants starts in isolated patches and spreads in circular fashion. The drying is called 'Hopper burns. BPH transmits grassy stunt virus of rice.

Duration, Grain yield and characters of important rice varieties

Variety	Season	Duration	Yield (t/ha)	Characters
Tellahamsa	For all seasons	115 days	6	Early maturing, semi-dwarf and photo-insensitive. It grows to a height of 80-100cm. Profuse tillering, excellent long slende rice, tolerant to blast and bacterial blight, withstands cold in vegetative stage. Popular in Telangana and adjacent States.
Rajendra	-do-	110 days	6	Photo-insensitive dwarf variety, with-stands moisture stres in vegetative stage, grows to a height of 90cms. With profuse tillering, suitable for irrigated dry condition. Grain is long slender.
Surekha	Kharif and Rabi	135 days	6	A period bound semi-dwarf variety, grows to a height of 105-110cms. Immune to gallmidge and tolerant to bacterial blight and blast diseases. Popular in gallmidge endemic areas in Telangana regions. Long, slender rice. Suitable for rabi when water is available.
Phalguna (RP-6-17)	Early..and..late Kharif	140 days	6.7	A semi-dwarf, photo-insensitive variety, grows to a height of 100-105cm. Resistant to gallmidge and tolerant to a blast disease. It has sturdy culm and long slender rice. Popular in Godavari delta and late planted areas of NSP.
Prakash (RP-4-14)	Kharif and Rabi	135..days early..Kharif 125..days late Kharif	5.5-6	A semi-dwarf, weekly photo-sensitive variety, grows to a height of 100cm. Tolerant to blast, brown spot and green leaf hoppers. Suitable for salinity, can be grown in Krishna, Godavari deltas and nondeltaic areas in rabi season.
Rasi (IET-1444)	-do-	115 in kharif 120 in Rabi	5-5.5	Weakly photo sensitive, semi-dwarf variety, height 100cms. Tolerant to blast, leaf blight, green leaf hoppers, moisture stress, zinc, phosphate deficiency. Rice medium slender, recommended for 2nd crop in coastal districts and for 1st crop in upland areas.
Jagannath	Kharif	150 days	5-5.5	Season bound, semi-tall variety, Rice medium slender, tolerant to gall midge, suitable for delta areas of Krishna, Godavari and Srikakulam districts. Not suitable for late sowing. Lodges in heavy soils.
Danyalaxmi (BPT-1235)	Rabi	125 days	6-6.5	Photo insensitive semi-dwarf variety, grows to a height of 100cms. Moderately resistant to BPH, stemborer, resistant to gall-midge and blast, susceptible to cold.

Vijaya-Mashuri (MTU-4407)	Kharif	1350-145 days	5-5.5	Weakly photo sensitive semi-dwarf variety, grows to a height of 80-90cms. Grain medium slender, non-lodging, resistant to blast.
Sona-Mashuri	Kharif	150-160 days	7.5	Weakly photosensitive, dwarf variety grows to a height of 80-90cms. Compact tillering, uniform flowering and long slender grain.
Goutami (MTU-8002)	Kharif	160-175 days	5.5	A season bound, semi-dwarf variety, grows to a height of 100-110cms. Moderately resistant to bacterial blight. Grain long bold with good milling quality, suitable for early planting in Krishna, Godavari deltas.
Vasista (MTU-8089)	Kharif	160 days	5.5	It is similar to Goutami except its foliage, which is dark green in colour, grain medium slender.
Nagavalli (RAL-52)	Kharif	155 days	5-5.5	A photo sensitive, semi-dwarf variety, grows to a height of 100cm. Withstands planting of over-aged seedlings. Tolerant to gall midge. Moderately resistant to bacterial leaf blight. Grain medium slender, suitable for Northern circars.
Kotha Bayahunda (AKP-70-73)	Kharif	166 days	5-5.5	A photosensitive, semi-dwarf variety grows to a height of 100cms withstands partial drought in vegetative phase, suitable for late sowing. Grain medium slender. Suitable for Vizianagaram, Visakhapatnam districts.
PLA-1100	Kharif	170 days	–	Semi-dwarf variety, grows to a height of 100-110cms withstands water logging condition. Recommended for low lying areas. Grain resembles Masuri, medium slender.
Swarna MTU-7029	Kharif	150 days	6.5	Mashuri grain type, possessing better grain quality besides dormancy for a fortnight. It is having wider adaptability with high yield. Under low nitrogen management conditions gives best yield. Moderately resistant to brown plant hopper, tolerant to stemborer and bacterial leaf blight. Slightly susceptible to sheath blight.
NLR-9672	Kharif	160 days	5-6	Weakly photosensitive, dormant, tolerant to blast and blight, white transluscent grain.
NLR-9674	Kharif	160 days	4-5	-do-
IET-2508	Kharif/Rabi	90-95 days	5-6	Resistant to tungro virus, tolerant to low phosphorus, alkaline soils and has dormancy.
Jaya	Kharif	135 days	6-7-	Cosmopoliton in adoptation, moderately resistant tobacterial leaf blight, grain is long bold.
IR-20	Kharif/Rabi	130 to 140 days	5-6	Modeately resistant to stem borer, green leaf hopper, bacterial leaf blight and tungro virus. Grain is medium slender.

Control : a) Spraying of chloripyriphos; (2 ml/litre) or Monocrotophos (1.5 ml/litre) or application of Carbofuran (10 kg/acre) eff-ectively controls BPH. b) Growing resistant varieties like MTU 2067, MTU 2077, MTU 5249, MTU 4870, MTU 5182, MTU 5293, IR 62 etc. wherever is suitable.

2. Yellow stem borer *(Scirpophaga incertulas)*

Nature of damage : The larvae first enters into leaf sheath and moves into central whorl and subsequent feeding results in death of the whorl and it is called dead hear. The damage caused in reproductive phase is called 'white ear.'

Control: (a) Spray chloripyriphos (2 ml/litre) or Monocrotophos (1 ml/litre) soon after noticing stem borer adult moths; (b) Dipping of the seedlings at the time of transplanting to avoid carry over of eggs to main field; (c) Harvesting crop close to ground level; (d) Ploughing the stubbles after harvest of the crop to destroy the pupae.

3. Green leaf hopper *(Nephotettix variscens)*

Nature of damage : The nymphs and adults suck the sap from the leaves and the effected plants turn yellow to orange. The affected plants are stunted and sometime the plants also die, if the population is much. Leaf hopper transmits Rice Tungro Virus, Yellow dwarf, transitory yellowing, etc.

Control : (a) Spraying chloripyriphos (2 ml/litre) or Monocrotophos (1.5 ml/litre) or Formaton (2 ml/litre) or Zolone (2 ml/litre) application of carbofuran (10 kg/acre). (b) Removal of alternate hosts like *Echinocloa colour, E. crusgalli, Panicum triferon*, etc.

4. Gall midge *(Orseopis oryzae)*

Nature of damage : In Gall midge, the adult moth lays eggs near the leaf ligules and the resulting maggot feeds on the shoots. This results in suppression of central stem and then the leaf sheath gets elongated and from galls and it is known as 'silver shoot'.

Control: (a) Spraying Thiodan (1.5 ml/litre) or Phosphomidon (1 ml/litre) and application of carbofuran (10 kg/acre); (b) Seeding root dip in 0.1% chloripyriphos; (c) Grow resistant varieties like Phalguna, Surekha, Dhanyalaxmi, Vikram, etc., wherever suitable.

5. Leaf roller *(Cnaphhalocrosis medinalis)*

Nature of damage : The larvae folds the leaves longitudinally and brings the two margins of leaf together and webs with skeleton threads.

It lives within leaf fold and feed on chlorophyll creating whitish membranous markings on the leaves, which subsequently dry up.

Control: (a) Spray chloripyriphos (2 ml/litre) Monocrotophos (1.5 ml/litre); (b) Early clipping of the infested leaves; (c) Application of moderate doses of Nitrogen fertilizer.

B. Diseases

1. Blast *(Pyricularia oryzae)*

Symptoms : The fungus attacks leaves, nodes and neck of the panicle. It develops on leaves as small specks which slowly enlarge into spindle shaped spots of different sizes. The center of mature spot shows whitish grey colour with brown margin.

The neck infection results in the breakage of panicle. This results in heavy yield loss.

Control: (a) Spray Edifenphos (1 ml/litre) or Carbendazim (1 g/litre); (b) Judicious application of Nitrogenous fertilizer; (c) Grow resistant varieties like Rasi, IET 2508, NLR 9674, IR 20 etc.

2. Brown spot *(Helminthosporium)*

Symptoms : Both leaves and grains are affected. The initial symptoms start as small brown spots and enlarge to big oval spots. In severe cases the spots combine to form large patches and leads to necrosis. The grains are also affected and in very severe cases it may lead to chaffyness.

Control: (a) Spraying Carbendazim (1 g/litre) or Edifenphos (1 ml/litre); (b) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed; (c) Growing resistant varieties.

3. Sheath blight *(Rhizoctonia solani)*

Symptoms : The initial symptoms usually starts at the base of the plant starting from tillering stage. The spots are greenish grey and enlarge in length and becomes greyish white with brown margins with irregular outline. In severe cases the fungus spreads to leaf laminae resulting in death of the leaf and sometimes in the death of whole plant.

Control: (a) Spraying Carbendazim (1 g/litre) or Mancozeb (2.5 g/litre); (b) Removal of weed hosts from the vicinity of rice crop; (c) Judicious application of N- fertilizer depending upon the severity of infection.

4. Stem rot *(Sclerotium oryzae)*

Symptoms : The initial symptoms start as small, black irregular lesions on the outer leaf sheath and the discolouration spreads up and down. It leads to excessive production of late tillers at the stem base and becomes discoloured and rotten. The affected plants collapse due to wearing of stem base and end up with less grain weight.

Control: (a) Burning of infested stubbles after harvest; (b) Drying of soil by dry ploughing the infested field; (c) Avoiding flow of irrigation water from affected field to healthy one; (d) Growing resistant varieties.

5. Bacterial blight *(Xanthomonas campestris pv. oryzae)*

Symptoms : It starts as small greenish water soaked or yellow spot on the leaf tips or margins. Then the infection spreads from tip downwards on the margins and show blighting appearance. In severe cases the whole leaf and portion of leaf sheath also gets blighted and droplets of yellow bacterial ooze are also observed.

Control: (a) Balanced application of N- fertilizers; (b) Growing resistant varieties like IET 4141, IET 4140, IR 20 etc.

6. Rice Tungro Virus

Symptoms : The disease is transmitted by Nephotettix sp. The initial symptoms start 7-10 days after the leaf hopper transmits the virus, as yellowing of leaf tips of lower leaves. The yellowing symptoms changes to orange yellowish colour from tip to downwards. In severe cases stunting is also observed. The affected plants produce small panicles with discoloured and chafe grains.

Control: (a) Spraying chloripyriphos (2 ml/litre) or Monocrotophos (1.5 ml/litre) or Formathion (2 ml/litre) or application of Carbofuran (10 kg/acre) soon after observing population of leaf hoppers; (b) Growing resistant varieties like IET 7563, IET 7530, IET 6301, IET 7302, Annapurna, Ratna, etc.,

7. Sheath rot *(Sarocladium oryzae)*

Symptoms : The rot occurs on the leaf sheaths which enclose the panicles. The initial symptoms start as oblong or somewhat irregular spots with brown margins and grey centers. Sometimes they may be greyish brown throughout. Under favourable conditions they enlarge and often coalesce and may cover the whole leaf sheath. Depending upon the seriousness of damage, the young panicles may remain within the sheath or only partially emerge. White to violet powdery growth of the fungus with spores may be observed on the affected sheaths.

Control: (a) Spray Edifenphos (1 ml/litre) or Carbendazim (1 g/litre); (b) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed to prevent seed borne infection.

8. False smut *(Ustilaginoidea virens)*

Symptoms : The fungus invades the grains and converts into greenish spore balls of velvety appearance. Generally very few grains in a panicle are infected and hence the yield losses are not significant.

Control: (a) The disease does not require special control measures.

Check Your Progress - 5

What are the causal organisms of blast and sheath blight diseases of rice?

Note :(a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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10.12. SUMMARY

Rice is the most important staple food crop of India being grown in almost all the states. Rice is adaptable to a wide range of soil and climatic conditions. It is semi-aquatic in nature and hence it is uniquely adapted for growing even in submerged conditions. Highest rice hields are obtained between 30^0 to 40^0 North and 30^0 South of equator. The temperature required during the crop growth period is in the range of 21^0 to 35^0C. Rice is a short day plant. The short duration varieties are non-sensitive to photoperiod, can be grown at any time during the year. The photo-sensitive varieties can be grown only during Kharif season. Rice can tolerate a fairly wide range of soil pH from 4 to 8.5, but is best-grown within the limit of pH 5.0 to 6.5. Rice is mainly grown on alluvial soils. The crop is sown by either broadcasting, dibbling, drilling or by raising nursery and then transplanting in the mainfield. Upland rice is mostly sown by drilling and the low land rice by transplanting method. Transplanting of rice ensures optimum plant spacing. The crop yields are high in transplanted low land rice compared to upland rice. Seedlings of 15 to 20 cm height at sixth leaf stage are ready for transplanting. Two to three seedlings are planted per hill. Usually the first top dressing nitrogen coincides with the first weeding at 20-25 days after transplanting. The first top dressing helps in production of good number of tillers, while the second top dressing given just before the primordia initiation increases the panicle size and grain number. Ammonium sources of fertilizer nitrogen is better than nitrate nitrogen. Further the Ammonium are more stable and efficiently utilized by rice plant. The recommended dose of phosphorus and potassium has to be applied before last puddling. The water requirement of rice ranges from 750 mm to 1250 mm for a medium duration variety of 130 days. The moisture sensitive periods are, soon after transplanting of seedlings, panicle initiation, heading and flowering stages. Maintenance of five cm depth of submergence in these sensitive periods are essential. Mid season drainage is essential in fertile heavy clay soils for improvising soil aeration and removal of toxic substances. The crop is to be harvested when the moisture content in the grain is 18 per cent. After threshing, winnowing and cleaning, the grain is dried to a moisture level of 12 to 14 per cent. Of the 27 accepted species of genus *Oryza*, two species *Oryza sativa* and *Oryza glaberrima* are only cultivated. Indicas are tall, vigorous growing, leafy, profuse tillering, late maturing, photo-sensitive and lodging susceptible. Indicas have ability to produce moderate but stable yield even under adverse conditions. Japonicas are mainly grown in subtropical and warm temperate regions of the world. Japonicas are short with sturdy stem narrow erect dark green leaves, medium tillering, nonlodging, photoperiod insensitive and fertilizer responsive. Lack of photo-sensitivity and grain dormancy in Japonica strains and short duration Indica types make multiple cropping feasible on a commercial basis. Javanicas are mostly confined to the equatorial countries like Indonesia. Javanicas are photo-insensitive with sturdy stem, non-lodging, poor tillering, awning tendency and course grain. Rice revaluation in Indica started with the introduction of Taichung (native)-1. Several varieties with desirable plant characteristics were released from many research stations which had an impact on increasing rice production. Tella hamsa rice variety is most popular in Telangana and withstands cold in vegetative stage. Rasi rice variety can tolerate zinc and phosphate deficiency. Phalguna, surekha and kakatiya are highly resistant to gall midge. The important pests of rice crop are : Brown plant hopper, yellow stem borer, gall midge and leaf roller. The important diseases of rice crop are : Blast, Brown spot, Bacterial blight and Rice Tungro Virus.

10.13. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The average temperature required throughout the life period of rice crop ranges from 21°C 35°C.
2. The recommended seed rates of rice per hectare is 50 to 60 kg for transplanting, 80 to 100 kg for Broadcasting and 80 to 90 kg for Dibbling or Drilling.
3. The 3 geographical groups or varieties of *Oryza sativa* (rice) are Indicas, Japonicas and Javanicas.
4. Blast of rice is caused by Pyricularia Oryzae and sheath blight is caused by *Rhizoctonia solani.*

10.14. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Explain in detail the climatic factors that influence rice production?
2. List out the five groups of rice growing regions in India? Give the detailed account of various rice zones of Andhra Pradesh?
3. Give the detailed account of wet land nursery in respect of nursery bed preparation, seed rate, treatment, and advantages of wet nursery?
4. Discuss on water requirements of rice with special reference to depth of submergence and total quantity of water required at various stages of crop growth.
5. Discuss the fertilizer nitrogen to rice in respect of sources, method, time and depth of nitrogen application?
6. Write a detailed account on varietal improvement of rice.
7. Discuss the merits and demerits of Indica, Japonica and Javanica rice types.
8. What are the important pests and diseases of rice crop. Write in detail about their nature of damage and control measures.

9. What are the various rice based cropping systems followed in Andhra Pradesh?
10. Give the nature of damage and control measures for the following pests of rice crop.
(a) Brown plant hopper (b) Yellow stem borer.

II. **Answer the following questions in about 10 lines each.**

1. Briefly discuss the soils of rice growing areas?
2. Explain the precautions to be taken while pulling and transplanting of nursery seedling.
3. Mention various conditions favouring the direct seeding.
4. Write down various conditions congenial for transplanting.
5. Give an account of the essentiality of mid-season drainage in problematic soils.
6. Write the chemical weed control for transplanted rice.
7. Explain how the pH is related to phosphorus availability to the plant.
8. Write briefly about Indicas.
9. Write briefly about Japanicas.
10. Write briefly about Javanicas.
11. Give atleast four suitable high yielding varieties recommended for Andhra, Telangana and Rayalaseema regions.

UNIT - 11: WHEAT AND MAIZE

Contents

11.1. OBJECTIVES

By the end of this unit you will be able to:

1. describe the climatic requirement for Wheat and Maize
2. describe the method of field preparation for Wheat and Maize.
3. list out the important varieties of Wheat and Maize recommended to different seasons and regions,
4. list out the crops that are used in Crop rotation and mixed cropping in the fields of Wheat and Maize,
5. explain the manures and fertilizers and also their applications for Wheat and Maize,
6. describe the method of intercultivation, harvesting and threshing of Wheat and Maize.
7. list out the important pests and diseases of Wheat and Maize and suggest the methods of control.

11.2. INTRODUCTION

Wheat is the World's most important food crop in quantity of grain (about 420 million tons in 1972-80, 95% being bread wheat) and produced about 45 million tons of proteins. The important countries that are growing wheat are USSR, USA, China, Canada, India, France and Italy.

In India it is cultivated in all most all the North Indian states where the climatic conditions are favourable. After rice, Wheat is very important staple food and, Wheat straw is a good source of feed for a large number of cattle in our country. Of major crops, wheat is relatively drought resistant, moderately frost resistant, except from the stage of rapid stem elongation until flowering when frost can cause major yield losses.

Maize is one of the most important cereal food crops in the world. It has very high potential and lends itself very well to management practices. The world's average maize yields are the highest of all the cereals. It is used as food for man and feed for animals. Over 85% of maize produced in our country is consumed as human food only. Maize grain contains 10% protein, 4% oil and 70% carbohydrates. Several industries like starch are based on maize production.

The primary centre of origin of maize is considered to be the *Central America* and *Mexico*, where fossil grains were recovered in the excavations.

11.3. WHEAT

Wheat production has recorded a *tremendous* improvement in our country, which has increased three times in productivity and two and half times in area over the last three decades. A turning point came in the history of wheat cultivation in India in 1963 with the introduction of dwarf, photoinsensitive, high yielding Maxican wheat varieties developed by Nobel laureate *Dr.Norman E Borlaug*. *Larma Rajo* and *Sonara* - 64 are the first two varieties introduced in India. The green revolution was realised only due to the introduction of these Mexican dwarf wheat varieties.

Wheat crop is grown mostly in temperate regions where the annual rainfall averages between 350 to 700mm. It is poorly adapted to warm or moist climates unless there is a comparatively cool dry season which favours plant growth and reduces pests and diseases. Wheat requires a frost free period of 100 days or more for safe production. Although wheat is a long day plant, quick maturing varieties can be grown in any *photoperiod ranging* from 12 hour days to 20 hour days. Wheat plants grown under continuous artificial light will be poorly developed and will produce small earheads with few grains.

Wheat is not well adapted to saline or acid soils, although useful genetic resistance to the soils exists. Foliage disease, insect attack, and high mean temperature that causes excessively rapid and abnormal development now presently exclude wheat from the humid low land tropics (less than about 25 ^{o} latitude) although some wheat is grown in lowland areas below this latitude where the winter is dry. It is now cultivated in all regions of the world with the exception of lowland humid tropics.

In terms of area and production India ranks 4th among the nations that are growing wheat. In India during 1970 tripled-dwarf wheat varieties were also evolved and released. Since then so many dwarf varieties have been released for cultivation for different regions in India.

In India wheat is mainly grown in Uttar Pradesh, Madhya Pradesh, Punjab and Haryana, Rajasthan, Bihar, Maharashtra and West Bengal. In Andhra Pradesh this crop is grown in Northern Telangana, Southern Rayalaseema and Srikakulam Areas. Andhra Pradesh has mild and short winter and hence yields are not very high as those of North India.

Wheat yields were stabilized in India due to creation of assured irrigation and introduction of dwarf varieties which are highly responsive to Nitrogen fertilizer application.

11.3.1. Classification

Wheat is an annual plant of Gramineae belongs to genus Triticum, and has 18 species. In India only 3 species of wheat namely (1) *Triticum aestivum* (common bread wheat), (2) *Triticum durum* (macroni or durum wheat), and *Triticum dicoccum* (emmer wheat) are economically important.

Triticum aestivun is the most common wheat which can account for nearly 87% followed by *T.durum* (12%) and *T.dicoccum* (1%). Aestivum is used for making chapati and other bakery products, and is grown in both South and North India. The durum wheat is good for Suji, Semya, durum and macroni is grown in central and South India. The dicoccum wheat is grown in Andhra Pradesh, Tamilnadu Maharashtra and Gujarat and is good for Uppma.

11.3.2. Climatic Requirement

It can be cultivated from mean sea level to as high a level as 3300 metres. The optimum temperature range for ideal germination of wheat seed is 20 to 25 ^{o}C. Rains just after sowing hamper germination and encourage seedling blight. Areas with warm weather and damp climate are not suitable for sowing of this crop. The excessive high or low temperature or drought are harmful to the crop during heading and flowering stages. Cloudy weather with high humidity and low temperature is congenial for rust attack. Temperature above 25^{o}C at the time of grain filling and development reduces the grain yield drastically.

The crop duration varies from North to South due to difference in temperature. For tillering mean temperature should not be less than 20^{o}C and for flowering the minimum temperature should be 25^{o}C. The yield of wheat depends upon day temperature and the period of cool season.

Higher temperature during day reduces the duration of the crop and consequently the yield. Higher elevations and long cooler periods are conducive to higher yields.

11.3.3. Soil

It is grown in a variety of soils in India. Clay loam soil with good structure and moderate water holding capacity is ideal for wheat cultivation. Care should be taken to avoid very porous and excessively drained soils. Soils should be neutral in reaction. Heavy soils with good drainage are suitable for wheat cultivation under dry condition as such kind of soils absorb and retain moisture well. Wheat is very sensitive to water logging. Heavy soils with poor structure and drainage are not suitable. Under irrigated condition wheat can be grown on light soils also.

11.3.4. Field Preparation

Wheat crop requires well pulverised seed bed for good and uniform germination. After harvest of the Kharif crop the field should be ploughed with disc or mould board plough followed by 2-3 harrowings. In case of tractor one deep ploughing followed by 2-3 harrowings, or 2-3 tillerings will be enough. Planting should be done after each ploughing. Soil should not be worked too much otherwise it may become powdery. One pre-sowing irrigation 5-6 days before sowing is necessary to ensure good germination. In case when the previous crop is sugarcane, toria, redgarm etc. presowing irrigation may be given to the previous standing crop just before harvesting, so that the field may become available for the preparation and sowing. One light cultivation and levelling is required before sowing.

In rainfed areas the field should be prepared with great care so as to conserve maximum moisture. Field is prepared by one deep ploughing followed by 2-3 ploughings with local plough and planking.

11.3.5. Varieties

A bumper crop of wheat can be obtained only if a locally, adopted high yielding, disease resistant variety is chosen for cultivation in a particular area.

The varieties recommended for Andhra Pradesh are given below.

Under irrigated condition	Under Rainfed Conditions (R)
NI 5439	NI 5439
Malavika, HD 2189	
HD 2278	N 59
DWR 39	B. Yellow
HD 4502	MAC 8-9
Kalyan Sona	HW 657
NI 747-19	NI 747-19
CC 464, UP 215	HY 65
HY 65	

The duration and yield of same of the varieties are given below.

	Variety	Duration	Yield/ Q/ha	Remarks
1.	Kalyan Sona	95-105	25-30	Resistant to loose smut, Amber colour Grain, medium size, easy for-threshing Double dwarf.
2.	NI 5429	100-105	20-25	Bold grain amber colour. (D.D)
3.	HD 2189	100-105	25-30	Resistant to Rust, Bold grain amber colour. D.D.
4.	DWR 39	100-105	25-30	Resistant to Rust. D.D.
5.	Malavika	105	20-25	Triple Dwarf
6.	UP 215	100	20-25	D.D. Resistant to Rust. grain.
7.	HY 65	90-95	20-22	Grain Amber coloured.
8.	Sonalika	90-95	25-30	Single Dwarf, Suitable for late sowing.
9.	N 59	90-95	12-15	Susceptible to brown rust.
10.	HW 657	90-95	12-15	Single Dwarf High Resistant to Rust.

11.3.6. Crop Rotation and Mixed Cropping

With the introduction of dwarf Mexican wheat varieties a series of crop rotations and sequences have been develped with wheat. These crop sequences have been designated as crop cafeteria, which denotes that farmers can choose any cropping sequence best suited to their area depending upon the soil and climatic conditions.

Some ot the most common rotations are given below.

Rotation	Duration
Rice-Wheat	1 Year
Maize-Wheat	1 Year
Redgram-Wheat	1 Year
Bajra-Wheat	1 Year
Maize-Wheat Cotton-Berseem	2 Years
Rice-Wheat, Jowar - Gram	2 Years
Maize Wheat, Sugarcane Ratoon	3 Years
Maize Wheat Green manure Potato Sugarcane	3 Years

Some of the crop sequences that were found to be successful in Agro- climatic regions of India are furnished below.

	Potato	Wheat	1 Year
	Wheat	Green gram	1 Year
Soyabean	Wheat	Greengram	1 Year
Rice	Wheat	Cowpea	1 Year
Rice	Wheat	Greengram	1 Year
Maize	Toria	Wheat	Greengram
Miaze	Wheat	Groundnut	"
Rice	Wheat	Groundnut	"

Besides the above combinations of sequence crops, mixed cropping of wheat with mustard, gram, linseed were also found to be successful. Now a days inter cropping with autumn sugarcane and potato is becoming popular in some parts of the country.

11.3.7. Seeds and Sowing

Time of sowing is an important factor in obtaining higher yield. The time of sowing varies widely. It depends on the soil type, temperature, irrigation facilities and duration of the varieties. Rainfed up to the first week of November. The normal time of sowing for high yielding dwarf varieties is the month of November. Among them the long duration varieties should be sown in First fortnight of November and short duration varieties during the 2nd fortnight of November. Under specific circumstances wheat is sown in December month also but the yields are drastically reduced. For the late sowing only short duration varieties should be used. For Andhra Pradesh the middle of November is found to be the optimum time of sowing. Delay in sowing reduces the yield drastically.

Seed rate and spacing: It varies with the variety used, seed size, tillering ability moisture content at the time of sowing in the soil and method of sowing. Usually a seed rate of 100 kg/ha for medium size grained varieties for normal sowing under irrigated condition is sufficient. For bold grained varieties the seed rate should be increased to 125 kg per hactare. In peninsular India seed rate required for medium and bold grained varieties is 125 and 150 kg/ha respectively. For late sowing variety the seed rate should be increased by 25% irrespective of seed size.

Spacing: Wheat crop that is sown under normal circumstances and under irrigated conditions a spacing of 20 to 22.5 cm between rows is recommended. For delayed sowing a closer spacing of 15 to 18 centimeters should be adopted. Recently recommendation has been made to sow the wheat at 15cm row distance or criss cross sowing with row spacing of 22.5 cm to suppress the weed growth which is as good as hand weeding and for getting higher yield. For rainfed condition a spacing of 20-22.5 was found to be optimum.

Depth of Sowing: The depth of sowing is one of the most important aspects in successful wheat cultivation as the coleoptile length is shorter in Mexican wheats compared to traditional tall wheat varieties and it is about 5 cm only. Therefore seeds of these varieties should not be covered more than 5 cm depth of soil to ensure early and uniform germination. Similarly triple dwarf gene varieties should not be sown more than 4 cm deep. Similarly in late sown crop also the sowing depth should not be more than 4cm. Method of sowing: Sowing with seed drill or ferti-seed drill is better than any other method as it gives higher yield.

11.3.8. Manures and Fertilizers

Manures and fertilizers play an important role in wheat cultivation. A liberal quantity of bulky organic manure (F.Y.M) should be applied if available (5-7.5 tons/ha). The high yielding dwarf varieties of wheat fully exhibit their yield potential only when they are supplied with adequate quantities of nutrients at proper time. A wheat crop yielding 5000 kg/ha removes 100-150 kg of Nitrogen. 70-80 kg of Phosphorus and 125-150 kg of Potash from the soil.

For normal irrigated crop 80-120 kg nitrogen, 40-60 kg phosphorus and 40 kg Potash/ha is recommended. In zinc deficient areas zinc in the form of zinc sulphate at the rate of 50 kg/ha has to be applied. Entire quantities of phosphorus and Potash and half of the quantity of Nitrogen should be applied as basal and remaining half of the quantity of nitrogen has to be top dressed just before first irrigation (20 to 25 days after sowing).

In the case of Rainfed crop an optimum dose of 40 Kg Nitrogen and 20 Kg Phosphorus/ha has been recommended. In Rainfed condition all the quantity of Nitrogen and Phosphorus should be applied at the time of sowing.

Application of fertilizer through ferti-seed drill at 5 cm below the seed is found to be better than broadcasting.

Due to scarcity of water supply if the number of irrigations are to be limited then 60 Kg Nitrogen, 30 Kg P_2O_5 and 40 kg K_2O/ha be applied. For late sown crop 60-80 Kg N, 30-40 Kg P_2O_5 and 40 Kg K_2O/ha is recommended.

Wheat after maize bajra, jowar or rice need 120 Kg nitrogen/ha; wheat after fallow or legume would require only 80 Kg N/ha.

11.3.9. Water Management

Adequate soil moisture is required for normal development of the wheat plant at all the stages of growth. In case of high yielding dwarf varieties 6 irrigations are required excluding pre-sowing irrigation. The crop should be sown when the fields becomes fit for sowing. The number of irrigations depends upon soil texture, soil depth and climatic conditions.

The crown root initiation and heading stage are the critical stages when plant suffers most due to moisture stress.

The following is the irrigation schedule for dwarf varieties under normal situation.

1st irrigation - Crown root initiation (CRI), 20-25 days after sowing; 2nd irrigation - Late Tillerring 35-40 days after sowing; 3rd Irrigation - Late jointing (Boot leaf stage, 65-70 days after sowing); 4th irrigation - Flowering stage, 85-90 days after sowing; 5th Milky stage - 95-100 days after sowing; 6th Dough stage - 110-115 days after sowing.

Under limited supply of water the following schedule of irrigation can be adopted.

1. If only one irrigation is available, it should be given at crown root initiation stage (CRI) only.
2. If two irrigations are available first at CRI stage and second at flowering stage may have to be given.
3. If 3 irrigations are possible the first at CRI, second at late jointing stage and third at milk stage can be given,
4. If only 4 irrigations are available, irrigation at late jointing and dough stages can be avoided.
5. If 5 irrigations are available, the last irrigation at dough stage can be avoided.

11.3.10. Intercultivation (Weed Control)

Weeds in wheat crop take upto 20-25% of the major nutrients and competes for water and sunlight and reduce the yield from 10 to 40% depending upon the intensity and kind of weeds. Generally weeds can be controlled with the help of hand hoe, Khuroi etc. However due to increase in cost and non availability of labour, the manual weeding becomes prohibitive.

Phalaris minor a new monocot weed becomes a major problem in wheat fields. In certain localities, the intensity of this weed is so high that it has become rather impossible to grow wheat crop. An average plant produces 10,000 to 30,000 seeds. The weed seed germinates along with wheat and resembles wheat seedlings. Therefore it is difficult to recognise it in the initial stage hence the mechanical method of controlling this weed is not possible; only chemical method of weed control has to be adopted.

Recommended Herbicides for Different Situations

Weeds	Herbicide	Dose a.i/ha	Time of appli cation.
All broad leaved weeds	2,4-D	0.4	Post emergence 35 days after sowing.
Phalaris minor	Tribunil, or Dosanax	1.5	30 - 35 days after sowing
"	Isoproturon (Tolkan or Arelon)	0.75	"
" Wild oat and *Aphalari minor*	Isoproturon (Tolkan or Arelon)	0.75	30 - 35 days after sowing
Phalaris minor	Tolkan or Dosanax	1.5	
All weeds	Stamp (Pendimethalin)	1.0	Pre emergence (Soon after sowing)

In all the cases 750 litres of water is needed.

11.3.11. Harvesting and Threshing

High yielding dwarf varieties off wheat are harvested when the leaves and stems turn yellow and fairly dry to avoid loss in yield. In late harvesting grain may be lost due to damage by rodents birds shattering and lodging. Timely harvesting ensures quality and consumer's acceptance.

The right stage is to harvest the crop when moisture is 25-30% in grain. For harvesting hand sickless or combines or bullock driven reapers are also used. If harvesting is done by hand, it is dried for 3-4 days on threshing floor and then threshing is done by trampling with bullocks or power driven threshers.

yield Under irrigated condition is 40-45 Quintals/ha in North India and 25-30 Q/ha in South India. Under Rainfed condition the yield is 20-25 Q/ha in North India and 10-15 Q/ha in South India.

Check Your Progress - 1

What is the weed which is a major problem in wheat field? Why?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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11.3.12. Important pests and diseases on Wheat

A. PESTS

1. Wheat termites *(Microtermies obese and Odonototermies obsesus)*

Symptoms: They feed on the roots and stems of the growing plants. The infested plants are tall, yellow and show wilting symptoms.

Control: (a) Dig the termatrium and kill the queen; (b) Fumigate the termatrium with chloroform or Carbon disulphide; (c) Drench the soil with Aldrin 30 EC at the rate of 2 lit/acre or apply BHC 10% dust before sowing.

2. Leaf eating cater pillar *(Agrotis yepsilon)*

Symptoms: The larvae feed on the leaves and defoliate extensively. They also cause damage severely by cutting the plants.

Control: (a) Spray chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre) in the evening times at the rate of 300-400 ml/acre.

B. DISEASES

1. Loose smut of Wheat *(Ustilago tritici)*

Symptoms: The ear heads of all affected plants is converted to black mass of spores. The smutted plants produce less trillers, shorter rachi and peduncles.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed and hot water treatment prevent seed borne infection; (b) Resistant varieties like S 227, PV 18, WG 407, C 302, N 791, 729 and 823 may be tried wherever suitable.

2. Kernal bunt of Wheat *(Neovossia indica)*

Symptoms: The grains are converted into black powdery mass enclosed by the pericarp either partially or fully. Only few grains in a ear are affected.

Control: (a) Seed treatment with Agrosan or Sulphur at the rate of 3 g/kg of seed prevents seed borne infection; (b) Continuous cropping of wheat should be discouraged. Crop rotation may be followed; (c) Deep ploughing during summer may be encouraged to bury spores deep into the soil.

3. Flag smut of Wheat *(Urocystis tritici)*

Symptoms: The affected leaves are twisted and droop and shed away. The older leaves and leaf sheaths show slightly swollen bands of grey to greyish black, running parallel to the veins.

Control: a. Seed treatment with copper sulphate at the rate of 3 g/kg of seed; (b) Crop rotation, burning of stubbles and early sowing of crop reduces the incidence; (c) Growing resistant varieties.

4. Black or Stem rust of Wheat *(Punccinia graminis tritici)*

Symptoms: The affected leaf blade and other part gives a brownish appearance when uredosori burst and release the spores. Later, teleutosori develop which are linear or oblong, brown to black.

Control: (a) Spraying lime-sulphur,m Zineb-Zinc sulphate checks the rust incidence to some extent; (b) Growing resistant varieties like NP 700 and NP 800.

5. Leaf or brown or Orange rust *(Puccinia recondita)*

Symptoms: The initial symptom of the disease is the development of small round, orange sori, irregularly distributed on the leaves. Severe rusting of leaves results in poor quality of grains and reduction in grain yields.

Control: The control measures given under stem rust are applicable.

6. **Yellow or stripe rust** *(Puccinia striiformis)*

Control: (a) Spraying with Zineb and Maneb (2.5 g/lit) is effective; (b) Growing resistant varieties like NP 4, NP 52, 125, etc.

7. **Leaf blight** *(Alternaria triticina)* **Symptoms:** The disease appears as small, oval spots, which enlarge to become irregular in shape with bright yellow margin. The symptoms may be seen on leaf sheath, ears etc. If the infection takes place before boot leaf stage, the losses in grain yields may be upto 90%.

Control: (a) Presoaking of seeds in water for four hours followed by 10 minute dip in hot water at 52^{O}C; (b) Spraying Ziram or Maneb or Zineb (2.5 g/lit) is effective.

8. **Ear cockle disease or Tundu or Yellow ear rot**

The disease is caused by the combined infection of a nematode *Anguina tritici and a bacterium Corynebacterium tritici*.

Symptoms: The nematode and bacterium infect stem, leaves and floral organs. The infected plants become dwarfed, leaves twisted and crinckled and thus prevents the emergence of young leaves. The affected panicles are short and broad and remain green for more time.

Control: (a) Nemaphos granules are effective at the rate of 10 lb a.i/acre; (b) Selection of healthy seed; (c) Removal of galls by floating seed in water or brine solution; (d) Crop rotation by non host crops like barley and oats.

Check Your Progress - 2 & 3

2. Flag smut of wheat is caused by ______________________________.
3. ______________________________ is the causal organism of loose smut of Wheat?

Note: (a) Write the answer in the space given above.

(b) Compare your answer with the one given at the end.

11.4. MAIZE

It is essentially a tropical plant, due to its wide range of adaptability, it is being cultivated in temperate regions. Considering production United States of America, stands first followed by China. With regard to average yield per hactare United States of America again ranks first (6692 kg) followed by Canada (5575 kg). World area and production are (130 million hactares) and 450 million tons respectively. In India it is grown over an area of 6 million hactares with total production of about 7.95m tons. In India, Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh and Punjab are the leading states in area as well as in total production but Karnataka has recorded highest average yield of 2955 kg per hactare followed by H.P. and Punjab. The average yield in India is about 1043 kg per hactare.

In Andhra Pradesh it is cultivated over an area of 3.0 lakh hectares annually and it is grown mostly in Northern and Southern Telangana Zones particularly in the districts of Karimnagar, Medak, Nizamabad, Warangal and Adilabad.

11.4.1. Climatic Requirement

Maize crop requires warm weather throughout its active growing period and is sensitive to frost at all the stages. It is grown from mean sea level to an altitude of 3000 meters. It can be grown under diverse climatic and soil conditions. It's response to temperature varies with the state of the crop. The most suitable temperature for germination and growth is 21 ^{o}C and 32^{o}C respectively. Extreme temperature and low humidity during flowering damage the foliage, desiccate the pollen and interfere in pollination resulting in poor grain formation. Fifty to seventy five centimeters of well distributed rainfall is conductive for proper growth and higher yield but it is sensitive to water stagnation and water logged condition particularly during its early stages of growth.

11.4.2. Soil

Maize can be grown on variety of soils ranging from sandy to clayey with appropriate management and fertilizer application methods. However deep medium type and clay loams are preferable. The ideal soil is generally considered to be well granulated, medium textured, preferably high in organic matter, well drained, high in moisture holding capacity. The optimum pH range is between 6.5 to 7.5. Maize will not do well on alkaline and water logged soil.

11.4.3. Season

Maize is grown in many parts of our country throughout the year. *Kharif* (rainy) season is the main growing season and 80-85 percent of the crop is raised under rainfed condition in *Kharif* season only. Date of planting differs from place to place. The weather conditions especially rainfall and temperature exert profound influence in determining the date of sowing.

In Andhra Pradesh it is grown in *Kharif* as well as in rabi season. In *Kharif* season the appropriate date of sowing is about 2nd fortnight of May i.e., two weeks prior to the break of monsoon and this is possible where facilities for giving initial irrigation are available, otherwise sowing should be taken up immediately after the onset of monsoon (First fortnight of June) and accomplished as early as possible.

Early sowings help to avoid excess rainfall during early stages of growth. When the plants are highly sensitive to excess moisture, early planting also helps to avoid moisture stress at critical stages of flowering.

Pre-monsoon sowing had several advantages. Plant stand is easier to establish, the first weed control operation and insecticide application can be completed before onset of regular monsoon. The crop also develops a good root system because of brighter weather in the initial stages. After the regular monsoon once sets in, it will not be possible to do all these operations in time effectively due to interference by the rains.

Similarly early plantings will also enable us to clear the fields of maize early so that the subsequent crops can be raised in time.

In *Rabi* season the most suitable period for sowing maize is from middle of October to middle of November. For Rabi maize it is imperative that irrigation facilities have to be made available. In Rabi season the yields are higher than in *Kharif* due to mild temperate, better water management practice, higher response to fertilizer application, lesser incidence of pests and diseases hence better plant stand. However, the maturity period of maize get extended by few weeks in *Rabi* as compared to *Kharif* due to mild weather condition. For seed production maize is sown in January.

11.4.4. Crop Rotation and Mixed Farming

If the irrigation facilities are available, maize can be grown as *Kharif crop followed by crops like wheat, potato, bengal gram, berseem, Lucerne. Crops like green gram Black gram, cowpea* *etc. can be grown as intercrops in the space between two rows of maize. In Rayalaseema area of Andhra Pradesh groundnut and redgram are grown as intercrops in the ratio of 5:1.*

11.4.5. Classification of Crop and Varieties

Maize belongs to Gramineae family. It is a tall plant growing to a height of 1-3 metres. The root system of maize is fibrous, deep and well developed. Leaves are alternate.

Maize is monoecious having two types of inflorescence. The female inflorescence will later develop into cob and are born inside cobs which springs from one of young nodes and will be usually located about mid way of the stalk. The male inflorescence is born in a cluster (Tassel) on the top end of the stem as a Terminal panicle.

Corn is often classified into seven groups or types, based upon endosperm and glume characteristics. There are dent, flint, flower, pop, sweet waxy and pod corns.

1. Dent corn - *Zea mays indentata*

Both corneous and soft starch are formed in dent corn. When the grain dries, a pronounced wrinkle or dent forms on the top of the kernal because of the shrinkage of the soft starch. Mostly cultivated in U.S.A. and Kernals have a wide range of colours but yellow or white are the most commercial types.

2. Flint corn - *Zea mays indurata*

The endosperm of lint corn usually is soft and starchy in the centre but completely enclosed by a corneous outer layer. Kernals are usually rounded at the tip. It is widely grown in Argentina.

3. Flour corn - *Zea mays amylacea*

Kernals of flour corn are composed almost entirely of soft starch. They are shaped like flint kernals because they shrink uniformly as they ripen.

4. Popcorn - *Zea mays everta*

This group is characterised by a very hard coneous endosperm and small kernals. There are two sub groups of pop corn rice, with pointed kernals and pearl with rounded kernals. Grains may differ greatly in colour and size.

5. Sweet corn - *Zea mays saccharata*

The kernals of sweet corn or wheat translucent and more or less wrinkled at maturity. Sweety corn, before it is ripe and dry, has a sweeter taste than do other types because the endosperm contains sugar as well as starch. It lacks ability to develop starch grains.

6. Waxy corn

The kernals of waxy corn have a uniformly dull rath, a soft endosperm showing neither white starch nor corneous translucent layers. The endosperm breaks with a wax like Fracture. The starch of waxy corn contains amloperfin, which has a branched chain molecular structure and a high molecular weight.

7. Pod corn - *Zea mays turicata*

In pod corn each kenal is enclosed in a pod husk. The ear formed is also enclosed in husks as in other types. Pod corn may ~~be dent~~ sweet waxy pop flint or flour corn in endosperm characteristics.

Maize: Varietal Characters

Variety	Season	Duration	Yield (t/ha)	Characters
Deccan..Hybrid Maize	Kharif/Rabi	110-130	45	Grows to a height of 2.25 meters. It flowers in 60 to 70 days after sowing. It is non lodging fairly resistant to leaf blight and stem borer. Grains orange in colour, Semident and round in shape. It yields 65% more than local maize.
Deccan 101	Kharif/Rabi	105-125	52	It grows to a height of 1.7 to 1.9 meters with 12 to 14 leaves. It flowers in 60 to 70 days after sowing. It is non-lodging fairly resistant to blight and stem borer. Grains are light yellow in colour, semi dent and flatish in shape.
DHM-103	Kharif/Rabi	104-124	52	It flowers in 61 days, non lodging, resistant to 4 major diseases (leaf blight, sorghum downy mildew, bacterial stalk rot, and late wilt) and insect pest (stalk borer). Grain is very attractive, bold slightly dentish and yellow in colour, ears are well filled with 14 to 16 rows. The husk cover is good and rated 2.16. More nutritive with a high protein content of 14.4%.
Rohini	Kharif/Rabi	95-110	40-57	Suitable for kharif, fairly resistant to drought conditions. Multiplication is easy and seed can be used year after year.
Amber Composite	Kharif/Rabi	110-130	38	Grows to a height of 2.5-3 meters with 16-18 leaves tolerant to leaf blight and borer. Susceptible to lodging. Yields 59% more than local maize. Multiplication is easy and seed can be used year after year.
Ganga-5	Kharif/Rabi	105-125	44	Grows to a height of 1.8-2.1 meters with 12-14 leaves, resistant to leaf blight, downy mildew and stalk borer. Flowers in 55-65 days. Grains are light orange in colour, semi-dent and round in shape.
Amber Popcorn	Kharif/Rabi	90-95..in 100-105		It grows to a height of 1.2-1.5 meters with 12-14 leaves and two ears. It fits well in multiple cropping schemes. Grains are pearly yellow with a popping expansion of 800 cubic inches per pound of grain. Isolation of 400 meters is essential for seed production.

11.4.6. Field Preparation

Maize seed requires well aerated moist and weed free field to provide better contact between seed and soil. There is no need of preparing extremely fine seed bed. The normal practice of soil preparation includes ploughing, followed by discing and harrowing to prepare well pulverised field. Unless the soils have a hard pan or perennial weeds, ploughing deeper than 18 cm is not recommended. After the soil is prepared well a gentle slope has to be maintained so that no water stagnates. If the crop has to be grown under irrigated conditions ridges and furrows are formed. The distance between the two ridges will be 75 cms. Ridger or Bund former is used for making ridges and furrows.

11.4.7. Seeds and Sowing

Normally maize varieties and hybrids do not produce effective tillers hence they are less capable of adjustment to poor stand than the other tillering cereal crops, therefore to get higher yield the adequate plant stand at harvest is necessary. With increase in plant population lodging of plants will be more and hence silking will be delayed. The delay in silking will increase the number of barren cobs. Similarly higher plant population adversely affects the essential amino acids such as leucin, tryptophan and oil content but favours isoleucine, a non- essential amino acid.

A population of 60 to 65 thousand plants per hactare at harvest is necessary to get optimum yield both for Kharif and Rabi seasons. The seed rate works out to be 20 to 25 kg for hybrids and 18-20kg per hactare for composites depending upon the size of the seed. In rabi seasons a slight increase (10 to 15%) in the plant population is found be advantageous.

Maize is usually sown behind the plough furrow or on ridges and furrows or on flat beds. Sowing by dibbling on the side of ridges at 1/3 distance from the top is preferable both under rainfed and irrigated condition, and affords good drainage wherever there is more rainfall. Normally hybrid maize plantings are recommended at a distance of 75cm apart maintaining a distance of 20cm within the row. However in certain situations 60cm and 90cm also can be adopted with suitable adjustments between the hills within the row by maintaining 66000 plant population per hactare. For pop corn a spacing of 60cm x 20cm was found to be optimum. The seed has to be treated before sowing with Agrosan at the rate of 3gm per kg of seed.

11.4.8. Manures and Fertilizers

Hybrids and composite varieties of maize exhibit their full potential only when adequate quantities of nutrients are made available at proper time. Farm yard manure at the rate of 10-15 tonns per hactare can be applied if available. Otherwise as a general recommendation 120kg Nitrogen, 60kg Phosphorus and 40kg Potassium can be applied per hectare for hybrids and 80kg Nitrogen and 30kg Phosphorus per ha. for composite is sufficient. However the fertilizer dose can be altered based on soil test values. Entire Phosphorus, Potassium and 1/3 Nitrogen must be applied at the time of sowing. The remaining 2/3 quantity of Nitrogen can be applied in two equal splits, 1/3 at the knee high stage and the other 1/3 primordial stage.

In certain areas soils are deficient in zinc. It is advisable to apply 30-50 kg of zinc sulphate per ha before sowing. The basal dose of fertilizer should be placed in the soil 3-5 centimeter to the side and 3-5 centimeter deeper than the seed. The fertilizers can be applied through ferti-seed drill.

11.4.9. Intercultivation and Weed Control

The favourable season in Kharif encourages rapid weed growth; the reduction in grain yield due to weeds ranges from 50 to 100 percent. Intercultivation with the help of push hoe or bullock drawn hoe (Danti) can be carried out before weeds are 5cm tall which can control weeds very effectively. Under heavy weed infestation manual weeding may be necessary or integrated weed management i.e., use of Atrazine or Simazine as pre emergence application followed by hand weeding 30 days after sowing will effectively control the weeds. The Atrazine/Simazine at the rate of 0.5 to 1.0 kg a.i and 1.0 to 1.5 kg a.i. per hactare in light and heavy soils respectively is recommended. The critical stage of crop weed competition is 30 to 45 days in maize crop.

11.4.10. Water Management

Maize belongs to C_4 plants and is capable of utilizing water most efficiently. It is susceptible both to excess water and moisture stress. It is not drought resistant hence moisture stress before tasseling, during tasseling, silking and grain formation stages reduce the yield considerably. A good crop of maize required 450 to 6000 mm of water during its life. It is advisable to provide one or two supplemental irrigations in Kharif during prolonged droughts, especially when the drought occurs at reproductive phase.

In rabi, maize crop may require 5-8 irrigations depending upon the soil and climate conditions. A preplanting irrigation to bring 100cm of the soil depth to field capacity seems to be essential. The first post emergence irrigation has to be given 10 days after sowing. Normally irrigations are to be given at the interval of 10-15 days depending upon soil and climatic conditions. The other irrigations one at flowering (65-70 days) second at fertilization stage and third at milky stage (80 days) are essential.

Seedling and flowering stages are very sensitive to excess moisture and even for four days the yield reduction will be to the extent of 50 per cent.

11.4.11. Harvesting & Yield

Harvesting should be taken up when the cob sheath dries completely and the moisture percentage in the grain is less than 30%. Remove the cob sheath and then dry the cob in the sun for 7 to 8 days and then shell the cobs by sheller. The grain can be stored safely when moisture is 10-12%. Pop corn should be harvested when the moisture is between 20-30 percent and cobs should be dried in shade. Maximum poping expansion is obtained when the grain has 12 to 14 percent moisture.

Under rainfed conditions the grain yield will be 2000-2500 kg in hybrids and 1500-2000 kg in composites. If improved practices are followed the grain yield will be 5000-6000 kg for hybrids and 4500-5000 kg for composites under irrigated conditions.

11.4.12. Important Pasts and Diseases of Maize

A. PESTS

1. Pink borer *(Sesamia inferens)*

Symptoms: The young larvae bores into the stem causing the death of central shoot which is commonly known as 'dead heart'.

Control: (a) Application of Carbofuran granules in the whorls at the rate of 5-7 kg/acre; (b) Removal and destruction of stubbles after harvest.

2. Shoot bug *(Pundatuva simplicia)*

Symptoms: The tender portions of the leaves are suck by colonies of adults and nymphs. Plants become stunted and show scorched appearance.

Control: (a) Spray Methyl parathion at the rate of 300 ml/acre

B. DISEASES

1. Stalk rot *(Erwinia carotovora f.sp. zeae)*

Symptoms: The lower nodes show the rotting symptoms initially and spreads to up and down to a limited distance. This follows decay of interior of the stalk or sometimes involves only the rind.

At the advanced stages leaves become yellow and dry. The infected parts of the stalk are soft initially but later turn to dry mass of shreaded fibres and consequently the plants fall down.

Control: (a) Diseased plants should be destroyed; (b) Crop rotation to be practiced; (c) Excess irrigation should be avoided.

2. Downy mildew *(Sclerospora sacchari)*

Symptoms: The important symptoms is the appearance of long and broad chlorotic stripes on the entire length of leaf blade. Downy growth of the fungus is observed on both sides of the leaves.

Control: (a) Spraying Dithane M-45 at 0.25% at the rate of 500 g/acre; (b) Crop rotation to be practiced; (c) Destruction of alternate hosts.

3. Common smut *(Ustilago maydis)*

Symptoms: The fungus not only affects grains but affects even the other plant parts as well. It produces galls on ears, axillary buds, tassels and stalks. The infection of female flowers gives rise to galls in the place of grains. The seedling infection leads to stunting.

Control: (a) Crop rotation and field sanitation may help to reduce the infection.

4. Brown spot *(Physoderma maydis)*

Symptoms: Initially light green water soaked areas develop on leaf blade which turns to reddish brown at first and becomes brown finally.

Control: (a) Crop rotation and field sanitation may help to reduce the infection.

5. Rust *(Puccinia sorghi)*

Symptoms: The pustules are yellowish in the initial stages of development and later turn to brown and are encircled by chlorotic haloes.

Control: (a) Crop rotation may be encouraged.

6. Leaf Blight

The symptoms and control measures are given under sorghum.

7. Virus diseases *(Maize Mosaic Virus)*

Symptoms: Diseased plants produce lighter panicles and chaffy seeds. Maize mosaic may reduce yield upto 30% in severe cases of attack.

Control: (a) Growing resistant varieties.

Check Your Progress - 4 & 5

4. The Scientific name of Pink borer of Maize is ______________________

5. The rust of maize is caused by ______________________

Note: (a) Write the answer in the space given above.

(b) Compare your answer with the one given at the end.

11.5. SUMMARY

Wheat is one of the most important cereal food crops in the world. Green revolution in wheat was made possible only with the introduction of Mexican dwarf varieties into India. Dr. N.E. Borlaug was the first scientist to evolve these dwarf varieties in mexico. In India only 3 species of wheat are mainly cultivated among them. *Triticum aestivum* is the most common. Wheat is a winter (Rabi) season crop and it requires cool climate. Due to favourable climatic conditions existing in North, cultivation of wheat crop is mostly confined to North Indian states with high hectare yields. Wheat can be grown as rainfed crop on residual moisture. Optimum sowing time is the 2nd fortnight of October to 1st week of November and under irrigated conditions it can be grown from Middle of November. Seed rate ranges from 100-125 kg/ha and optimum spacing will be 20 to 22.5 cm between rows. Sowing with fetiseed drill is always advantageous. The fertilizer dose recommended for irrigated crop is 80-120kg N, 40-60kg P_2O_5 and 40kg K_2O per ha. For rainfed crop a dose of 40 Kg N and 20 kg P_2O_5 per ha. is recommended. Wheat crop requires 6 irrigations excluding the per-swing irrigation. Crown root initiation (CRI), late tillering, late jointing, flowering, milk and dough stages are very sensitive for moisture stress and hence irrigation at these stages is most important. Irrigation at CRI stage is a must and is crucial. This is the most important stage (20-25 days after sowing) which can reduce 50% of the yield if the crop suffers moisture stress at this stage. Wheat crop is very sensitive to weed competition and the reduction in yield can go up to 10 to 40%. In recent times a new weed namely *Phalaris minor* has become a problematic weed. For controlling this weed herbicides like Tribunal, Dosanax, Tolken and Arelon were found to be most suitable. Irrigated wheat crop can produce upto 40-45 q/ha of grain yield as against 20 to 25 q/ha produced by rainfed crop. Among the diseases Rust, Loose smut, Kernal bunt are very common. Termite is the only common insect pest which affects wheat.

Maize is one of the most important cereal crops in the world. It is used as food for man and feed for animals. Maize contains 10% protein and 4% oil. United States of America Stands first in area production and productivity. In India it is grown almost all the states. Uttar Pradesh stands first in area but the productivity is highest in Karnataka, with average Indian productivity being 1046. In Andhra Pradesh it is grown in Northern and Southern Telangana. Maize is warm weather crop, sensitive to frost and requires 21°C and 32°C for germination and growth. It requires well granulated medium textured well drained soil. Kharif (Rainy) is the main growing season. Optimum time of sowing in Kharif is the onset of monsoon (June) under rainfed conditions. If irrigation facilities are available pre-monsoon sowing with one or two irrigations is best. In Rabi season sowings are taken up from Mid October to mid November.

Maize is classified into 7 groups based on characteristics of seeds. They are (1) Flin corn (2) Dent corn (3) Pop corn (4) Sweet corn (5) Soft corn (6) Pod corn (7) Waxy corn. For hybrids 120kg N, 60kg P_2O_5 and 40kg K_2O/ha and for others 80kg N and 30kg P_2O_5/ha is recommended. Entire dose of P_2O_5 and K_2O along with 1/3rd does of N/ha has to be applied as basal and remaining 2/3rd N/ha in two equal splits i.e. 1/3 at knee high and 1/3 at primordial stage is recommended. For effective weed control Atrazine/Simazine as pre-emergence herbicide at the rate of 1.0 to 1.5kg a.i. per ha is recommended depending upon soil type. Moisture stress at silking, flowering, fertilization and milk stage reduces the yield considerably. Harvesting should be taken when moisture percentage is less than 30. Grain yield ranges from 4500-6000 kg/ha under irrigated and 1500 to 2500 kg/ha under rainfed condition. Stem borer, shoot fly, cut worm and white grubs are the most important insect pests of maize.

11.6. CHECK YOUR PROGRESS: MODEL ANSWERS

1. Phalaris minor, a new monocot weed is a major problem in wheat fields. It is because it resembles the wheat seedlings and the mechanical method of controlling it is not possible.

2. *Urocystis tritici.*
3. *Ustilago tritici.*
4. *Sesamia inferens.*
5. *Puccinia sorghi.*

11.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in 30 lines.

1. Discuss in brief the adaptation and climatic requirement of wheat crop.
2. Give an account of crop rotations and crop sequence that can be adopted in cultivation of wheat crop.
3. Discuss the water management aspect in wheat crop.
4. Which is problematic weed in wheat crop. How do you control it.
5. Briefly discuss the main pests and diseases of wheat crop with control measures.
6. Discuss in brief the adaptation and climatic requirement of maize crop.
7. Give the classification of maize based on endosperm and glume characteristics.
8. Discuss the manures and fertilizer requirement of Maize crop.
9. Briefly discuss the sowing season of maize crop.
10. Write in detail about water management for maize.

II. Answer the following questions in 10 lines.

1. List out the wheat varieties that are recommended for Andhra Pradesh under irrigated and rainfed conditions.
2. Write in brief about time of sowing of wheat crop.
3. Under limited water supply mention the stage of the crop that should be irrigated to get optimum production.
4. Write briefly the classification of wheat varieties.
5. Write in brief about Mexican wheat varieties.
6. In north India the productivity of wheat is high compared to South India? Why?
7. Write the soil requirement of wheat crop.
8. Give in detail fertilizer recommendation for irrigated wheat crop.
9. Write in brief about the time of sowing and spacing in wheat.
10. Discuss in brief spacing, seed rate and depth of sowing of wheat.
11. Write a short note on harvesting and threshing of wheat crop.
12. List out the hybrids and other varieties recommended for Andhra Pradesh.
13. Furnish the following information pertaining to DHM 103 and Ganga 5 - Season duration and yield.
14. Write the detailed characteristic of any pop corn variety.
15. Write the soil requirement of maize crop.
16. Discuss the brief spacing, and seedrate in maize.
17. Write in brief about maize hybrids.
18. What is meant by synthetic varieties.
19. What is meant by composite varieties.
20. Write a short note on weed control in maize.
21. Write the description of maize plant.

UNIT - 12: SORGHUM

Contents

12.1. OBJECTIVES

By the end of this unit you will be able to :

1. describe the climatic reqauirement and list out the different varieties of sorghum,
2. describe the method of commercial production of hybrids,
3. describe the method of land preparation and application of fertilizers
4. give a list of pests and diseases caused to sorgum, the causal organisms and suggest the control measures,
5. describe the harvesting and threshing techniques

12.2. INTRODUCTION

Sorghum popularly known as jowar is the most important food and fodder crop of India. It is mostly grown under rainfed conditions and in soils that are less suitable for maize and wheat crop. In India it ranks next to rice in acreage and occupies third position in production after rice and wheat. Sorghum grain is used in various forms such as roti (bread) or cooked like rice. It is also used as malt or popped. Sughum grain is used for beer production. It is superior to rice in food value being richer in protein and fat. Green and dried fodder is the most important roughage for cattle. The crop can withstand drought better. Under rainfed conditions the total dry matter yield (grain and straw) is more in jowar than any other cereal crop.

It has wide distribution. It is grown in Asia, Africa, North and Central America, South America, Sudan, South Africa, Australia, Europe and U.S.S.R. World area under sorghum is about 388 million hectares with a production of 489 million tonnes of grain. India ranks first in acreage and second in production after U.S.A. Table I gives the area and production of this crop in different states of India. It is grown in an area of aobut 16 million hectares in India with a production of 10.6 million tonnes of grain. Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Gujarat are the important states which comprises 90 per cent of the total area and 89 per cent of the total production. In Andhra Pradesh it is mainly grown in the districts of Kurnool, Mahaboobnagar, Khammam, Adilabad, Cuddapah and Medak producing more than a lakh tonnes.

12.3. JOWAR GROWING ZONES OF ANDHRA PRADESH

1. **Low rainfall kharif zone :** The red soil area in the districts of Mahaboobnagar, Nalgonda and Ananthapur.
2. **High rainfall kharif zone :** It consists of the districts of Adilabad, Karimnagar, Medak and parts of Ranga Reddy, Warangal, Guntur and Prakasam where sowings are done during the second week of July.
3. **Early rabi or Maghi zone :** Contiguous area in the districts of Khammam, Warangal, Nalgonda and Krishna forms third zone.
4. **Nandyal Valley :** This zone includes the districts of Kurnool and Cuddapah where sowings are done during second fortnight of September.
5. **Normal rabi zone :** Parts of Adilabad, Ranga Reddy, Karimnagar, Medak, Mahaboobnagar, Nizamabad and Guntur districts constitute this zone. Normal sowing period is first fortnight of October.
6. **Late rabi zone :** The district of Nellore and adjoining areas of Prakasam constitute this zone which comes under the influence of North-East Monsoon.

Check Your Progress - 1

What are the districts included in the low rainfall Kharif Zone of Jowar?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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12.4. CLAMATIC REQUIREMENTS

It is a tropical crop. However it is grown in temperate regions in summer when temperatures are high and the growing season is sufficiently long. It is a hard crop and can withstand adverse climatic conditions more than any other kharif crop. The drought resistance of sorghum is due to its extensive root system with profuse rootlets and reduced transpiration losses from leaves under stress conditions. In contrast to crops like maize, and rabi, sorghum recovers from severe drought as its stomata resume their normal function even after 14 days of severe drought. It is successfully grown in a dry climate of Rajasthan and also in humid areas of West Bengal and Bihar. It can be grown in regions receiving rainfall from 400 to 1000 mm per annum. A soil profile contaiing 100-150 cm water is sufficient to suppport the crop. Water received over and above this limit will result in additonal yield. Although it is known for drought resistance, it can withstand water logging.

It can withstand a wide range of temperature from 15.5°C to 40.5°C. It requires a minimum temperature of 10° C for germination. The optimum temperature for growth is 27°C to 40°C. Sorghum yields are adversely affected when mean temperature exceeds 26°C during heading period.

12.5 SEASONS

It is grown in kharif, rabi and summer seasons. In north India it is mostly grown in kharif while in South India it is grown both in kharif and rabi seasons. The rabi crop constitutes about 36 to 38 per cent of the total acreage. In Maharastra and Karnataka Rabi Jowar occupies 55 to 60 per cent and in A.P. its distribution is 50-60 in both seasons. The sowing and harvesting months in different seasons are as follows:

i) Kharif	:	June to September/October
ii) Maghi (late kharif or early rabi)	:	August/September to December
iii) Rabi	:	October to January.
iv) Summer	:	January to April.

12.6. SOILS

It is grown in a wide range of soil types. Medium and deep black soils are most suitable and in such soils it is often grown as late kharif crop or rabi crop. As kharif crop it is grown in red loams, clay loams and light black soils. It does not grow well in gravelly and marshy soils. It comes up well in soils having pH range of 7 to 8.

12.7. VARIETIES

In the past 25 years considerable improvement has been made in sorghum and the first hybrid (CSH-1) was released in the year 1962. There after a number of hybrids and varieties were developed suitable for different tracts keeping the following characters in view.

1) Exploitation of hybrid vigour and development of hybrids suitable for kharif, rabi and summer seasons
2) Reduction in plant height particularly in varieties to avoid losses due to lodging.
3) Evolving the sorghum varieties suitable both for grain and fodder purposes.
4) Evolving varieties low in prussic acid.
5) Evolving insect pest and disease resistant varieties.
6) Developing suitable management practices for recommended varieties and hybrids for different sorghum growing regions of India.

In the varietal improvement programme equal emphasis was given to hybrids as well as selection of varieties by breeding. About nine hybrids (CSH-1 to CSH-9) and seven high yielding varieties (CSV-1 to CSV-7) have been released. The current programme emphasises on the incorporation of disease and insect resistance and quality into varieties and hybrids that are already developed.

Co-ordinated sorghum varieties CSV-4 and CSV-5 are resistant to downy mildew. The varieties CSV-6 and CSV-5 are resistant to shoot fly and CSV-5 to most leaf spots and striga. Co-ordinated sorghum hybrids CSH-5, CSH-6 and variety CSV-4 are tolerant to head mould and grain deterioration if caught in rains before harvesting. The varieties and hybrids recommended for Kharif and rabi seasons in Andhra Pradesh are as follows:

Season	Hybrids	Varieties
Kharif	CSH-1, CSH-5 and CSH-6	CSV-3 (370), CSV-4 (CS 3541), CSV-1 (Swarna), CSV-2 (302/303), CSV-6 (604) and 329.
Rabi	CSH-1, CSH-7R and CSH-8R	CSV-2, CSV-4, CSV-5 (148/168) for maghi and CSV-7R (R-16)

12.8. COMMERCIAL PRODUCTION OF SORGHUM HYBRIDS

Male sterility in sorghum is controlled by both genetic factors as well as by cytoplasm. The male sterile genes in the back ground of sterile cytoplasm result in male sterility. The action of male sterility can be modified by pollen carrying restore genes. For maintenance of male sterile line 1A' (CK 60A)., A line is grown in isolated plots along with its 'B' line. The 'B' line is identical to A line in genetic make up except that it is male fertile. The seed from A line is collected which will be male sterile.

For hybrid seed production 4 to 6 rows of male sterile line A is alternated with two rows of male parents carrying fertility restoring genes. The A line is pollinated by the pollen from restorer line and thus the seed obtained from A line is a hybrid seed (A x R) and will be fertile in F_1.

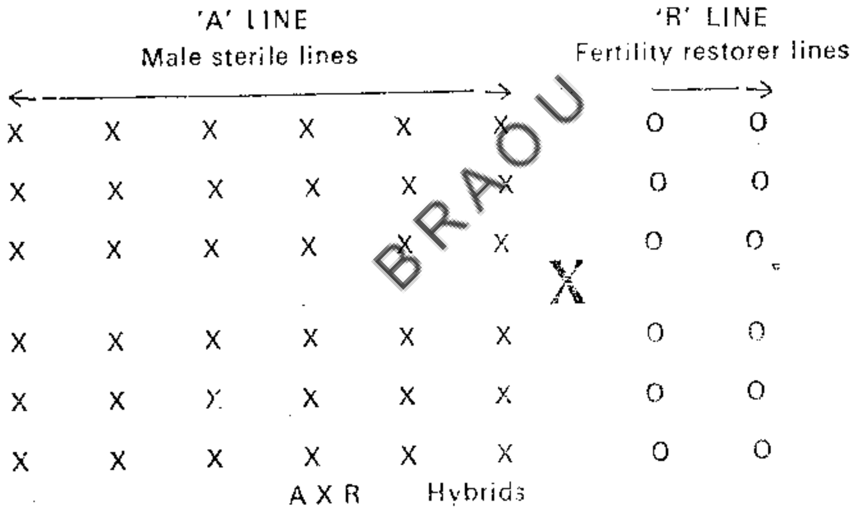

Fig.12.1. A x R Hybrids

The single cross hybrid (AXR) is sold to the farmer for commercial production.

Care should be taken in the production of hybrid seed that both the parents i.e., A line and restorer line 'R' come to 50 per cent flowering at the same time. If there is any difference in duration of 50 per cent flowering between these parents, the sowing time of one of the parents needs to be preponed so as to have synchronisation in flowering.

12.9. LAND PREPARATION & SOWING

Depending upon the previous crop and soil type, the land is brought to fine tilth by initial ploughing followed by harrowing or by two to three harrowings. For kharif crop in the summer season before the onset of monsoon the land is either ploughed or harrowed and with the onset of the monsoon it is brought to fine tilth by subsequent harrowings and the land is levelled finally.

Seed treatment in jowar is essential to prevent it from seed borne diseases especially grain smut. The seed should be treated with thiram at the rate of 3g per kilogram of jowar seed or with sulphur at the rate of 5g per kg of seed. In areas where shootfly is a problem, treat the seed with carbofuran 50 W.P. at the rate of 100g per kg of seed to protect the crop.

In early stage, sorghum is a slow growing crop. To minimise the competition from weeds and to avoid shootfly attack, rainfed crop should be sown immediately after the onset of monsoon. Experimental results clearly indicated that progressive delay in sowing by 7 or 14 or 21 days after first monsoon rain caused substantial reduction in yield. The average reduction in yield varied from 37 to 319 kg grain/ha/day. The crop should not be sown after the first week of July as it is subjected to shootfly and midge attack. In jowar tracts, sowings are delayed beyond the first week of July due to aberrant weather conditions, it is advisable to grow alternate crops like bajra or sunflower or castor in place of jowar. The sowing of irrigated crop also should be completed by the first week of July. Rabi sorghum is mostly grown on receding soil moisture on black soil. The soil moisture reserve or rain in the month of September or October is the main factor influencing the yields. In rabi areas sorghum is usually sown in October-November. By that time some of the soil moisture is lost by evaporation. Experimental results clearly indicated in favour of advancing the sowing time to the first week of September. The crop can utilise the stored moisture and the rainfall received in October-November most effectively.

The optimum plant population for high-yielding cultivars is about 1,80,000 plants/ha as against 90,000 plants per hectare for local tall types. Varieties like Swarna can respond well even upto a plant density of 2,70,000 plants/ha. Low plant population of 45,000 plants in farmers field is the main reason for the low yields of rabi sorghum. The optimum population for rabi crop should be ranged between 90,000 to 1,35,000 plants/ha in different localities.

A plant density of 1,80,000 plants/ha is obtained by sowing seeds with an inter row spacing (row to row) of 45cm using seed drill or country plough with slightly higher seed rate. The crop is thinned during the third week by keeping one plant at 12cm apart within the row (intra row). In areas where the labour is easily available it can be sown by dibbling two to three seeds per hill at a spacing of 45 x 12cm and finally one plant per hill can be maintained. The inter row spacing of sorghum can be increased upto 60 to 90cm without much reduction in yield by decreasing intra row spacing so as to obtain 1,80,000 plants/ha. The increased row width may help in taking up an intercrop to augment the total production per unit area per unit time.

12.10. FERTILIZER RECOMMENDATION

The fertilisers recommended for sorghum at different stages are given below.

Fertilizers	Kg/ha	No. of doses	Stages
Rainfed crops:			
Farm yard manure	12.5 tonnes	One	Before the last ploughing
Nitrogen	80	Two	1. 1/2 at sowing. 2. Remaining 1/2 as top dressing at knee high stage of the crop.
Phosphorus	40	One	At sowing
Potash	30	One	At sowing.
Irrigated			
Farm yard manure	12.5. tonnes	One	Before the last ploughing
Nitrogen	120	Two	1. 1/2 at sowing. 2. Remaining 1/2 as top dressing at knee high stage of the crop.
Phosphorus	60	One	At the time of sowing.
Potash	40	One	At the time of sowing.

12.11. INTERCULTIVATION

The crop does not tiller. It usually attains a height of 1.8 to 2.5M. Taller plants are generally longer in duration. The duration of crop varies from 90 to 170 days. The crop is intercultured with bullock drawn blade harrow (danti) during third and sixth weeks after owing. Weed within the row and weeds left over very close to the row are removed by hand weeding. In regions of labour shortage, any one or two of the following chemicals can be used to control the weeds effectively.

Herbicide	Dose active ingredient Kg/ha in 600 litres of water	Time of application
1. 2-4-D Amine	1.8	Pre-emergence to crop and weeds.
2. 2,4-D Sodium	2.0	-do-
3. Atrazine	0.5 to 1.0	-do-
4. 2,4-D ester	0.9	25 days after sowing.
5. Cyanaine	1.5 to 2.0	-do-

12.12. IRRIGATION

For irrigated crop, weekly irrigation in light soils and once in 12-15 days in heavy soils is recommended. Irrigation at flowering and grain filling stage is essential.

12.13. IMPORANT PESTS AND DISEASES OF SORGHUM

A. Pests

1. Sorghum shoot fly *(Antherigona soccata)*

Symptoms: The maggot bores into the central axis of the seedlings and destroys the growing point resulting in the formation of 'dead heart'. The dead hearts can be easily pulled out and they emit offensive smell.

Control: (a) Treatment of seed with carbofuran 50 SP at the rate of 10g/kg. of seed, (b) Application of carbofuran in the whorls at the rate of 10-15 kg/acre, (c) Spraying of carbaryl 50 WP at the rate of 2 kg/ha or Lindane 20 EC at the rate of 250 ml/acre, (d) Sowing of crop early during June will prevent infestation.

2. Sorghum stem borer *(Chilo partellus)*

Symptoms: The larvae initially scrapes and feed on the leaves and migrate into central whorl and this results in the formation of 'dead heart'. The dead heart can be easily pulled but it will not give any bad odour as in the case of the shoot fly damage.

Control: (a) Spray carbaryl 50 WP at the rate of 2 kg/ha. or Endosulfan (2ml/lit) at the rate of 250 ml/acre at 15 days interval starting from one month after sowing (b) Apply endosulfan 4 G at the rate of 8 kg/ha or Carbaryl 4 G at the rate of 12 kg/ha or Lindane 2 G at the rate of 15kg/ha at 20, 30 and 40 days after sowing to control the first instar larvae which feed on central whorl.

3. Sorghum midge *(Contarinia sorghicela)*

Symptoms: The maggots feed on the developing grain and ovary preventing the formation of full grain. It results in chaffy grains.

Control: (a) Spray ear heads before flowering with Endosulfan 35 EC (1.5ml/litre) at the rate of 300ml/acre, (b) After floweing spray carbaryl 50 WP (2.5 g/lit) or Lindane 20 E.O. (2.5 ml/litre), (c) Alternatively dust either with Endosulfan 2% or carbaryl 10% at the rate of 10 kg/acre.

4. Sorghum earhead bug *(Calocoris angustatus)*

Symptoms: Both nymphs and adults suck the sap from the developing grains which results in poor setting of grain and chaffyness.

Control: Ear head dusting with 10% carbaryl or 10% BHC at the rate of 10-14kg/ha when the gloom appear on the panicle.

5. Sorghum aphid *(Rhopholosiphum maidis)*

Symptoms: The aphids suck the sap from the lower surface of the young leaves and young ear heads. The affected earheads in severe cases are ill developed and sometimes do not emerge.

Control: Spray Dimethoate (1 ml/litre) or Monocrotophos (1.5 ml/litre) or phosphomidon (1 ml/litre) at the rate of 250 ml/acre.

B. Diseases

1. Grain smut *(Sphacelotheca sorghi)*

Symptoms: Smut sori are formed in the place of normal grains in severe cases but in light infection only a few may be smutted.

Control: Treat the seed with ceresan or Thiram or sulphur at the rate of 4g/kg of seed to prevent seed borne infection.

2. Loose smut *(Sphacelotheca cruenta)*

Symptoms: The infected plants are dwarf, produce more tillers, flowers come early but they are not healthy ones. Most of the infected spikelets are malformed. The infected ear gives the appearance of leafy or leathery structure.

Control: Treat the seed with Thiram or Ceresan at the rate of 4g/kg of seed.

3. Long smut *(Tolyposporium ehrenbergi)*

Symptoms: The smut sori are generally scattered sporadically through out the ear and only rarely a few grains are smutted.

Control: (a) Adjusting of sowing dates helps in controlling the disease to some extent.

4. Head smut *(Sphacelotheca reiliana)*

Symptoms: The head is replaced by a large whitish gall either completely or partially. The gall ruptures, often before the head emerges from the boot, to expose the mass of brown-black smut spores.

Control: Crop rotation is helpful in checking the disease.

5. Rust *(Puccinia purpurea)*

Symptoms: The lower leaves first show rust infection on both surfaces. Typical rust pustules

(Uredosori) develop mainly on lower leaf surfaces, which rupture to release reddish powdery masses of uredospores.

In highly susceptible cultivars the pustules occur so densely that almost the entire leaf tissue is destroyed.

Control: Growing resistant varieties on hybrids is the only solution.

6. Downy mildew *(Sclerospora sorghi)*

Symptoms: The fungus *Sclerospora sorghi,* is the cause of downy mildew of sorghum and maize. The pathogen invades the growing points of young plants and as the leaves unfold they show various types of symptoms. During humid weather abundant downy white growth (Conidiophores and conidia) is produced nocturnally on the under surfaces.

Control: (a) Collect and destroy the diseased plants before the formation of oospores, (b) Grow resistant varieties.

7. Ergot or sugary disease *(Sphacelia sorghi)*

Symptoms: The first symptom of sorghum ergot is the secretion of creamy sticky liquid (honey dew) from infected florets. Often the honey dew is colonised by saprophytic fungi, which give the head, a blackened appearance.

Control: (a) The seed should be free from sclerotia, (b) The grass hosts should be removed from the vicinity of the crop, (c) Rotation avoiding cereals will help in reduction of the inoculum.

8. Charcoal rot *(Mecrophomina phaseolina)*

Symptoms: The external symptoms of charcoal rot are lodging and poor grain filling. The causal fungus (*Sclerotium bataticola*) invades the crown through the roots and then proceeds to colonize and disorganize the cortical tissues of the lower internodes. The lower stems of the infected plants become soft and week resulting in lodging, usually at the second or third internode.

The disease will become serious if the sorghum crop experience drought stress and high soil temperatures during the grain filling period.

Control: Crop rotation.

Check Your Progress - 2& 3

2. The scientific name of Sorghum stem borer is ______________________________

3. Grain smut of sorghum is caused by ______________________________

Note: (a) Write the answer in the space given above.

(b) Compare your answer with the one given at the end.

12.14. HARVESTING, THRESHING AND STORAGE

In case of hybrids and other varieties with shorter plant height, the earheads are first removed with sickles. In varieties that grow tall, the plants are cut outright 45 to 75cm above the ground level with sickle and then the earheads are separated. The harvested earheads are well dried and threshed. Cattle threshing or stone threshing or machine threshing are adopted. The threshed grain is winnowed and dried thoroughly before storing. It should be stored in gunny bags or seed bins or godowns. Periodical drying of grain once in a month will control the stored pests like weevils. The sorghum yield per hectare is given below.

Yield

Rainfed crop

Local varieties	=	500 Kg/ha.
Hybrids and high yielding varieties	=	2000 to 3000 Kg/ha

Irrigated crop

Hybrids and high yielding varieties	4000 to 6000 Kg/ha.

12.15. SORGHUM EFFECT

The sorghum has a depressing effect on succeeding crops particularly on cotton. This may be due to the toxic effect of root exudates of sorghum or thorough removal of nutrients from different layers of the soil by sorghum crop. This effect is less on pulse crop. The ill effect of jowar can be minimised by inter- cropping with legumes and by adequate application of organic and inorganic manures to the succeeding crop after jowar.

12.16. INTERCROPPING

Intercropping is commonly adopted in sorghum. Greengram or Blackgram or redgram are usually taken as inter crops in jowar. In Punjab guar is taken as intercrop in sorghum. Recent studies at ICRISAT and dryland Project have indicated that 60 to 70 per cent yield advantage can be obtained by intercropping redgram with sorghum. One row of redgram should be sown after every two rows of sorghum by skipping one row of sorghum.

12.17. RATOONING IN JOWAR

Hybrids can be ratooned with good success. They give even more yields that the main crop, if properly managed. Of all the hybrids, CSH-1 is the best for ratooning and the local varieties are not at all fit for ratooning. This is possible only under irrigated condition.

The crop has to be harvested while the stem is green, leaving 10 to 15cm stubble above ground level. On the second day of the harvest, an irrigation has to be given to induce sprouting from the nodes. Fertilizer at the rate of 60 Kg N/hectare has to be applied. Half of the nitrogen has to be applied at the base of the stubble and covered before the 1st irrigation and the second half, 30 days after from the date of ratooning. From each stubble, a number of sprouts will come up. The week sprouts have to be thinned out leaving 2 or 3 good healthy sprouts in each stubble. Maintenance of sufficient moisture from boot leaf to grain hardening stage is necessary for getting good yields.

Advantages: (a) Eventhough the ear head size is small the ratoon crop gives equal or more yield than main crop as it puts forth 2 or 3 sprouts.

(2) Ratoon comes to harvest in 80-85 days.

(3) Ratooning reduces expenditure on land preparation, seeds, sowing and gives more income than plant crop, wherever it is managed well.

12.18. FORAGE SORGHUM

Among the cereals, sorghum has special significance as it is extensively used as fodder crop besides being one of the major grain crops. In recent years the varieties which can be exclusively grown for fodder purpose are being identified and five to six improved varieties of forage sorghum namely Pusa Chari, S.L. 44, M.P chari and SSG 59-3 and pioneer forage hybrid are popular with cultivators. From the first two varieties only one cut is taken. Two to three cuttings can be obtained from M.P. Chari and Sweet Sudan grass (SSG 59-3) and pioneer hybrid.

The seed rate adopted for forage sorghum is higher than the grain crop. Seed rate for bold type is about 40-50 Kg/ha and for small and light seeded varieties like SSG-59-3 and pioneer hybrid is 25 Kg/ha. Time of sowing for summer forage crop is March in North India and February in South India. Kharif forage crops are sown in June-July. The crop is sown by broadcasting or by drilling with seed drill in rows at 25 to 30cm apart.

The crop is fertilized with basal application of 40-25 Kg of NPK per hectare at the time of sowing. The crop is top dressed with 35 Kg N/ha at 30 days after sowing. The crop is ready for first cut after 60-70 days. It should be cut when it is in 50% flowering. After every cut 40 to 50 Kg N/ha may be given immediately and irrigated. Subsequent cuttings are obtained 40 to 50 days after the first cutting.

Yield (Average) - 40 to 50 t/ha

Under good management - 80 t/ha.

Toxicities: The young sorghum plants upto the age of 30 to 40 days contain glucoside in appreciable quantities which breaks into Hydrocyanic acid (HCN) or prussic acid in the stomach of animal. hence the young plants should not be fed to the animals.

Check Your Progress - 4 & 5

4. What are the four crops that are usually grown as intercrops in sorghum fields?
5. The young sorghum plants should not be fed to the animals - Why?

Note: (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end.

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12.19. SUMMARY

Sorghum is the most important food and fodder crop in India. The grain sorghum is richer in protein, fat and minerals than rice and wheat grain. It is grown in most parts of the world either for grain or fodder purposes. In India it is mostly grown in Maharashtra, Karnataka, Madhya Pradesh, Andhra pradesh and Gujarat contributing 90% of the total area. It is a hardy crop and can withstand drought better than other kharif crops. It can be grown both in kharif, rabi and summer season. For hybrid seed production four to six rows of male sterile line is alternated with two rows of male parents having fertility restorer genes. The seed rate is 10 kg/ha. In areas where shootfly is a problem, sorghum seeds have to be treated with carbofuran besides treating the seeds with thiram. In kharif season sorghum should be sown immediately after the onset of monsoon and in rabi during September. The spacing for kharif sorghum is 45 x 12cm and for rabi sorghum 45 x 15cm or 45 x 20cm. The fertilizer recommendation for rainfed sorghum is 80:40:30 and for irrigated sorghum it is 120:60:40 kg of N, P_2O_5 and K_2O/ha. The crop is intercultured by bullock drawn blade harrow followed by hand weedings during the third and the sixth weeks. The duration of hybrids and improved varieties is about 120 days while local tall types, it is about 170 days. Shootfly, Stem borer, midge and earhead bug are the main pests and smut and sugary diseases are the major diseases in sorghum. Intercropping with greengram or blackgram or redgram is the common practice in sorghum. The yield of grain sorghum under rainfed conditions for hybrids and improved varieties is 2000-3000 kg/ha and under irrigated conditions 4000 to 6000 kg/ha. Ratoon crop after main crop from sorghum hybrids can be taken by cutting the stem when it is green and allowing the stubble to sprout. A number of varieties are available exclusively for fodder purpose.

12.20. CHECK YOUR PROGRESS: MODEL ANSWERS

1. Mahaboobnagar, Nalgonda and Ananthapur are the districts included in the low rainfall Kharif zone.
2. *Chila partellus*
3. *Sphacelotheca sorghi*
4. Greengram, blackgram or redgram are usually grown as intercrops in Sorghum field.
5. The young 30 to 40 days old plants of sorghum contain glucosides in appreciable quantities and it breaks into hydrocyanic acid or pussic acid in the stomach of animals. So the young plants should not be fed to animals.

12.21. MODEL EXAMINATION QUESTIONS

I. Answer the following question in about 30 lines each.

1. What characteristic features that should be kept in view in varietal improvement programme of sorghum? List out recommended varieties and hybrids for Kharif and Rabi seasons.
2. Describe the production of hybrid seed in sorghum.
3. What is the seed rate, time of sowing in Kharif and Rabi season's, spacing, fetilizer schedules followed and appreciate grain and straw yields that can be produced in jowar under rainfed and irrigated conditions.
4. Describe the symptoms caused by important pests of sorghum along with their control measures.
5. Describe the various types of smut and other diseases in sorghum with their symptoms and control measures.

II. Answer the following questions in 10 lines.

1. Give an account of the jowar growing regions of Andhra Pradesh.
2. Give an account of intercultivation and chemical weed control in sorghum.
3. Discuss in brief the cultivation of forage sorghum.
4. Give an account of ratooning in jowar and what are its advantages and limitations?

UNIT - 13: BAJRA, RAGI AND KORRA

Contents

13.1. OBJECTIVES

By the end of this unit you will be able to:

1. describe the climatic requirement for Bajra, Ragi & Korra,
2. list out the seasons for Bajra, Ragi & Korra
3. suggest the type of seeds required and the method of sowing and transplantation of seedlings of Bajra, Ragi & Korra
4. list out the Manures and fertilisers required and also suggest the time of application of them for Bajra, Ragi & Korra

5. describe the intercultivation methods and also list out the herbicides used of all these crops,
6. list out the important pests & diseases of these three crops and suggest the control measures,
7. describe the process of harvesting and threshing of these three crops and estimate the yields.

13.2. INTRODUCTION

Bajra *(Pennisetum typhoides L.,* Hindi-Bajra, Telugu-Sajja, English-Peart millet) is an important minor millet crop. It is generally grown under marginal conditions of moisture and fertility. The yield per hectare is consequently very low. Bajra is a poor man's crop. It is more drought tolerant among cereals and millets. The grain of bajra is superior in nutritive value to sorghum grain but inferior in feeding value. The grain is used in the preparation of bread and the straw is used as fodder for cattle. It is very difficult to point out the country in which it was originated. Most of the scientists believe that it had its origin in Africa where it is largely grown and it is a common food for the Arabs.

Ragi *(Eleusine coracana;* Hindi-Marua, Telugu-Ragi, English-Finger millet) is a widely cultivated crop of the tropical and sub- tropical regions of the world. It is cultivated in Africa, India, Srilanka, Malaya, China and Japan. In India it is grown to an extent of 2,361 million hectares with a total production of 2.610 m.t. India's per hectare yields are 861 kg/ha. Among the states, Karnataka ranks first in area and production followed by Orissa and Andhra Pradesh.

Korra *(Setaria italica Beaur;* Telugu-Korra, English-Italian millet or Foxtail millet) is grown in many of the Asian, African and American countries, especially where the climatic hazards do not permit the cultivation of other cereals. It is mostly grown under dry farming conditions. It is cultivated in many parts of the country, but is mainly grown in Andhra Pradesh, Karnataka, Tamilnadu and Maharashtra states.

13.3. BAJRA

Bajra is a crop mostly grown in tropical and temperate regions. Important countries that grow bajra are China, India, Pakistan, Iran, Egypt, South West Africa and U.S.S.R.

In India, Bajra is grown in most of the states except in high rainfall areas like West Bengal, Assam and Orissa. In Rajastan, Maharashtra, Gujarat and Uttar Pradesh bajra is cultivated on large scale.

Andhra Pradesh ranks sixth in area and production. Bajra covers 4.5% of the total cropped area of Andhra Pradesh. It is primarily grown in Kharif as a rainfed crop. Among the different districts Nalgonda ranks first in area followed by Prakasam and Anantapur. Regarding production, Prakasam ranks first followed by Nalgonda and Visakhapatnam.

13.3.1. Climatic Requirement & Soils

Bajra is a rainfed crop and is mostly grown in areas where the annual rainfall is between 40 and 200cm. Moist weather is very useful during the vegetative growth of the crop. But at the time of flowering and grain formation there should be no rain and the weather should be clear and dry. Bajra is grown in those areas where it is not possible to grow jowar because of high temperature. The optimum temperature is 20-22^{o}C.

Bajra can be successfully cultivated in different types of soils. But it is grown generally in black cotton soils, alluvial soils and sandy loams. Generally a heavy soil is not suitable for Bajra cultivation. The soil must have good drainage facility because water stagnation is very harmful for this crop.

Varieties recommended

Variety	Season	Duration	Yield (t/ha)	Characters
BJ-104	Kharif, Rabi and Summer	85	25-40	This hybrid bajra grows to a height of 150-200cm wih 3-4 tillers per plant. Length of the earhead is 20-25cm. Grains are bold. Protein content is 10.3% and lysine is 2.8%. Resistant to downy mildew disease. Suitable for entire state both for rainfed and irrigated areas.
BK-560	-do-	80-90	30-35	It grows to a height of 215cm with 3-4 effective tillers. Earheads are long compact, rod shaped slightly tapering at both ends. Grains are bold and greyish-yellow in colour.
Vijaya composite	-do-	86-90	18	It grows to a height of 200cm with 2-3 effective tillers per plant. Earheads are long, compact and cylindrical. Grains are medium bold with grey colour to whitish grey. Recommended for all bajra growing areas of Andhra Pradesh.
Nagarjuna composite	Kharif	75-80	21	Plant height is 190cm. Earheads are long (28cm) and the grain is bold. Highly tolerant to downy mildew. Protein content is 13.3%. Recommended for low rainfall districts of Anantapur, Mahaboobnagar, Ranga Reddy, Guntur and Prakasham.
Visakha	Kharif and Summer	80-85	15-20	Plant height is 220cm with 2-3 effective tillers. Earheads are long (30cm). Cylindrical and compact. Grains are medium and grey in colour. Protein content is 10.7% suitable for Srikakulam, Vizianagaram and Visakhapatnam districts.
Balaji	Kharif	80	15-20	Plant height is medium (170cm). Earhead is long (29cm), cylindrical and compact. Grains are bold and light grey in colour. Protein content is 11.9%. Suitable for Chittore, Nellore and Cuddapah districts.

13.3.2. Seasons in Andhra Pradesh

There are two main seasons for Bajra cultivation.

1. **Kharif:** Bajra is mostly grown under rainfed conditions as a kharif crop in the state. The main sowing period is June-July and it extens up to August in some districts.
2. **Summer crop:** It is grown as an irrigated crop to a limited extent in few districts in the state. Summer sowings are generally done in the months of January-February.

13.3.3. Land Preparation

Bajra requires a fine seed bed free from clods as the seeds are very small. The land should be ploughed about 15m deep followed by working with cultivator and blade harrow for 2-3 times to obtain fine tilth. In the case of the irrigated crop the field is thrown into beds and irrigation channels are formed at regular intervals to irrigate the beds.

13.3.4. Seeds & Sowing

The seeds have to be treated with Thiram (250) or Agroson GN (400) before sowing for controlling seed borne diseases.

The spacing to be adopted is 45cm between rows and 12 to 15cm between plants. The seed should be dibbled 3 to 4 per hills at 15cm apart. When the crop is sown with a seed drill, excess seedlings have to be thinned at 15 days after sowing leaving a distance of 12-15cm between the plants. Gaps in the rows have to be filled with the thinned out seedlings to maintain optimum population. The recommended seed rate is 4kg/ha. Only certified seed should be used.

13.3.5. Transplantation

About 1/15 hectare of land is required to raise seedlings for transplanting in one hectare of main field. Raised seed beds are best to avoid water stagnation. About 2kg of bajra seed is required for one hectare. Seeds are sown on raised seed beds (12.0 x 7.50m) in rows of 10cm apart and at 1.25cm depth. The beds are frequently irrigated by sprinkling water. The seedlings are uprooted and transplanted after 25 days at a distance of 45cm from row to row and 15cm from plant to plant.

The seedlings are also planted in plough furrows when it is drizzling. The seedlings are dropped behind a country plough at regular intervals and they are automatically earthed up with the next plough furrows.

13.3.6. Manures and Fertilizers

For hybrid bajra or composite bajra, apply 2 tonnes of FYM as basal dressing before final ploughing and incorporate the same with a country plough. The following quantities of fertilizers have to be applied per hectare.

Fertilizer	Kg/ha	No.of doses	Stages
Rainfed			
Nitrogen	80	2	For direct seeded crops, half at sowing and remaining half 25-30 days after sowing, for transplanted crop half at the time of transplanting and remaining half 25 to 30 days after planting.
Phosphorus	30	1	At sowing or planting.
Potash	20	1	At sowing or planting.

Irrigated			
Nitrogen	100	2	1/2 at planting, 1/2 at 30 days after planting.
Phosphorus	50	1	At sowing or planting.
Potash	20	1	At sowing or planting.

Under conditions of drought with low soil moisture availability foliar application of urea (4%) as a part or whole off nutrient has been reported to be effective.

13.3.7. Intercultivation & Chemical Weed Control

The field is to be kept free of weeds. Intercultivation is done between rows twice or thrice with small blade harrows or by hand hoeing. This operation has to be completed during the third week after sowing or transplanting. The chemicals used, dosage, and the time of application of herbicides are given below.

The weeds can be controlled by using chemical herbicides also The herbicides that can be used, their dosage and the time of application are given below.

Herbicide	Dosage (kg a.i./ha)	Time of application
a) 2,4-D amine	1.2	Pre-emergence to crop and weeds
b) 2,4-D amine	0.9	Post-emergence 15 days after sowing.
c) Atrazine	0.375	Pre-emergence to crop and weeds.

13.3.8. Important Pests and Diseases on Bajra

A. PESTS

1. Blister beetle

Symptoms: Beetles attack inflorescence and feed on pollen and petals of flowers and thus seriously affecting grain setting.

Control. (a) Collection of beetles by handnets, (b) They may be attracted by light traps, (c) Spraying of chloripyriphos (2.5 ml/litre) or Methyl parathion (2 ml/litre) at the rate of 300 ml/acre.

B. DISEASES

1. Green ear disease or downy mildew *(Sclerospora graminicola)*

Symptoms: The disease occurs in two stages. The leaves show downy mildew stage and ears exhibit green ear stage. The infected plants produce more tillers and appear sick with pale and chlorotic and broad streaks extending from base to the tip of the leaf. Fine downy growth of the fungus may be observed below the streaks. With the advancement in disease the streaks turn brown and the leaf becomes shredded lengthwise. Most of the infected plants fail to produce healthy ears but give rise to green leaf-like structures.

Control: (a) Spraying of Dithane M-45 (2.5 g/litre) at the rate of 500 g/acre. (b) Growing resistant varieties like HB-5, PHB-10 and PHB-14.

2. Ergot *(Claviceps microcephala)*

Symptoms: The disease is evident at the time of flowering as small droplets of pinkish or light honey dew coloured fluid exceeding from the spikelets. These sclerotia replace ovary or gram and they are hard and contain several alkaloids. These alkaloids are responsible for poisoning in animals.

Control: (a) Use of clean seed by soaking the seed in salt solution and removing sclerotia, (b) Long rotation may be followed to avoid soil borne inoculum.

3. Smut *(Tolyposporium penicillariae)*

Symptoms: The disease is evident at the time of grain filling. Sori project clearly beyond the glumes and may be twice the diameter of grains. The affected grains are bright green to dark black on maturity.

Control: (a) Use of clean seed and removal of smutted ears, (b) Deep ploughing in hot weather to kill sclerotia, (c) Crop rotation.

4. Rust (Puccinia penniseti)

Symptoms: Uredosori occur is minute and round bodies in groups on both surfaces of the leaves, mostly towards the end of the blade, leaf sheath and stem.

Control: (a) Growing resistant varieties.

Check Your Progress - 1

What is the causal organism of smut disease of bajra? How do you control it?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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13.3.9. Irrigation

As bajra is a rainfed crop, there is hardly any need for irrigation. If monsoon fails, light and frequent irrigations should be given. Enough moisture should be present at the time of flowering and seed development.

Four to six irrigations are required to the crop grown in summer. The frequency of irrigation depends on the physical condition of the soil and weather conditions prevailing in a given area during the crop season. The crop may require irrigation once in 10 to 15 days. Excess water should be drained out in time.

13.3.10. Harvesting, Threshing & Yield

The crop generally matures in 85-90 days. The main shoots mature earlier than the tillers. The rainfed crop has a prolonged tillering phase and so the harvesting is done in two or three instalments at intervals of about a week. The irrigated crop is generally harvested in one instalment. The earheads are generally removed first by sickless and then the straw. The earheads are dried on a drying floor and threshing is done by stone rollers or by cattle. Machine threshing is also done to some extent. The grain has to be winnowed, cleaned and dried perfectly before storage.

Higher yields can be obtained with Bajra hybrids or composites than local varieties both under irrigated and rainfed conditions. The yield attributes are effective number of tillers, length of earheads, number of filled grains per earhead and thousand grain weight. Hybrids have better tillering ability which contributes for more grain yield.

The yield of grain is 800-1000 kg/ha under rainfed conditions. Under irrigated conditions improved varieties can yield 1500-2000 kg/ha. The yield of dry stalk is 3000-4000 kg/ha.

13.4. RAGI

In Area, Mahaboobnagar stands first followed by Visakhapatnam and Chittor while in production Anantapur ranks first followed by Chittor and Prakasam.

Ragi is mainly grown for the sake of grain. It is a favourite food of the hard toiling class and also very useful to persons suffering from diabetes. In South India the grains are malted and fed to infants also. It is a nutritive food for adults of different ages. Ragi stalk is considered to be a good fodder.

13.4.1. Seasons in Andhra Pradesh

Ragi is not a season-bound crop, so it can be grown throughout the year if water is available. There are three seasons in Andhra Pradesh.

Kharif *(May to August)*

In Srikakulam and Visakhapatnam districts, it is grown in 25% of the area as early crop with short duration (80-90 days) varieties from May to July before the planting of paddy in wetlands as 'Punasa Ragi' or 'Burada chodi'. AKP-2, is recommended.

Main Season or Pedda Panta *(July-August to November-December)*

The main season is Pedda Panta after the onset of monsoon. The varieties found suitable are VZM-2, Sarada (AKP-7) and C.R. 652 (Kalyani Ragi).

Rabi and Summer Seasons *(November-December to February-March)*

In the Rabi season it is grown as an irrigated crop known as 'Pyru Ragi' or 'Pyru Chodi'. As the crop is grown under assured irrigated conditions, the yields are high. VZM-2 Variety is recommended.

13.4.2. Climate

It is the only cereal crop thriving equally well both in the warm plains and in the cold hilly regions. It is grown where the rainfall ranges from 50cm to 90cm. The optimum temperature range is from 21^{o}-40^{o}C throughout the crop growth. In regions of higher rainfall and under irrigated conditions it can be grown as a transplanted crop.

13.4.3. Soils

It can be grown in light red loams and sandy loam soils of good fertility. Clayey soils or heavy black cotton soils are not suitable for this crop. Likewise gravelly and stony soils are also not suitable for this crop. It is moderately tolerant to alkalinity.

13.4.4. Recommended Varieties & Characters

Visakhapatnam and Srikakulam region	AKP-2, VZM-1, VZM-2, Sarada
Chittor, Cuddapah, Hyderabad	Kalyani (KR-652), H-1
Upland of East and West Godavari Dist	PR-202

The important varieties, their duration, yield etc are given below.

Variety	Duration (days)	Yield (Kg/ha)	Remarks
PR..202 (Godavari)	115-125	2900	Suitable for rainfed punasa and irrigated pyru. Grain are brown high stability of performance.
HPB-76	110	3000	A derivative from the cross between the varieties Hamsa and Purna. Heavy tillering, grains are brown, uniform maturity, height 88cm.
Shakti	120-Kharif 128-Rabi	1600-2000 (dry) 2500-3000 (irrigated)	Has tolerance to moisture stres, Good tillering with high synchronization, grains are reddish brown, bold and non shedding.
Kalyani (CR-652)	110-115	3500-4000	Suitable for Kharif and summer seasons. Seed is reddish brown, tillers 2-3 and 8-10 fingers per ear.
Sarada (AKP-7) AKP-2	112-120	3500	Tillers 3-4 and suitable for late Kharif.
AKP-2	85-90	2000-5000 (irrigated)	Used for Burada Chodi, Tillers 2-4 and 3-7 fingers/ear.
VZM-1	100	3000	Suitable for punasa season. Tillers 3-5 and 5-7 fingers/ear.
VRM-2	105-110	3500	Suitable for pyru, 3-5 tillers and 5-7 fingers/ear.
Hamsa	85-90	2200..(dry)..4000 (irrigated)	Good and synchronized tillering and high % of productive tillers.

13.4.5. Preparation of Land

Ragi requires fine tilth. The first ploughing is given just after the harvest of the preceeding crop. Generally preparation of land starts after the first shower of rain. Ploughing with mould board plough followed by harrowing and planking is necessary to make the land quite suitable for crop growth.

13.4.6. Sowing Methods

General methods of sowing are: (a) Broadcasting, (2) Drilling, (3) Dibbling of seeds, (4) Transplanting

Broadcasting: In drylands sowing is done by broadcasting and the seed is covered by working blade harrow. Seed rate for broadcasting method is 8-10 kg/ha.

Drilling: Seeds are drilled in shallow depths (1-1 1/2cm) by bullock drawn seed drills. This is generally practiced in Rayalaseema and Telangana regions. The seed rate is 6kg/ha.

Dibbling: Dibbling of seeds at 20cm row to row and 15cm plant to plant distance gives good results.

13.4.7. Transplantation

Transplanting of ragi is mostly practiced in areas where the crop is grown under assured irrigated conditions and in heavy rainfall areas. Seedlings are raised in special nurseries and thinnings from broadcast or drill sown field are also used. The seedlings are transplanted in line in beds or on ridges at the rate of 2 seedlings per hill. Nursery of 8-12 cents will be sufficient for one hectare of land. Seed rate is 4-6 kg/ha.

Age of Seedling: For transplantation should be 21 days for short duration varieties and 28 days for long duration varieties. Delay in transplanting reduces the yield.

Spacing generally depends on the duration. Season and variety. A spacing of 25 x 15cm for long duration varieties and a spacing of 15 x 10cm for short duration varieties is given.

13.4.8. Manures and Manuring

The crop responds to manuring although it is seldom given due recognition. Sheep penning at 3500-5000 sheep per hectare is also practiced.

Fertilizers schedule for local varieties is 45:22.5:22.5 and for improved varieties 90:45:45 kg NPK/ha. Nitrogen is applied in two splits i.e. 1/2 at planting and other half 21 days after planting.

Check Your Progress - 2

At what age do you transplant the seedlings of Ragi?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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13.4.9. Important Pests and Disease on Ragi

A. PESTS

1. Ragi Pink borer *(Sesamia inferens)*

Symptoms: The larvae immediately after hatching bore into the stem and feed on it resulting in the formation of 'dead hearts'. During flowering time the same larvae may cause 'white ears'. The larvae migrate from one plant to another and cause damage.

Control: (a) Apply carbofuran 3 G granules or Endosulfan 4 G granules in the central whorl at the rate of 8kg/ha, (b) Crop rotation.

2. Ragi cut worm *(Spodoptera exigrea)*

Symptoms: The larvae attack the nursery and main crop. The larvae feed on leaves voraciously and cause considerable damage.

Control: (a) Spraying chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre) at the rate of 300 ml/acre during evening or early mornings. (b) Making trenches and applying BHC to prevent migration of larvae from one field to another.

3. Ragi Thrips *(Heliothrips indicus)*

Symptoms: Nymphs and adults lacerate the leaf tissues and suck the sap resulting in the formation of silver glissery strips on the lower side of leaves. The leaves become brittle and the plants become stunted.

Control: (a) Spray Methyl dematon (2ml/litre) at the rate of 300 ml/acre or Dimethoate (1 ml/litre) at the rate of 250 ml/acre.

4. Ragi root aphid *(Tetranewra nigriabdominates)*

Symptoms: The plants are susceptible both in the nursery and the mainfield. Numerous pale green aphids attack the roots and suck the sap. In severe cases the plants die. Colonies of aphids may be seen when roots are observed.

Control: (a) Drench the soil with BHC 0.5% solution or Dimethoate (1 ml/1litre) at the rate of 300 ml/acre.

B. Diseases

1. Blast *(Pyricularia sp.)*

Symptoms: The lesions start as characteristic spindle shaped spots on the leaves with yellow margins and greyish green centres. Later the centre becomes grey or whitish grey. The plants are susceptible at all stages of crop growth. The fungus attacks the node and neck region of panicle causing node and neck blasts.

Control: (a) Spraying Edifenphos (1 ml/litre) at the rate of 250 ml/acre, (b) Judicious application of N-fertilizers.

2. Seedling blight or Foot rot *(Helminthosporium nodulosum)*

Symptoms: Light brown lesions appear on young seedlings. With the development of seedlings the lesions elongate and become dark brown. Several lesions may coalesce to form large patches and finally blighting occurs. Post emergence rot also is observed when basal portion of seedlings and roots is affected.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed controls seed borne infection, (b) Spraying Bavistin (1 g/litre) or Dithane M-45 (2.5 g/litre) at the rate of 250 and 500g respectively.

3. Wilt *(Sclerotium rolfsii)*

Symptoms: The basal portion of the stem and basal leaf sheath become water soaked and soft, which later turn brown and dark brown. The plants wilt with the advancement of the disease.

Control: (a) Crop rotation, (b) Good drainage.

4. Smut *(Melanopsichium eleusinis)*

Symptoms: The disease is clear only at the time of grain filling. Few sori are produced in the place of healthy grains. The sori are rounded, greenish to dirty black in colour 5-15mm in diameter.

Control: (a) Crop rotation, (b) Use of clean and healthy seed, (c) Growing resistant varieties.

5. Mosaic disease complex

The disease is caused by one or more viruses and one or more species of *Helminthosporium* and *Sclerotium rolfsii.*

Symptoms: The plants are susceptible to disease at all the stages. The initial symptom is chlorsis followed by severe stunting and mosaid mottling. The affected plants rarely flower and even if they flower, they will be completely chaffy. With the advancement of disease the plants wither prematurely and die.

Control: (a) Application of high doses of phosphatic fertilizes. (b) Spraying of Bavistin (1 g/litre) or Dithane M-45 (2.5 g/litre).

Check Your Progress - 3

Foot rot of Ragi is caused by______________________________________

Note: (a) Write the answer in the space given above.

(b) Compare your answer with the one given at the end.

13.4.10. Intercultivation & Irrigation

Two hoeings followed by hand weedings is the general practice. A row crop can be intercultivated with bullock drawn implements, like tyned guntaka.

The beds are irrigated on the 3rd day after transplanting and then once in a week regularly. In the case of good retentive soils like black clayey loams, the irrigations are given once in a fortnight. Adequate moisture is necessary at flowering and grain setting stages.

13.4.11. Harvesting & Yield

Irrigated ragi tillers freely and maturity is uneven as the main shoot ripens earlier than the tillers. Harvesting is generally done in two stages. Dry crops do not tiller much and the earheads mature more or less uniformly. The earheads are cut with sickles and then the straw is removed. The harvested earheads are heaped up for 3-4 days. During this period it undergoes slight fermentation. Heat also develops inside. This process is known as curing which helps the grain to separate easily from the night grip of the spikelets. Then the grains are separated by beating with sticks with manual labour or by using bullock drawn stone rollers or by machine threshing. The grains are winnowed and stored properly.

Yield	Grain	Straw
Rainfed crop	700-800	1100-1800 kg/ha
Irrigated	2300-3500	3500-5000 kg/ha

13.5. ·KORRA

The important setaria growing districts are Kurnool, Anantapur, Prakasam, Cuddapah and Mahabopbnagar. The grains are used for food. The dehusked grains are cooked and then utilized as cattle feed.

13.5.1. Climatic Requirement

Setaria is essentially a dryland crop and suited to conditions of low or moderate rainfall ranging from 400 to 600 mm. It is grown from mean sea level to 200 m and can be grown in the foot hills of the Himalayas. It can withstand weather, hot or cold.

13.5.2. Soils

The crop can come up on a variety of soils ranging from light red loams to black cotton soils. heavy and sticky soils seem to be well suited for the crop.

13.5.3. Seasons

Early crop	:	May-June-Srikakulam and Visakhapatnam.
Main crop	:	June-July-Other Coastal districts.
		July-Aug-Rayalaseema and Nellore
Late Crop	:	Aug-Sept.-As a mixed crop with Cotton in Rayalaseema.
Irrigated Crop	:	Dec.-Jan. to Feb. - March.

13.5.4. Recommended varieties

The important varieties, their duration, characters etc are given below.

Variety	Duration	Yield (Ka/hn)	Characters	Recommended areas.
Arjuna	90-95	1200-1600 (rain-fed) 2000 Irrigated)	Tall plant type (150 cm) shytillering (3-4/hill). Protein content is 12.5% suitable to irrigated and rainfed conditions. Semicompact panicle bulging in the middle and tapering at tip.	For Guntur and Ongole districts.
N-1	90	-do-	Same as above but having more tillers.	For Kurnool and Cuddapah.
H-1	80-85	1600 kg	Heavy tillering, 100-120 cm height, compact panicle with short hairs	All districts of Rayalaseema.
H-2	80-90	2000 kg	compact panicle with short hairs.	Black cotton soils of Rayalaseema.

13.5.5. Seeds & Sowing

A fine seed bed has to be prepared by repeated ploughings and harrowings. The weeds and stubbles of the previous crop are collected and removed from the field.

Spacing adopted is 25-30 cm between rows for drilled crops. Irrigated crop is generally sown by broadcast and then beds and channels are formed. The seed rate per hectare is 7-10 kg. Korra + cotton is a common mixture in Rayalaseema. It is also mixed with Ragi, Jowar, Castor and Pulses.

13.5.6. Intercultivation

One hoeing has to be given with bullock power using metal guntaka or Danti followed by hand weeding.

13.5.7. Manures and Fertilizers

Generally F.Y.M. or compost at the rate of 16-20 cart loads per hectare has to be applied at the time of land preparation. The recommended fertilizer dose for improved varieties is 40 kg N and 30 kg P_2O_5/ha. Full dose of phosphate and half of the amount of nitrogen has to be applied at sowing and the remaining half at tillering.

13.5.8. Important Diseases on Korra

1. Downy mildew or Green ear disease *(Sclerospora graminicola)* **Symptoms:** The terminal spindle does not unroll. It later becomes chlorotic and turns brown. The infected plants may not flower under severe conditions. In the cases of mild attack the floral parts are converted to green leafy structures.

Control: (a) Seed treatment with Ceresan or Thiram at the rate of 3 g/kg of seed, (b) Removal of affected plants.

2. Rust *(Uromyces setariae-italicae)*

Symptoms: On both surfaces of leaves numerous minute, brown uredosori appear initially. Sometimes they are arranged in linear rows and in severe infections they completely cover the entire blade.

Control: (a) Calixin (1 ml/litre) spray two times is effective.

3. Smut *(Ustilago crameri)*

Symptoms: The fungus attacks majority of the grains in the panicle and produces sori of 2 to 4 mm in diameter.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed. (b) Steeping the seed in 2% copper sulphate solution for 10 to 30 minutes.

13.5.9. Harvesting and Threshing

The earheads are harvested by sickles and removed to the threshing floor, where they are kept piled up for a few days and then threshed by bullocks or use of stone rollers.

Yield: The average yield of Korra is 600-800 kg/ha but under favourable conditions it may go upto 1500 kg/ha. The straw is thin and can be fed unchaffed to cattle.

Check Your Progress - 4

Downy Mildew of Korra is caused by ______________________________

Note: (a) Write the answer in the space given above.

(b) Compare your answer with the one given at the end.

13.6. SUMMARY

Bajra is more drought-tolerant among cereals and millets. Bajra is mostly grown in tropical and temperate regions and in India, it is grown in most of the states except in high rainfall areas. It is grown in areas where the annual rainfall is between 40 and 200 cm and the optimum temperature requirement is 20-28^{O}C. It can be grown both in Kharif, Rabi and summer seasons. The seed has to be treated with thiram or agrosan to avoid seed-borne diseases. It can be sown by dibbling, drilling and transplanting and the recommended seed rate is 4 kg/ha. Fertilizer requirement is 80 : 30 : 20 kg of NPK/ha for rainfed bajra and 100 : 50 : 20 kg of NPK/ha for irrigated bajra. Bajra crop matures in 85-95 days after sowing. The grain yield is 800-1000 kg/ha under rainfed and 1500-2000 kg/ha under irrigated conditions.

Ragi is very useful to persons suffering from diabetes and the grains are malted and fed to infants also. It can be grown in Kharif, Rabi and Summer seasons. it is the only cereal crop thriving equally well both in warm plains and in the cold hilly regions. It is moderately tolerant to alkalinity. General methods of sowing are broadcasting. drilling, dibbling and transplanting. The seed rate varies from 8-10 kg/ha under broadcasting to 4-6 kg/ha under transplanting. Spacing is 20 x 15 cm for long duration varieties and 15 x 10 cm for short duration varieties. Fertilizer schedule for local varieties is 45 : 22.5 : 22.5 kg of NPK/ha and for improved varieties 90 : 45 : 45 kg of NPK/ha. Grain yield is 700- 800 kg/ha under rainfed conditions and 2300-3500 kg/ha under irrigated conditions.

Korra is mostly grown under dry farming conditions. It can withstand both hot and cold weather. Heavy and sticky soils are well suited for this crop. Spacing adopted is 25-30 cm between solid rows. Seed rate is 7-10 kg/ha. Korra + Cotton is a common mixture. It is also mixed with Ragi, Jowar, Castor and Pulses. Recommended fertilizer dose for improved varieties is 40-30-0kg of NPK/ha. The average yield of Korra is 600-800 kg/ha but under favorable conditions it may go up to 1500 kg/ha.

13.7. CHECH YOUR PROGRESS : MODEL ANSWERS

1. The smut disease of bajra is caused by *Tolyposporium penicillariae*. It is controlled by the (a) use of clean seed and removal of smutted ears, (b) deep ploughing in hot weather and (c) crop rotation.
2. For transplantation the age of the seedlings of Ragi should be 21 days for short duration varieties and 28 days for long duration varieties.
3. *Helminthosporium nodulosum.*
4. *Sclerospora graminicola*

13.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the soil, climatic requirements and sowing seasons of Bajra, Ragi and Korra.
2. Write in brief about the sowing methods and recommended varieties of Ragi for different regions of A.P.
3. Explain the symptoms of important diseases on Bajra with control measures.
4. Discuss in brief the Package practices of Korra crop.

II. Answer the following questions in 10 lines.

1. Give seed rate, spacing and manurial and fertilizer schedules for rainfed and irrigated crop of Bajra.
2. Describe any two hybrids and composites of Bajra with reference to their duration of sowing season, resistance to pest and diseases and yield potentials.
3. Give a brief account of control measures of important pests of Ragi.
4. Mention the symptoms caused by important diseases of Ragi.

UNIT - 14: GROUNDNUT

Contents

14.1. OBJECTIVES

By the end of this unit you will be able to:

1. describe the climatic requirement for groundnut,
2. suggest the type of soils required and seasons for groundnut,
3. list out the crops used in crop rotation and intercropping in groundnut fields,
4. describe the method of field preparation, seed inoculation & sowing of seeds,
5. suggest the manures and fertilisers required, and describe the method of intercultivation,
6. describe the method of harvesting and threshing,
7. list out the pests and diseases of groundnut & suggest the control measures.

14.2. INTRODUCTION

Groundnut is the leading oil seed crop of India in terms of area (46.72%) and production (67.27%). Groundnut is primarily grown for oil purpose and is used for cooking. It contains about 45% oil and 26% or protein. Kernels are also consumed as raw or in roasted form. It is also good source of all B Vitamins except B 12 and vit. E. Oil cake can also be used as organic manure or as animal feed and contains 7.8% Nitrogen.

In India it is mainly grown in Gujarat, Andhra Pradesh, Tamilnadu, Maharashtra and Karnataka and accounts for nearly 50% of the area and 64% of production.

During the last 50 years the area under Groundnut has increased by 146% and production by 96% but the productivity has declined by 20%.

Average yields in India under rainfed and irrigated condition are about 876 kg/ha and 1546 kg/ha respectively where as in Israel it is 5784 kg/ha. There is great instability in production and productivity.

In Andhra Pradesh it is cultivated in about 14 lakh hectares in all the 3 regions with total production of about 12 lakh tonnes. Ananthapur has the highest area followed by Chittoor, Kurnool, Mahaboobnagar etc.

14.3. CLIMATIC REQUIREMENT

It is essentially a tropical plant and requires long and warm growing season. It requires 50 cm to 100 cm of well distributed rainfall. The optimum temperatures for vegetative growth period is between 27^{o}-30^{o}C and for reproductive growth it is between 24^{o} to 27^{o}C. Constant temperature above 33^{o}C at the reproductive phase has adverse effect. Similarly the top soil temperature of less than 18^{o}C affects the germination. Rabi groundnut is raised on limited area where night temperature do not go below 15^{o}C. Southern States are most suitable for rabi crop.

14.4. SOIL

Groundnut thrives best in well drained sandy and sandy loam soil as the light soil helps easy penetration of pegs. Clay or heavy soils are not suitable as they interfere in the penetration of pegs and harvesting becomes difficult. Often yields are limited by the physical condition of the soil. After flowers are fertilized, peg is formed and this has to penetrate the soil upto a depth of 5 cm where pod development takes place. Peg penetration is influenced by the soil condition at the surface and pod development depends on the soil conditions surrounding it. In rainfed groundnut, when there are prolonged dry spells between two rains, the sandy clay loam soil becomes hard due to loss of moisture and compaction of the soil takes place. When the soil strength exceeds 3 bars, peg penetration is hindered. When the bulk density of the soil increases beyond 1.5 g/cc, pod development is hindered. Application of powdered groundnut shells to the soil at 5T/ha or FYM at 10 T/ha or Gypsum at 1 T/ha improves the soil physical condition.

Ill drained saline soils are not suitable. Salinity upto 3200 micromhos/cm will not affect the yields but 4700 mm/cm will reduce the yield by 50%, whereas at 6500 micromhos/cm no yield will be obtained. Soils containing high clay content with more than 5% Na, more than 8pH and $CaCO_3$ more than 4% are not suitable for groundnut cultivation.

14.5. SEASON

The rainfall, temperature and soil nutrients, pests and diseases are major factors which limits yield. Due to varied climatic conditions in our country, the seasons vary considerably.

1. Kharif:

About 90% of the area in India is under rainfed condition and sowings are taken from May to July depending upon the rains.

The onset of S.W. monsoon (rainfall) determines the actual item of sowing of rainfed crop. The optimum time for sowing groundnut in different states is given below.

1. Andhra Pradesh

   (a) Telangana and Coastal region : First fortnight of June.

   (b) Rayalaseema region : Middle of June to first week of July.

2. Gujarat : 15th June to 1st week of July.
3. Karnataka : (a) Bunch varieties 1st week of June.
(b) Spreading: From last week of June to end of July.
4. Maharashtra : Last week of June to first week of July.
5. Punjab : 20th June to 10th July.
6. Tamilnadu : (a) Pollachi Tract (Coimbatore Dist) : April.
(b) Rest of the State : First fortnight of July.

2. Rabi/Summer

Temperature is an important factor in cultivating the Rabi/Summer groundnut. If the temperature of the top 10 cm soil is less than 18^{o}C and night temperature goes below 15^{o}C emergences of seedling will be slow and crop stand will be poor. Hence rabi/summer groundnut is cultivated only in the stages like Tamilnadu, Andhra Pradesh, Karnataka, Orissa, Maharashtra, and Gujarat where temperatures are favourable and the winter is not severe. Rabi crop is normally taken from September onwards on residual moisture in rice fallows. Some time 2-3 irrigations are also given at later stages when winter rains are scanty. Summer groundnut is taken only under assured irrigation and sowings are taken from December to January in Andhra Pradesh, Tamilnadu, Karnataka and Orissa where as in Maharashtra and Gujarat the sowings are taken up from 2nd fortnight of January to 1st fortnight of February. Actual sowing times of Rabi/Summer Groundnut are given below.

1. Andhra Pradesh
   (a) Telangana : Last week of September to middle of October.
   (b) Coastal Andhra Pradesh in rice fallows: Middle of November to last week of December.
   (c) Rayalaseema.
   Kurnool and Mahaboobnagar: Middle of December to early January.
2. Karnataka
   (a) Raichur area - Middle of November to third week of December.
   (b) Dharwar - Dec. to 1st week of January.
3. Maharashtra
   (a) Marathwada region - Middle of January to Third week of February.
   (b) Vidharba : Middle of Nov. to Early December.
4. Tamilnadu : Middle of Dec. to Early January.
5. Gujarat : Last week of January.
6. Orissa (coastal district) : October-November, January to early February.

14.6. CROP ROTATION AND INTERCROPPING

Generally *Kharif* groundnut is sown year after year under rainfed condition. In certain areas where late rains are received or winter rains are sufficient or irrigation facilities are available groundnut is followed by rabi crops viz., wheat, jowar, barley, bengal gram, safflower, sesamum, linseed, rapeseed, mustard, onion and potato. The second crop of groundnut during Rabi/Summer is also taken after cotton, cowpea and soyabean. Under intercropping by appropriate row arrangements it can be profitably grown along with redgram, cotton, castor, tapioca, the long duration crops, while short duration crops are sesamum, sunflower, cowpea, greengram and blackgram. The intercrops suggested for different states is given below.

Intercropping system

1. Groundnut + Redgram	5:1 or 7:1 or 10:1
Groundnut + Bajra	5:1
Groundnut + Cowpea	6:1
Groundnut + Castor	5:1
Groundnut + Greengram	3:1, or 5:1

Table 14.1. Crop Rotation for different regions of Andhra Pradesh

Region	Rainfed (Two year mono-cropping)	Residual moisture (Double cropping one year)	Irrigated (Double cropping one year)
1. Telangana	G.nut-Jowar	Groundnut-Bengalgram	Groundnut-Maize
	G.nut-Maize	G.nut-Saff	G.nut-Onion
2. Rayalaseema	G.nut-Jowar (R)	G.nut-Safflower	G.nut-Maize
	G.nut-Korra G.nut-Tobacco G.nut-Bajra		
3. Coastal (A.P.)	G.nut-Ragi G.nut-Bajra	G.nut-Sesamum (Rabi)	G.nut-Sesamum (Rabi)

Bajra = Pearlmillet, Ragi = Finger millet.

Korra = Italian millet, Jowar = Sorghum.

All the cultivated groundnut varieties belong to varieties of *hypogea* and *vulgaris*. The groundnut belongs to the leguminoseae family.

It is an annual plant grows from 30 to 60 centimetres height.

14.7. VARIETIES

If improved varieties are used the yield increase will be by 20% over local. The improved varieties recommended for different states are as follows (Kharif).

1. Andhra Pradesh : K-1, K-2, K-3, TMV-2, J-11, JL-24, M-13, TMV- 10, Spanish improved.
2. Tamilnadu : TMV-1, TMV-2, TMV-3, TMV-4, TMV-7, TMV-8, TMV-10, TMV-11, TMV-12, POL-1, POL-2, Co-1, and Co-2.
3. Karnataka : Spanish Improved, S-206, S-230, Dh-3-30, KRG-1.
4. Maharashtra : AK 12-24, SB XI, TG-1, JL-24, TG-17, Kopergan-1, Kopergan-3, Karad 4-11.
5. Gujarat L : J-11, GAUG-1, GAUG-10.
6. Punjab: PG-1, C-501, M-145, M-13, M-37, M-197.

Varieties Recommended for Rabi/Summer

1. Andhra Pradesh : TMV-12, J-11, K-3.
2. Tamilnadu : TMV-2, TMV-7, POL-2, and Co-1.
3. Karnataka : S-206, Dh-3-30, Spanish improved, TMV-2, KRG-1.

4. Orissa : AK 12-24, Kissan.
5. Gujarat : J-11, GAUG-1, and GG-2.
6. Maharashtra : AK 12-24, Karad 4-11, UF 70-103.

Some of the important varieties, their durattion, yield and characters are given in the Table-14.2.

14.8. FIELD PREPARATION

For Kharif groundnut land should be prepared thoroughly with receipt of summer showers. This will help in sowing the crop early. Deep ploughing should be avoided because deep ploughing encourages development of pods in deeper layers of soil which makes harvesting difficult. One ploughing with mould board plough followed by two harrowings would be sufficient to achieve good tilth. One of two summer cultivations reduce the weed problem. Groundnut requires fine tilth.

14.9. SEED INOCULATION

Inoculation of Groundnut seed with efficient strains of N fixing bacteria is recommended for areas where Groundnut is not previously grown. Response to inoculation in traditional Groundnut area is not obtained. Inoculation of seed with *Rhizobium* can be done by any of the following methods.

1. Slurry method : Slurry of 5% jaggery is prepared by dissolving 5 g of jaggery in 95 ml of water. For 100 kg seeds about 800 ml slurry is needed. 200 grams of peat based *Rhizobium* culture is added to the cold slurry. Seeds are evenly spread on slab and inoculation slurry is spread on the seed uniformly without rupturing the seed coat. After inoculation the seeds are dried under shade and used for sowing.

2. Pelleting : About 200 g of peat based culture is added to 800 ml of 5% cold jaggery slurry. This mixed slurry is coated uniformly over seeds. When the seeds are still wet, the seed is further treated with 200 g of finely powdered calcium carbonate to get uniform coating. Pelleted seeds can be dried in shade and used

3. Trickle method : About 400 g of peat based *Rhizobium* culture is suspended in 50 litres of water and suspension is trickled into seed row using a hopper and bamboo tube. About 50 litres will be adequate per hactare. Suspension can also be trickled through tap fitted to plastic bucket.

14.10. SEEDS AND SOWING

Bold and well filled pods should be selected and shelling can be done by hand or power operated decordicator. Shelling must be done preferably just before sowing as the viability is lost faster and are attacked by store grain pest due to storing for long time. Small, shrivelled, damaged and broken kernels should not be used. Before sowing, the seeds should be treated with Thiram at the rate of 3 g/kg or Bhavistin at the rate of 2 g/kg. Kernels retained in 5 mm sieve may be used for sowing.

Table-14.2: Characters of different varieties of Groundnut.

Variety	Season	Duration	Yield (t/ha)	Characters
Kadiri-1	Rainfed	130-135	15 Pods	Suitable for Kharif season in dist. of Anantapur, Cuddapah, Kurnool, M.Nagar, V.Patnam and Vizianagaram. Pods are mostly 2 seeded and slightly beaked with shallow construction. The shelling out turn is about 75% and oil content in 49%.
Kadiri-2	Rainfed	130-135	15 Pods	A Virginia bunch type with semi-spreading habit; shelling out turn is 74% and oil contents 46%. Suitable for parts of Chittor, Cuddapah, Vizianagaram and Srikakulam districts in Kharif.
Kadiri-3	Kharif....and Rabi	100-110	17 Pods	A Virginia runner group with spreading habit. Duration extends by 15 days when grown as an irrigated crop. Shelling out turn is 74% and oil content 48%. Suitable for entire state of Andhra Pradesh.
M-13	Kharif	135	17 Pods	A Virginia runner group with spreading habit. Shelling out turn is 74% and oil content is 49%. A bold seeded variety but the quality of kernels will be adversely affected in prolonged dry spells. Suitable for Srikakulam, Vizianagaram, Visakhapatnam and parts of Kurnool and Mahaboobnagar districts.
TMV-10	Kharif	125 days	15 Pods	Virginia bunch group with semi-spreading habit. Shelling out turn is 74% and oil content is 50%. Sensitive to moisture stress. Suitable for Srikakulam, Chittoor, Vizianagaram and Visakhapatnam districts.
Spanish Improved	Kharif Rabi	105-110 115-110	11 pods (30 under irriga)	Belongs to spanish group with bunch type of growth habit, shelling out turn is 74% and oil content 50%. Fresh dormancy is absent. Suitable for Karimnagar, Adilabad, Khammam, Nalgonda, Nizamabad and M.Nagar dist.
TMV-2	Kharif Rabi	105-110 115-120	13..pods..(35 in..case..of irrigated)	Belongs to spanish group with bunch type of growth habit. Shelling out turn is 75% and oil content is 49%. Fresh seed dormancy is absent. Suitable for entire A.P.
J-11	Kharif Rabi	105-110 115-120	15..pods..(37 under irriga.)	Shelling out turn is 74% and oil content 49%. Bunch type of growth habit. It lacks fresh seed dormancy and tolerant to *Aspergillus flavus* and does not develop aflatoxin even if moist condition exists in the soil at the time of harvest.

14.11. PLANT POPULATION (SPACING)

Generally for bunch types 30 cm x 10 cm (100-110 kg seeds/ha and plant population of 3.33 lakhs/ha) and for semispreading and spreading types 30 cm x 15 cm (95 - 100 kg/ha seed and plant population of 2.22 lakhs/ha) spacing recommended for rainfed groundnut. The spacing between row depends on rainfall, soil type, fertility, variety, and cultural practices adopted. Considering all these optimum spacing recommended for groundnut in different states is as follows for rainfed condition.

State	Bunch varieties	Semi-spreading/ Spreading varieties
Andhra Pradesh	30 x 8/10 CM	30 x 15 CM
Gujarat	45 x 10 cm	60 x 10 cm
Karnataka	30 x 10 cm	45 x 15 cm
Maharashtra	30 x 8/10 cm	45 x 15 cm
Punjab		30 x 22.5 cm
Tamilnadu		
(a) Tindivanum region	30 x 8	30 x 20 cm (R and I)
(b) Aliyarnagar region	15 x 15 cm (rainfed)	
	30 x 10 cm (Irrigated)	22.5 x 15 cm

For irrigated condition bunch type or semi-spreading types are only suitable and the optimum plant population is 4.44 lakhs/ha with a spacing of 22.5 x 10 cm. To achieve this 140-150 kg of seeds per hactare is recommended. Seeds can be drilled with improved seed drill or behind country plough. Seeds should be sown 5-7 cm depth in light soils and 4-5 cm in heavy soils.

14.12. MANURES AND FERTILIZERS

Application of FYM at the rate of 10 T/ha improves the physical condition of the soil besides supplying nutrients. Varieties differ in their response to plant nutrients. Balanced fertilization has been found to be beneficial. The optimum dose for rainfed groundnut in general is 20-25 kg N/ha and 20-40 kg P_2O_5 /ha. When potash is deficient, 20-40 kg K_2O/ha is applied. The recommendations for different states are given below.

State	Rainfed (Kg/ha)			Irrigated (Kg/ha)		
	N	P	K	N	P	K
Andhra Pradesh	20	40	20	30	60	45
Gujarat	12.5	25	0	25	50	0
Karnataka	15	30	25	25	75	25
Maharastra	20	40	0	-	-	-
Punjab	15	40	25	8	26	24
Tamilnadu						
a. Aliyarnagar region	11	22	33	22	44	66
b. Tindivanum region	10	20	45	10	10	75

Response to P_2O_5 is not obtained unless the soil available P_2O_5 is less than 35 kg/ha. Single super phosphate is the best source of P fertilizer as it contains 19.5% Ca and 12.5% sulphur besides 16% P_2O_5. Nitrogenous fertilizer can be applied into doses.

Calcium deficiency leads to pops. Sulphur is directly involved in bio-synthesis of oil. Since the developing pegs and pods take up Ca and S from the soil in the pod zone, about 500 kg/ha Gypsum which is the cheapest source of calcium and sulphur, has to be placed in the pod zone at the time of first bloom. Zinc deficiency is common in sandy soils and can be corrected by the application of 50 kg/ha of zinc sulphate to the soil once in two years. The critical limits of calcium and sulphur are, 2 meq/100 g of soil and 10 ppm respectively in the pod zone (0-5 cm depth of soil). If the soil test values indicate less than the limits, application of gypsum becomes necessary. Gypsum contain 24% calcium and 18.6% sulphur. The zinc should be applied wherever the zinc in the soil is less than 0.6 ppm. Zinc can be applied in the form of zinc sulphate mentioned above or foliar application of zinc sulphate at the rate of 0.2%.

Iron chlorosis is a problem in most of the black soils which have high calcium content, and in soils with high pH (above 7.5). The deficiency of iron can be corrected by spraying 1% ferrous sulphate plus 1% ammonium citrate. The threshold value for boran is 0.25 ppm. The deficiency can be corrected by the application of 5-10 kg/ha of Borax depending upon the extent of deficiency to the soil, or by spraying 0.2% borax on the crop.

Apply all phosphorous, potassium and half of nitrogen as basal dose and incorporate into the soil before sowing. The remaining half of N may be applied 35-40 days after sowing if the nodulation is poor. The potassium should be applied when the soil has less than 150 kg K_2O/ha.

14.13. INTERCULTIVATION

It is necessary to control weeds effectively upto 45 days after sowing as maximum damage is caused during this period. Inter- cultivation has to be started early after germination of groundnut seed. Inter-cultivation with bullock drawn implements is cheaper. Star weeder can be worked if rows are narrower. Where-ever labour is expensive or not available, spraying herbicide followed by one hand hoeing on 40th day after sowing effectively control weeds. Basalin, nitrofen, fluchoralin, Goal are the herbicides that are recommended to control the weeds in groundnut.

Herbicides	Dose a.i. kg/ha	Time of application
1. Fluchloralin	1.25 - 1.50	Pre - sowing soil incorporation.
2. Nitrofen	1.5 - 2.0	Pre - emergence to crop and Weeds.
3. Pendimethaline	1.0 - 1.5	Pre - emergence to crop and Weeds.
4. Alachlor	1.5 - 2.0	Pre - emergence to crop and Weeds.
5. Oxyflurofen	0.25 - 0.50	Pre - emergence to crop and Weeds.
6. Fusilade	0.25 - 0.5	Post-emergence to crop and weeds. Effectively controls only monocot Weeds except *Cyperus rotundus*.

14.14. WATER MANAGEMENT

The moisture stress at critical stages of plant growth such as peak flowering, peg formation, peg penetration and pod development reduces the yield considerably. Life saving irrigation in *Kharif* season had increased the yield ranging from 30 to 60%.

Groundnut crop requires on an average 400-450 mm of water. Normally 9-10 irrigations are required to get a good crop. It is always better to give a pre - sowing irrigation and then sow the seed under optimum moisture conditions. After sowing the seed, irrigation is normally avoided as the soil becomes hard and encrustation of the soil will affect the germination. Hence only in extraordinary circumstances when the moisture is not sufficient for the seed to germinate then only light irrigation can be given. Normally after the germination of the seed no irrigations are given immediately to keep the crop under mild stress in the initial stages upto 21 days. The second irrigation will be given after observing the first flowers. This is the most critical period as flowering and peg penetration will occur only after 21 days. Irrigation is scheduled at weekly intervals upto pod development and kernel formation. Afterwards irrigations may be given once in 12-15 days. Irrigation may be stopped 10 to 15 days prior to harvesting depending on the soil and season. However, a light irrigation may be required to harvest the crop to reduce pod loss in the soils and facilitate easy harvest.

Border strip method of irrigation is most suitable for this crop. Excessive irrigation should be avoided as poor drainage may cause chlorosis in the crop. Irrigation water should be of good quality having electrical conductivity less than 4m mhos and residual sodium carbonate less than 2 milli. Wq./lit.

14.15. HARVESTING AND THRESHING

The bunch varieties mature in about 110-115 days, spreading and semi-spreading in 125-135 days. The crop harvested when 75% of the total pods are matured. The maturity of the pods are judged by the development of prominent net work of reticulation on the pods, and blackish coloration on the inner side of the shell. The testa of the seed will have pinkish coloration at maturity. Harvesting too early (before maturity) reduces the yield, quality and there are more chances of damage from *Aspergillus*. Delay in harvesting will result in stem rot and weakening of pegs, thus many pods may be left in the soil. The pods of the bunch types which are non dormant may germinate on plant it self, if not harvested in time. The bunch and semi-spreading types are usually harvested by hand pulling when there is sufficient moisture. The spreading types are harvested by working a blade harrow or a country plough. The harvested plants are stacked for few days for drying and pods are stripped afterwards. The produce is dried as quickly as possible to bring down the moisture to less than 8%. Higher moisture content is congenial for production of afflatoxin caused by yellow mould. After drying, the pods may be stored in gunny bags.

Yield

Rainfed : 1500 - 2000 kg/ha

Irrigated : 2000 - 3000 kg/ha

Check Your Progress - 1

What are the different methods of inoculation of *Rhizobium* to the seeds of Groundnut?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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14.16. IMPORTANT PESTS AND DISEASES ON GROUNDNUT

A. Pests

1. Red hairy caterpillar *(Amsact albistriga and A. moorei)*

Symptoms : The larvae feed gregariously by scrapping the tender surface of leaflets leaving the upper epidermal layer intact. With age they feed on leaves and leave the petioles and midrib. The caterpillars may be seen marching from one field to another in thousands. It is a very serious pest.

Control: (a) Egg masses should be collected and destroyed. (b) Deep ploughing during summer helps in killing pupae. (c) Spraying of chloripyriphos (2.5 ml/lit) or Monocrotophos (1.5 ml/litre) during night times helps in the control of the pest. (d) Make trenches around the field and apply BHC.

2. Leaf miner *(Aproacroma modicella)*

Symptoms: The larvae mines into tender leaflets or webs or the adjacent leaf lets together and feeds on the tissue. The leaflets get distorted and slowly dries up.

Control: spraying Quinolphos (2 ml/lit) or Monocrotophos (1.5 ml/lit) at the rate of 300 ml/acre.

3. Tobacco caterpillar *(Spodoptera litura)*

Symptoms: The larvae feed voraciously on the leaves leaving behind only stems and midrib. In severe cases the field presents an appearance of grazed field. The larvae feeds mainly during night times.

Control: (a) Spraying with chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre) at the rate of 300 ml/acre during night times (b) Making trenches around the field and applying carbaryl or BHC dust. (c) Arranging pheramone trap for monitoring the population.

4. Root grub *(Holotrichia consanguinea and H. insularis)*

Symptoms: The root grub feeds mainly on roots and causes extensive damage. The infested plants exhibit withering conditions. The grubs feed on nodules, fine rootlets and girdle of the main root, ultimately killing the plants.

Control: (a) Application of phorate granules at the rate of 2.25 a.i. kg/ha in endemic areas. (b) Summer ploughing to expose the eggs and grubs. (c) Spray the alternate host plants with chloriphos or Monocrotopyriphos.

5. The lab-lab aphid *(Aphis craccivora)*

Symptoms: The tender shoots are infested by aphids. Both adults and nymphs suck the sap and cause curling of leaves. Plants become stunted and flowers and pods are affected in severe cases. The aphids transmit groundnut rosette virus and groundnut stunt virus.

Control: (a) Spray Monocrotophos (1.5 ml/lit) or Dimethoate (1 ml/lit) or phosphomidon (1 ml/litre).

6. Pod borer *(Elasmolomus sordidus)*

Symptoms: The pest sucks the sap of groundnut pods both in the field and in storage. As a result of sucking, the seed gets shrivelled. The shrivelled grains give less oil recovery and poor germination.

Control: (a) Hoe with carbaryl 10%.

B. Diseases

1. Tikka disease or leaf spot *(Cercospora personata and C. arachidicola)*

Symptoms: The two fungi produces different types of lesions which vary in size, shape and colour. *C. personata* produces small, dark spots which enlarge to about 4 to 6 mm in diameter. Under favourable conditions they coalesce and form dark brown to black patches. The lesions mostly occur on leaf blade but may occur on petioles and stem also. The brown spots are to surrounded by yellow halo. The lesions caused by C. *arachidicola* are irregular to circular, bigger than those caused by C. *personata*. The lesions are surrounded by bright yellow, circular halo with dark brown center.

Control: (a) Spraying of Dithane M-45 (2.5 g/litre) or Bavistin (1 g/lit). (b) Seed treatment with Agrosan GN at the rate of 3 g/kg of seed. (c) Deep ploughing in summer (d) Burning of plant debris to avoid soil borne inoculum.

2. Rust *(Puccinia arachidis)*

Symptoms: The initial symptoms appear as orange red pustules on both surfaces of leaves. Red brown uredospores are produced within 48 hours and spread rapidly by wind under favourable conditions resulting in defoliation and death of the crop. The leaf tissue around infection sites dies and dries out in irregular patches.

Control: (a) Spray Dithane M-45 (2.5 g/litre) or Calixin (1 ml/litre).

3. Crownrot or Collar rot *(Aspergillus niger and A. pulverulentum)*

Symptoms: The seed can be attacked at any stage after sowing since the causal pathogen is soil - borne. Pre-emergence rots cause decrease in germination. The first symptom in emerged seedlings is a rapid wilting of the whole plant.

Control : (a) Seed treatment with Dithane M 45 at the rate of 3 g/kg of seed. (b) Deep ploughing during summer to kill the spores.

4. Stem rot or wilt *(Sclerotium rolfsii)*

Symptoms: The symptoms are characterised by the development of white fungal growth on the affected plant. Young plants may be completely girdled and killed in severe cases. The affected plants may be covered by a net of fungal threads. The leaves turn yellow, then brown and later desiccate and fall.

Control: (a) Seed treatment with Dithane M-45 at the rate of 3 g/kg of seed. (b) Crop rotation.

5. Chlorotic Rosette virus *(Vector : Aphis craccivora)*

Symptoms: Faint motling of the youngest leaf lets which may be accompanied by veinal chlorosis is the initial symptom. The next leaf to open is pale chlorotic and subsequent leaves may be completely chlorotic or may show mosaic pattern of dark green patches on chlorotic leaflets. The later leaves are slightly reduced in size and usually have distorted leaflets. The petiole and rachis are shortened and the axis of the plant ceases to grow making the plant rosetted. Infected plants flower, but the pegs usually do not elongate or bear seed.

Control: (a) Control of insect carriers, *Aphis craccivora*, by spraying Monocrotophos or Dimethoate or Phosphomidon at the rate of 1.5 ml/litre. (b) Early planting and close spacing may be followed.

Check Your Progress - 2, 3 & 4

2. Tikka disease of groundnut is caused by ______________________________

3. The Scientific name of Tobacco caterpillar is ______________________________

4. How do you control the wilt of groundnut?

Note: a) Write your answers in the spaces given above & below.

b) Compare your answers with those given at the end.

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14.17. SUMMARY

Groundnut is one of the most important oil seed crops of India with an area of 47% and producing 67% of the total oil seed crops. Area and total production has gone up in recent years but productivity has declined. As 90% of the crop is grown in *Kharif* under rainfed conditions which is erratic productivity is very low compared to the other countries. Groundnut is mainly cultivated for getting oil and it contains about 45% of oil. The oil cake is also used as animal feed and manure. Groundnut is mostly grown in Andhra Pradesh, Gujarat, Karnataka, Tamilnadu, Maharashtra which means nearly 80% of the total area. Commonly cultivated groundnut varieties belong to spanish bunch and virginia (spreading and semi spreading) group. This crop comes up well on sandy loam soil and can not come up well on heavy black soils. Crop can be grown in three seasons, *kharif, Rabi* and *Summer*. *Rabi* crop is taken on residual moisture in rice fallows or as on irrigated, summer crop is invariably cultivated under assured irrigation. A large number of varieties have been released recently in Andhra Pradesh viz., K-1, K-2, K-3, J-11, JL-24. For *Kharif* and *Rabi*, different varieties are available. Onset of the monsoon for rainfed, October-November for *Rabi* and December - January for *Summer* crop is the best time for sowing. A spacing of 30 cm x 10 cm for bunch, 30 cm x 15 cm for spreading is optimum under rainfed conditions whereas for irrigated crop condition 22.5 cm x 10 cm is found to be the best. For rainfed condition 20 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha and for irrigated 25 to 30 kg N, 50-60 kg P_2O_5 and about 40 kg K_2O/ha was found to be optimum. Groundnut also requires micronutrients especially Ca, Zn, S etc. Ca deficiency leads to pops. Gypsum is the best source to supply both calcium and sulphur. A quantity of 300 to 500 kg Gypsum is recommended to be applied in the pod forming zone of the crop. The crop is very susceptible for weed competition keeping the field weed free upto 45 days from sowing and also in loose condition is necessary. Herbicides are found to be very effective in controlling the weeds viz., Pendimethalin, Fluchloraline etc. The crop requires on an average 400 - 450 mm of water to obtain the optimum yield. The average yield of groundnut is 15-20 and 20-30 q/per hectare under rainfed and irrigated conditions respectively. The yields are always more in Rabi/Summer than in Kharif. Inoculation with efficient strains of Nitrogen fixing bacteria will be helpful in increasing the yield. Trickle method of innoculation was found to be more efficient than the other two methods. The important diseases in groundnut are, leaf spot, rust, collar rot and bud necrosis. Similarly a number of fungi cause pre- and post-emergence rotting of seeds and seedlings. The major pests causing considerable yield losses are leaf miner, white grub, red hairy caterpillar, aphids, jassids, thrips and white flies.

14.18. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The inoculation of *Rhizobium* to the seeds of Groundnut is done by slurry, pelleting and trickle methods.
2. *Cerocospora personata* and C. *arachidicola*.
3. *Spodoptera litura*
4. Wilt of groundnut can be controlled by treating the seed with Dithane - M45 or by crop rotation.

14.19. MODEL EXAMINATION EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write in brief about seasons and time of sowing of groundnut.
2. Give an account of crop rotations for different regions of A.P. and mention about the intercropping system in Groundnut.
3. Write the manure and fertilizer recommendations to Groundnut in different states.
4. Discuss in brief water management aspects in Groundnut.
5. Write in detail about seed inoculation.
6. What are the reasons for low yield of groundnut? Discuss.

II. Answer the following questions in about 10 lines each.

1. List out the Groundnut varieties that are recommended for A.P.
2. Write a brief note on herbicides used in Groundnut.
3. List out the important pests of groundnut and recommended any one insecticide to control each one.
4. What are the important diseases of Groundnut?
5. Write a note on Rabi/Summer groundnut cultivation.
6. What are the spacings that are recommended in different soils in Groundnut?
7. How do you rectify the Ca deficiency?
8. Write a brief note on intercultivation practices in Groundnut.
9. Write the soil requirement of Groundnut crop.

UNIT - 15: CASTOR AND SESAMUM

Contents

15.1. OBJECTIVES

By the end of this you will be able to :

1. describe the climatic and soil requirements for Castor and Sesamum,
2. List out the important varieties of Castor and Sesamum,
3. describe the method of field preparation and sowing of seeds of Castor and Sesamum,
4. list out the manures and fertilizers required for Castor and Sesamum,
5. describe the method of intercultivation and harvesting of Castor and Sesamum,
6. list out the important pests and diseases of Castor and Sesamum and describe the symptoms caused by them and suggest the control measures.

15.2. INTRODUCTION

Castor is an important industrial oil seed crop and plays an important role in our national economy. Annually country earns a substantial foreign exchange through export of castor oil to different countries apart from meeting fully the total industrial purposes. The oil is largely consumed in paints, varnishes, soaps and in lubricant. The oil is also used as purgative. The castor cake is valuable manure and contains about 5.5 percent nitrogen.

Due to deep root system of castor, hardiness and quick growth, it gets an important place in cropping systems of dryland agriculture in semiarid zones of India.

Sesamum which is also known as gingelly or til is one of the important and oldest oilseed crops cultivated in India. India is a major producer of this crop in the world and occupies well over 36 per cent of the area and about 25 per cent of the production. The sesamum crop has certain advantages over other oilseed crops. They are :

1. It is rich in oil (50 per cent) and due to it short duration, the oil out turn per day is more.
2. It contains 18-20% protein which has all the essential amino acids and vitamins.
3. The seed rate is very low i.e., 2 kg/ha and the multiplication ratio is more in sesamum, with the result, larger areas can be brought about under improved varieties in short period.
4. The crop possesses high degree of adaptability and drought resistance.
5. The oil cake can also be used as cattle feed as well as manure and the nutrient contents are, N 6.0%, P 2.2% and K 1.0 to 1.2%.
6. In South India sesamum oil is an important cooking oil.

15.3. CASTOR

The main Castor producing countries in the world are Brazil, India, China and USSR. India occupies 1st and 2nd position in respect of area and production respectively in the world. Although the castor is cultivated in most parts of the country it is mainly grown in the States of Andhra Pradesh, Gujarat, Orissa and Karnataka.

15.3.1. Climatic Requirement

The castor is raised in india from 300 m to as high as 800 m above mean sea level under wide range of soil and adaphic condition. Castor requires moderate temperature ranging from 20^{o}- 27^{o}C with low humidity. At flowering high temperature above 41^{o}C results in blasting of flowers and poorer seed set. Even prolonged cloudy weather along with low temperature also affects seed setting. About 250-300 mm evenly distributed rainfall in first 20 days is required by castor for good yield. High rainfall at flowering also adversely affects the yield.

15.3.2. Soils & Seasons

It can be cultivated on any type of soil but the loamy soil with good drainage is preferred. Very heavy or marshy soils, with poor drainage are not suitable for cultivation. It cannot tolerate alkalinity.

The principal cropping season is Kharif. The most ideal time to sow kharif is after the receipt of first showers from south west monsoon, from 20th June to 15th July under rainfed condition in Andhra Pradesh and 2nd week of July to 2nd week of August in Gujarat under irrigation. Sowing in Andhra Pradesh after first fortnight of July gives poor yield.

15.3.3. Cropping System

Castor is usually grown in different parts of the country as pure crop or as mixed crop with Kharif cereals/millets/grain legumes/chillies or turmeric etc. The studies conducted in Andhra Pradesh and Gujarat have indicated that the following inter- cropping system is more profitable and viable.

Recommended varieties and hybrids of Castor

Sl. No.	Variety	Recommended for	Yield (Q/ha)	Percent Oil	Nodel..to flower	Duration in days	Remarks
1.	Aruna (NPH-1)	Andhra Pradesh, Karnataka, Orissa, Rajastan, Haryana, Bihar and Madhya Pradesh.	10-25	51-52	9-15	150-180	Red stem, double bloom, spiny and non-shattering capsules. Medium tall and diverging plant type tolerant to jassids and white flies.
2.	Bhagya (63)	Andhra Pradesh and Karnataka	10-25	52-54	8-15	150-180	Red stem, double bloom, spiny and non-shattering capsules. Medium tall and diverging plant tolerant to Jassids and white flies.
3.	Sowbhagya	As an intercrop in Andhra Pradesh, Karnataka and Maharashtra	10-25	50-51	17-18	180-210	Red stem, double bloom, spiny and non-shattering capsules. Dwarf and converging plant, tolerant to jassids and white flies.
4.	GAUCH-1	Gujarat	10-25	47-48	14-18	180-240	Green stem, triple bloom, spiny and non-shattering capsules. Medium tall diverging plant and tolerant to jassids and white flies.

1.	Castor + Redgram in row proportion of	1:1
2.	Castor + Cowpea	1:2
3.	Groundnut + Castor	5:1 or 7:1
4.	Castor + Black gram	1:2
5.	Castor + Green gram	1:1

15.3.4. Varieties

The traditional varieties are generally tall and take about 250- 300 days for maturity and they have low harvest index. Their flowering and fruiting are not synchronised and their primary spikes mature in about 55 days after flowering whereas secondary and tertiary spikes appear quite late in the month of October when moisture becomes limiting factor making the yield low and unpredictable. Efforts in the last few years have been made to develop varieties with new plant type concept in this crop and as a result some promising new plant type varieties and hybrids have been released. The characteristics of some of the varieties have been given at the end of this chapter. These varieties have been tailored in such a way that their flowering upto fourth order spike could be completed during effective rainy season. Thus a plant type which would produce the first, second, third and fourth order spikes at about 40, 65, 70 and 90 days respectively after sowing is supposed to be the best variety.

15.3.5. Field Preparation

Ploughing should be done immediately after the onset of monsoon followed by two to three harrowings with blade harrows. Deep ploughing upto a depth of 30 cm is necessary for penetration of tap root system.

15.3.6. Seeds and Sowing

A plant population of 55000/ha has been found to be the optimum for rainfed castor in all the regions. Seed rate of 12 to 15 kg/ha is sufficient, but in case of irrigated castor 5 to 6 kg/ha is recommended for hybrids in Gujarat.

The following spacings are recommended for Castor for different regions.

1. Rainfed entire castor growing area 90 cm x 20 cm for improved early varieties.
2. Rainfed-Tall and late varieties 90 cm x 60 cm
3. Irrigated (Gujarat) 90 cm x 60 cm or 120 cm x 60 cm

Usually castor is planted behind country plough. The seeds may be sown at 8 centimeter depth. For good and even germination and good stand, castor seed requires moist soil for atleast 7-8 days in Kharif and 15 days in Rabi/Summer after sowing.

15.3.7. Manures and Fertilizers

If the compost or Farm Yard Manure is available 10-15 tonnes may be added per hectare about 15-20 days before sowing. Otherwise irrespective of the area, for rainfed castor a dose of 40 kg N and full dose P_2O_5 has to be applied as basal dose and remaining N must be top dressed after 25 to 40 days after sowing depending upon moisture availability in the soil. The response for Nitrogen was observed up to 80 kg/ha in Telangana region. In case of irrigated castor besides application of 20 kg N and 40 kg P_2O_5 as basal dose and the top dressing at the rate of 10 to 20 kg/ha at each successive sequential orders namely primary, secondary, tertiary and also synchronising with the productive phase of development is recommended.

15.3.8. Intercultivation

Conditions during rainy seasons are conducive to rapid and luxiriant growth of weeds and also due to wider spacing. Castor is very sensitive to weed competition during the first 60 days after sowing. Hence, timely weeding and frequent interculture operations are necessary as the crop responds for repeated interculture operations especially after getting continuous rain for 10 to 15 days. To keep the field free from weeds, two weedings-one between 25 to 30th day and second between 50th to 60th day after sowing-should be given.

Application of Fluchlorine or Trifluraline at the rate of one kg a.i./ha, incorporation in soil prior to sowing or pre-emergence application of Alachlor at the rate of 1.25 kg a.i./ha is equally effective in controlling the weeds.

15.3.9. Water Management

Castor is relatively drought tolerant crop and needs no irrigation and usually grown under rainfed condition. However it has been observed that it responds very well to irrigation. For Rabi/Summer generally 4 to 5 weeks depending upon soil type and temperature are recommended. Pre-planting irrigation is necessary and the second irrigation has to be given at 5 to 8 leaf stage. Heavy irrigation at long intervals are preferable after early growth period since light irrigation encourage root proliferation near the soil surface and tenders plant susceptible to drought injury. Moisture stress induces flowering. The plant is also very sensitive to excess of water in the soil at all stages of the growth. Irrigation should be stopped 3 to 4 weeks before harvest and water requirement is about 500 mm. No precise information is available on either the requirement of castor under different agro-climatic conditions or its scheduling for any crop season.

15.3.10. Harvesting

Depending upon variety crop matures between 120-280 days, the first picking is done 90-110 days after sowing. Normally 2 to 3 pickings are taken. Picking the capsule too early will lead to the reduced seed weight and oil content by 4-6%. Harvest is done when capsules are fully turned yellow and mature.

15.3.11. Important Pests and Diseases of Castor

A. Pests

1. Castor semilooper *(Achoea janeta)*

Symptoms: The larvae feed voraciously and defoliate the leaves, leaving behind the petiole and midrib.

Control: (a) The larvae may be collected and destroyed, (b) Spray chloripyriphos (1.5 ml/lit).

2. Shoot and capsule borer *(Dichocrocis punctiferalis)*

Symptoms: The larvae bore into peduncle and capsules and eat away the seed. Initially the larvae bore into petioles and later into shoots and capsules. Some times the ancillary shoots are also damaged. The seed capsule is covered.

Control: (a) Collection and destruction of infested capsules, (b) Spray chloripyriphos (2.5 ml/lit) or (1.75 ml/litre) at 50% flowering.

3. Castor slug *(Ratio lepida)*

Symptoms: The larvae feed voraciously on leaves and leave behind midrib and veins.

Control: (a) Spray chloripyriphos (2.5 ml/lit) or endosulfan (1.75 ml/lit).

4. White flies *(Triaeleurodes rara and T. ricini)*

Symptoms: The yellowish nymphs with waxy filaments feed on under surface of leaves. They suck the plant sap and cause yellowing and subsequent drying of leaves in severe cases of attack.

Control: (a) Spray Dimethoate (1 ml/litre) or Monocrotophos (1.5 ml/lit)

5. Mite *(Tetranychus telarius)*

Symptoms: The nymphs and adults of red spider mites suck the plant sap from the lower surface of leaves. Under severe cases the leaves show white blotches on the upper surface of leaves.

Control: (a) Spray Dicofol (5 ml/litre) on lower surface of leaves. (b) Dust sulphur at the rate of 10-12 kg/acre.

B. Diseases

Seedling blight *(Phytophthora sp.)*

Symptoms: The fungus attacks the young seedlings during monsoon. It attacks the basal portion of stems, which leads to rotting of stems and eventually in the death of plants. Adult plants are not generally affected.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed.

2. Rust *(Melampsora ricini)*

Symptoms: The rust pustules are minute, raised from the leaf surface and occur mostly on the under surface of leaves. In severe cases of infection it may lead to drying up of the leaves.

Control: (a) Sulphur dusting at the rate of 10-12 kg/acre.

3. Blight *(Alternaria ricini)*

Symptoms: The lesions on cotyledons and leaves are irregular which is covered with greyish growth of the fungus. They later turn brown and show concentric markings. Sometimes the fungus may attack the inflorescence and capsules and causing considerable yield losses.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed.

4. Leaf spot *(Cercospora ricinella)*

Symptoms: The lesions initially appear as water soaked spots which grows and turn brown, irregular, with deep brown margins and grayish white centres. Sometimes the infected leaf tissues may break off, causing holes on the leaf. The older leaves may be blighted under severe infections.

Control: (a) Spray Bavistin (1 g/lit) or Dithane M-45 (2.5 g/lit).

Check Your Progress - 1

What is the Causal organism of rust of Castor? How do you Control it?

Note: (a) Write the answers in the space given below.

(b) Compare your answer with the one given at the end.

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15.4. SESAMUM

The important sesamum growing countries are China, Sudan, Burma and Mexico. In India its cultivation is mostly confined to Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Orissa, Gujarat, Tamilnadu, and Karnataka.

15.4.1. Climate Requirement

Sesamum is a crop belonged to tropics and warm temperate regions. It grows well in plains but can also be grown up to 1250 meters above mean sea level. It requires warm weather to give maximum yield. The optimum temperature needed by this crop ranges from 25-27^{0} C during germination, initial growth and flower formation. Temperature below 18^{0} C after germination retards the growth. Temperature above 40^{0} C severely affects the fertilization. Low temperature at flowering can result in production of sterile pollen and pre-mature flower drop.

Sesamum is grown under rainfed conditions in India but the crop cannot withstand excessive moisture or water logged condition. With excessive moisture up to certain limit there is excessive growth and after that limit, the crop wilts.

15.4.2. Soil

Sesamum can be grown on wide range of soils ranging from light red soils to black cotton soils, with good drainage. Sandy loam soils with adequate moisture are the best. Very sandy soils, alkaline and acidic soils are not suitable.

15.4.3. Time of Sowing (Season)

Photoperiod and rainfall are most important factors that determine the time of sowing and yield. It is basically a short day plant, flowering in 40-50 days after sowing with 10 hours day length. Reduction in photoperiod results in the reduction of plant height and seed yield.

In North India it is sown in last week of June or first week of July. In South India it is cultivated as Kharif, Rabi, Maghi or Summer crop. It is sown in May-June as Kharif, August-September as maghi or semi rabi, December-January as Rabi and January- February as summer. As a rainfed Kharif crop it should be sown with the onset of monsoon. It should be sown when adequate moisture is present in the soil.

15.4.4. Rotation and Intercropping

Kharif sesamum is grown both as pure and mixed crop. In south India it is rotated with upland Rice, Jowar, Maize, Tobacco, Chilly and Cotton in drylands and under irrigated conditions, with gram and root crops in December-January. In wetlands usually after rice once in 3 or 4 years sesamum can be grown in the same plot. When grown as early crop it is followed by horse gram, fodder pillipesara or fodder jowar. In black soils it is followed by jowar, wheat, coriander and cotton. As a late crop it is preceded by dry paddy, ragi and fodder jowar. In rice fields it precedes rice as early crop and succeeds rice as late crop. In certain parts of Andhra Pradesh it is mixed with green gram in wet lands after rice. Greengram is harvested first and then sesamum.

15.4.5. Varieties

The sesamum varieties can be classified into different groups depending on seed colour, growing season, maturity period and number of carpels.

1. Seed colour : (A) White seeded (B) Black seeded.

2. Based on seasons : (A) Punasa (B) Pyru

3. Maturity period : (A) Early (B) Late

4. Number of carpels : (A) Bicarpellatum (B) Quadricarpellatum.

It is generally believed that white seed varieties have higher percentage of oil than black seeded.

Varieties recommended for Andhra Pradesh

Variety	Season	Duration	Yield/ Q/ha.	Characters
1. T-85	Kharif	90 days	4	Seed is bold white with an oil content of 52% Suitable in Kharif for Telangana region.
2. TMV-3	Late Kharif and Summer	80 days	4	Seed brown with an oil content of 52% and suitable for Coastal Andhra.
3. TMV-1	Kharif	85 days	4	Seed is grown with an oil content of 50%. Suitable for Kharif in Coastal Andhra.
4. Gowri	Kharif	90 days	6.25	Medium seed with brown colour. Oil content is 50% suitable for Northern Sarkars for Kharif season. Tolerant to Phyllody and gall fly.
5. Madhavi	Kharif and Rabi	70-75	6-9	Suitable for multiple cropping system. Oil content is 50.8.

15.4.6. Field Preparation

The nature of preparation depends on soil type and rainfall. The soil must be well pulverized and brought to fine tilth to ensure good germination and growth as the seeds are very small in size. The field is prepared by ploughing twice followed by two to three harrowings and planking. This will ensure good condition for planting.

15.4.7. Seeds and Sowing

Crop should be sown in lines as it is one of the critical factors limiting the yield due to plant population. To get the optimum plant population, a spacing of 30 x 15 cm or 45 x 15 cm is followed in most of the sesamum growing regions. However the spacing can be suitably altered depending on the variety, moisture content, type of soil and its fertility status. For sowing one hectare, 2-3 kg is sufficient. The seeds should be treated with Agrosan G.W. or Ceresan at the rate of 2 g/kg of seeds. As the seeds are very small, for uniform distribution it is mixed with sand earth or powdered F.Y.M. The depth of sowing should not be more than 2-3 centimeters. Slight compaction of the soil over the seed is necessary to ensure a firm contact of the seed with soil for quick and proper germination.

15.4.8. Manures and Manuring

Sesamum is generally grown by small and marginal farmers relatively on poor soils under rainfed conditions hence the productivity in India is very less.

Sesamum is an exhausting crop. It responds to manuring well. In the absence of inherent fertility in the soil, good amount of manuring is necessary.

A more common practice is to grow sesamum on residual fertility preceding crop. Application of F.Y.M. 20-25 tonnes/hectare one month in advance has given good results. However for obtaining higher yields 30-40 kg N, 20-30 kg each of P_2O_5 and K_2O per hectare is found to be optimum. Entire quantity of P_2O_5 and K_2O and half Nitrogen at the time of sowing and remaining Nitrogen 3 to 4 weeks after sowing has to be applied. In sandy soils, the Nitrogen may be applied in three split doses applying at each time i.e., 1/3, at sowing, 30 days after sowing and remaining 50 days after sowing. In heavy soils 2/3 Nitrogen at the sowing time and 1/3 at flowering, has given good results. Application of Nitrogen and number of seeds per capsules. In Rabi, Nitrogen dose has to be increased upto 60 kg/ha.

15.4.9. Intercultivation

Due to slow growth in the early stages sesamum is poor competitor with weeds. Therefore it is essential to keep the crop weed free for first 33 days. First weeding should be done when the plants are 15-20 days old or when plants are 20 centimetres tall. The second weeding can be given when the crop is 40-45 days old depending upon weed infestation. Weeds can also be effectively controlled by using Basaline at the rate of 1.0 kg a.i./ha as preplanting or Lasso at the rate of 1.0 kg a.i./ha as pre-emergence.

15.4.10. Irrigation

Sesamum is generally not irrigated but for summer crops irrigations are given. The crop requires 50 centimetres of water during the entire period. It requires one preplant irrigation, second 25 to 30 days after sowing. Third at flowering 45-50 days after sowing and the last at pod development stage 65-70 days from sowing. If water is a limiting factor for irrigation then atleast two irrigations one as pre-sowing and second at maximum flowering may be given. Only light irrigation must be given to avoid water logging.

15.4.11. Harvesting Threshing

The crop matures in 75 to 120 days depending upon variety. The signs of maturity are yellowing of plants and shaterring of pods. The pods should not be allowed to fully ripe at the time of harvest as the seeds will drop off. The crop is cut at base and transported to a clean threshing yard. The plants are stacked for 5-7 days for drying. The plants are turned upside down and shaked to remove the seeds from split pods every day before stacking. Stacking is done in a circular manner with off ends pointing upwards.

15.4.12. Important Pests and Diseases

A. Pests

1. Leaf and pod borer and leaf webber *(Antigastra catalaunalis)*

Symptoms: The larvae feed on leaves, bores the shoots, flower buds, flowers and pods. The larvae web together the top leaves. The early damage kills the plants but at later stages it affects the growth and ilowering.

Control: (a) Spray chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre) or Endosulfan (1.75 ml/acre).

2. Gall fly *(Asphondylia sesami)*

Symptoms: The fly lays eggs into ovaries of flower buds. The hatched small whitish maggot feeds on the buds and ovary and causes gall formation without proper setting of seeds.

Control: (a) Spraying Monocrotophos (1.5 ml/litre) or Dichlorophos (0.5 ml/litre).

3. Sphinx caterpillar *(Acherontia styx)*

Symptoms: The caterpillar feeds on leaves and causes defoliation.

Control: (a) Spraying chloripyriphos and Monocrotophos at the rate of 2.5 ml/litre and 1.5 ml/litre respectively.

B. Diseases

1. Leaf spot *(Cercospora sesami)*

Symptoms: The lesions start as small water soaked spots on leaves and enlarge to form round to irregular spots. Several lesion may occur on the leaf which eventually coalesce and results in blighting.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed. (b) Treat the seed with hot water at $130^{O}F$ for 30 minutes.

2. Phyllody *(Mycoplasma disease)*

Symptoms: The disease occurs mostly at flowering stage of the crop. The floral parts are transformed to green leafy structures. The sepals, corolla, stamens and carpels turn green and leafy. The leaves of affected plants are reduced in size. The internodes are shortened, the plants are stunted and branching is abnormal.

Control: (a) Spray Monocrotophos or Dimethoate at the rate of 1.5 ml/litre to control the insect vector *Orosius albicinctus.*

Check Your Progress - 2 & 3

2. What is the Scientific name of the gall fly of Sesamum? How do you control it?

3. Phyllody of sesamum is caused by ____________________

Note: (a) Write the answers in the spaces given above and below.

(b) Compare your answer with the one given at the end.

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15.5. SUMMARY

Castor oil is one of the important industrial oils and earns good amount of foreign exchange. Castor cake is used as an organic manure. Andhra Pradesh stands number one in area and number two in production in India. Castor comes up well in tropical climate. It requires loamy soil with good drainage. It is mostly grown in Kharif under rainfed. In Gujarat it is cultivated under irrigation. Sowing time in Andhra Pradesh is June/July. 55,000 plant population is optimum with seed rate of 12-15 kg/ha, 90 cm x 20 cm for dwarf varieties, 90 cm x 60 cm or 120 cm x 60 cm for irrigated crop in Gujarat. 40 kg N and 40 kg P_2O_5 is optimum dose for rainfed condition. Response upto 80 kg N is found. Critical stage of crop weed competitions, is about 60 days. Traditional varieties are tall with duration of 250-300 days. Presently Aruna is dwarf leading variety with 120-150 days duration. By adopting nipping practice from 35 days onwards the duration can be reduced. GAUCH-1 is a hybrid castor variety under cultivation in Andhra Pradesh and Gujarat. The yield will be 1200-2000 kg/ha under rainfed. Castor semilooper is the important pest of castor.

Sesamum has several advantages over other oilseed crops viz., higher out turn of oil per day due to short duration, high protein content and high degree of adoptability. Sesamum crop varieties are classified based on duration, colour of seeds and season. Sesamum grows well in tropics and warm temperature region. Photoperiod and Rainfall determine the time of sowing and yield. In South India it is grown in Kharif, Maghi, Rabi, and summer season. Spacing of 45 cm x 15 cm or 30 cm x 15 cm is recommended with seed rate of 2-3 kg seeds per hectare sown just 2-3 cm deep. 30-40 kg N, 20-30 kg P_2O_5 and 20-30 kg K_2O is recommended. Crop should be kept weed free at least upto 30 days after sowing. Basalin herbicides can be used to control the weeds. Sesamum crop requires 50 cm of water and four irrigations are sufficient. Crop matures in 75-120 days depending upon variety. T-85, Madhavi, TMV-2 are the varieties recommended for Andhra Pradesh.

15.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Rust of Castor is caused by *Melampsora ricini.* This can be controlled by rusting Sulphur at the rate of 10-12 kg/acre.
2. The Scientific name of gall Fly of Sesamum is *Asphondylia sesami.* This can be controlled by spraying Monocrotophos at the rate of 1.5 ml/litre.
3. Mycoplasma

15.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give the climatic soil and fertiliser requirement of castor crop.
2. Write in brief about season, seeding rate and spacing of castor crop.
3. Write the characteristics of Aruna and GAUCH-1.
4. What are the advantages of cultivation of sesamum crop over other oil seed crop.
5. Write in brief about climatic requirement and season of sesamum crop.

II. Answer the following questions in about 10 lines each.

1. What is nipping ? Why is it practiced?
2. Write the characteristics of Aruna variety of castor.
3. Write in brief about water management in Castor.
4. Give in detail the fertilizer recommendation to castor crop.
5. Write the spacing that is given for castor for different varieties under rainfed and irrigated conditions.
6. Write the weed control in castor crop.
7. Write in brief about fertilizer requirement of sesamum crop.
8. What are the crop rotation and mixed cropping adopted in sesamum crop.
9. Write the Classification of sesamum varieties.
10. Write a brief note on seeds and sowing of sesamum crop.

UNIT - 16 : SAFFLOWER AND SUNFLOWER

Contents

16.1. OBJECTIVES

After studying this unit you will be able to :

1. describe the climatic and soil requirements of safflower and Sunflower,
2. list out the important varieties,
3. describe the method of field preparation and sowing of seeds of safflower and sunflower,
4. list out the manures and fertilisers required for safflower and sunflower,
5. describe the method of intercultivation and harvesting of safflower and sunflower,
6. describe the method of hand pollination in Sunflower,
7. list out the important pests and diseases of safflower and sunflower and describe the symptoms caused by them and suggest the control measures.

16.2. INTRODUCTION

Safflower is mainly cultivated for seed which yields good quality oil and contains about 24 to 40 per cent oil. The oil is rich in unsaturated fatty acids (Linoleic acid 78%) which are important in reducing blood cholesterol level. This is useful for the persons suffering from heart disease. The oil has good drying properties therefore is used in manufacture of paints, and linoleum. It is also used in preservation of leather and production of water proof cloth. The seeds are also eaten after roasting. The oil cake can also be used as cattle feed or manure and contains 40-45 per cent protein in the cake formed from decorticated seeds. Once upon a time this crop was mainly cultivated for extraction of orange red dye. The advent of cheaper food colorants and synthetic dyes lead to its near disappearance from the traditional areas in our country.

Sunflower popularly known as Surajmukhi is a familiar plant in India. It has been grown for its ornamental value since quite some time. Sunflower crop was introduced into India during 1969 for commercial cultivation as an oilseed crop. Since it has the advantage of short duration and photoinsensitivity which enables the crop to be raised in any season. It comes up well under wide range of soils i.e., Red and black soils and it is also saline resistant crop and can be grown in saline areas. It produces more oil per unit area and per unit time. It is drought resistant or has drought evading ability. It is very easy to crush to extract the oil. It is considered as highquality edible oil because oil has anticholesterol properties. As the seed rate being low, seed multiplication is high (1 : 100) and hence facilitates rapid increase in area. It can be grown under very wide range of climatic conditions as it has very high degree of adaptability. It is a cross pollinated crop so there is a great scope for evolving hybrids, composites or synthetics. Some of the unfavourable points are, Poor seed filling and bird damage. Just like any other oil, the sunflower oil also can be used for cooling purpose, for manufacturing hydrogenated oil. It can also be used for manufacture of soaps and cosmetics. The oil cake is ideally suited for poultry and live stock rations. The sunflower kernels can be eaten or roasted.

16.3. SAFFLOWER

The important safflower growing countries are India, Mexico, U.S.A., Australia and Spain. In India it is mainly confined to Maharashtra, Karnataka and Andhra Pradesh, which accounts nearly 98% of total area. In these areas the safflower is mainly grown as mixed crop or intercrop with rabi crops like, sorghum, wheat, linseed, chickpea, coriander etc., or as border crop around them. It is only in recent years it has been realised that safflower as sole crop is more productive and remunerative than the conventional rabi rainfed crops.

16.3.1. Climatic requirement

Safflower is a cold season crop, grown during Rabi season mainly as rainfed crop but in some areas it is also grown as irrigated crop. It is thermosensitive crop. Optimum temperature required for germination is $15.5^{O}C$.

High temperature at the time of flowering is harmful to crop, the day temperature ranging from 24^{O} to $32^{O}C$ at flowering is conducive for higher yield. Frost or Temperature of $O^{O}C$ or less is harmful. At all stages of the crop due to excessive rainfall or humidity, the crop is effected by fungal disease. Hence the crop should not be cultivated in heavy rainfall areas. The rainfall between 60 to 90 centimeters is supposed to be optimum.

16.3.2. Soil

Safflower is drought resistant crop and can be cultivated on residual moisture. Hence it requires fertile, fairly moisture retentive soils but it should be well drained. Although it is generally cultivated in all types of soils - sandy loams, clay loam, and alluvial etc., shallow and light textured soil, gives less yield. It is fairly tolerant to salinity but oil content is reduced in such soils.

16.3.3. Time of Sowing

Proper time of sowing is a crucial non-monetary input for obtaining uniform plant stand and higher yield by using efficiently the stored moisture and nutrients in drylands. Following is the planting schedule for different regions.

1. Drought prone areas of Western Maharashtra, Maharashtra and adjoining Marathwada region and Bijapur area in Karnataka-Mid to late September.
2. Assured moisture tract of Western Maharashtra, Marathwada, Vidharbha in Maharashtra, Andhra Pradesh and Karnataka (Except Bijapur)-Early to mid October.

Whenever safflower is raised purely on conserved moisture, from rains, the delay in planting will adversely affect the plant growth and development and will increase pest attack, the flowering will also coincide with periods of high temperature, which will result in reduced yield. For irrigated safflower, the best time of sowing is the later half of October.

16.3.4. Rotation and Intercropping

In its traditional belt the safflower is commonly taken as mixed crop or inter crop with rabi crops like sorghum, wheat, linseed, coriander or bengalgram than as a pure crop. The productivity of safflower is found to be higher than the traditional rabi crops which are less paying in dry lands; for example in Maharashtra and Andhra Pradesh (Rainfed)-linseed, wheat, and bengalgram whereas in Karnataka-Harbaceum cotton, Bengalgram, Coriander and rainfed wheat.

As compared to various inter cropping systems also sole crop of safflower is more profitable. It however also pays more to intercrop safflower in a number of traditional crops, which otherwise are low in their production potentiality if they are raised as sole crops.

16.3.5. Varieties

Safflower is highly branched herbaceous annual plant. The leaves are sessile, dark green with pronounced mid rib. Leaves are toothed along their margins with short spines. The lower leaves in most of the varieties are spineless. The degree of spineness is a varietal character. Some are spineless also. The flowers are of brilliant yellow to orange, or orange red in colour.

Varieties recommended for A.P.

Variety	Season	Duration	Yield Q/ha	Character
1. Manjira	Rabi	115-120	17	A spiny variety of bushy habit with yellow orange florets. Oil content is 32.5%. Seed is of medium size and dirty white. Under good management practices the yield can be increased to 25% extra.
2. APRR-3	Rabi	120-125	25	Spiny variety with yellow florets. Seed is pearly white, small, oil content is 33%. Responds well to higher doses of 'N' fertilizers.

16.3.6. Field preparation

Safflower can be grown as mixed as well as pure crop. When cultivated as mixed crop the land can be prepared as per the main crop. For a pure crop one ploughing or two harrowings followed by planking is sufficient. Care must be taken to ensure that sufficient moisture is present for good germination at the time of sowing. Special care is necessary especially when safflower is to be sown after kharif cereal or legume so as to avoid too deep or repeated tillage after the harvest of kharif crops as it would result in loss of conserved moisture and consequently results in poor stand. If conditions warrant, prefer zero tillage wherever it is possible otherwise one or two harrowings or shallow ploughing followed by planking immediately after harvest of kharif crop is sufficient.

16.3.7. Seeds and Sowing

Optimum plant population in all the currently recommended varieties should not exceed 1,00,000/ha even under ideal conditions. In Maharashtra, Andhra Pradesh and Karnataka 45 to 60 cm row spacing with seed rate of 10 kg/ha (90,000 to 1,00,000 plants/ha) is recommended. In case of kharif cropped areas 50% additional seed rate may be used for satisfactory stand. Besides timely sowing, seeding depth is also important. In no case, seed should be placed more than 5 cm below the soil as it would hinder emergence. The intra row spacing should be 15 cm to 25 cm depending upon variety.

16.3.8. Manures and Fertilizers

1. **For kharif fallow crop :** In sandy soils apply 15-20 tonnes of compost or FYM just before the last harrowing. Crop responds well to Nitrogen. The higher N dose will give more number of heads per plant. Under favourable conditions the response upto 60 kg N/ha can be obtained. In scanty rainfall areas as in Maharastra, Andhra Pradesh and Karnataka 25 to 30 kg N/ha can be used but in conserved moisture areas like Kandesh tract, Vidharba and Marathwada areas of Maharashtra 40 to 50 kg N/ha can be recommended. The phosphate requirement of safflower is moderate, however based on soil test values 20 to 30 kg P_2O_5 per/ha is suggested. There is no response for Potassium. In the scanty rainfall areas if seasonal conditions are favourable an additional dose of 10 to 15 kg N/ha can be used.

2. **Kharif cropped area :** Response of safflower to fertilizer applications in cereal legume, safflower sequence system depends mainly on available moisture at the time of sowing or on the receptor of rains immediately thereafter. If the moisture is a problem and chances of getting rains are remote, normal dose of fertilizer is recommended for the kharif cereals/legume and the second crop of safflower is grown on residual fertility. If there are rains or there is provision of pre-sowing irrigation, 20-25 kg N/ha (if previous crop is cereal) or 10-15 kg N/ha (if previous crop is legume) is recommended to safflower crop. The entire quantity of fertilizers as basal in both the cropping systems is applied for maximum efficiency. Fertilizer should be placed deep in used furrows. For irrigated crop 40 kg N and 40 kg P_2O_5 per hectare is recommended.

16.3.9. Weeding

Taking into consideration the rainfall at the time of sowing or moisture available in soil, the thinning must be done within 10 to 15 days after emergence so as to maintain intra row spacing of about 20-30 cm in 45 cm inter row spacing or 15 to 18 cm in 60 cm inter row spacing.

Safflower is very susceptible to weed competition during its rosette stage which lasts for 25 to 30 days. The field should be kept weed free during this critical phase through timely weeding and interculture operation by using hoes or harrows once or twice. In general two weedings combined with hoeing on 20th and 40th day after sowing is essential for better weed control. Herbicides like pendimethalin at the rate of 1.5 a.i./ha can also be used, which control the weeds effectively without any phytotoxic effect on the crop.

16.3.10. Water Management

The black soils start losing subsoil moisture rapidly as they develop cracks from December onwards. To delay cracking, they have to be closed superficially with dust much as and when they appear and there by reduce the moisture loss.

Although this crop is grown without irrigation, over large areas, even one or two irrigations given at critical growth stage will increase the yield by 30% to 60% Safflower can tolerate water shortage between emergence and rosette formation. The moisture sensitive period is from rosette to flowering and grain filling. Especially the moisture stress during flowering will reduce yield and oil content. There is need to give one good irrigation a week after 50% flowering for good seed filling. THe crop is however sensitive to excessive moisture also, hence heavy black cotton soils with improper surface irrigation will lead to water logged condition and create problems like with and root rot.

16.3.11. Harvesting and Threshing

The present varieties take about 115 to 140 days in major safflower growing areas. The crop is ready for harvest when leaves and bracteoles become dry and brownish yellow. Harvesting should be done in morning to avoid breakage of plant parts and trouble due to spines. The ripe plants are cut or pulled out and stacked for few days for drying. Then it is threshed by beating with sticks, and winnowed to get clean seed. A good managed crop can give yield of 12-15 Quintals per hectare.

16.3.12. Important pests and diseases of Safflower

A. Pests

1. Safflower caterpillar *(Perigea capensis)*

Symptoms : The larvae feed on leaves and defoliate which results in loss of vigour and become stunted.

Control: (a) Spray Monocrotophos (1.5 ml/litre).

2.Safflower aphid *(Dactynotus carthami)*

Symptoms: Both the nymphs and adults suck the plant sap from leaves and shoots.

Control: (a) Spray Monocrotopho (1.5 ml/litre) on Dimethoate (1 ml/litre)

3. Leaf trips *(Frankliniella sulphurea)*

Symptoms : The nymphs and adults feed on the leaves and causes curling in severe cases.

Control: (a) Spray Dicofal (5 ml/litre) or Salfur WP (3 g/litre).

3 Gram pod fly *(Melanagromyza obtusa)*

Symptoms : The maggots bore into the stem and girdle the plants resulting in withering of the plants.

Control: (a) Spray Monocrotophos (1.5 ml/litre) or Endosulfan (1.75 ml/litre).

5. Semilooper caterpillar *(Eublemma rivula)*

Symptoms : The larvae bore into the stem and flower heads and feed on the tissues.

Control: (a) Spray chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre).

B. Diseases

1. Rust *(Puccinia carthami)*

Symptoms : The initial symptoms appear as small pustules on the cotyledons, leaves and other parts of the plant.

Control: (a) Seed treatment with Thiram or ceresan at the rate of 3g/kg of seed, (b) Burning of infected plants, (c) A long crop rotation may be followed.

2. Cercospora leaf spot *(Cercospora carthami)*

Symptoms : The lesions start as round to irregular spots, on leaves and sometimes infects bracts, stem and nodes causing withering of plant parts. Severe attack on leaves may lead to shot hole and leaf blight.

Control : (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed.

3. Alternaria leaf spot *(Alternaria carthami)*

Symptoms : The fungus attacks all parts of the plant producing round, dark brown spots in concentric rings on leaves, stem and floral parts.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3g/kg of seed.

Check Your Progress-1

What is the scientific name of Safflower aphid? How do you control it?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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16.4. SUNFLOWER

The major sunflower producing countries of the world are Soviet Union. U.S.A.. Argentina. Rumania and Spain.

In India the crop is mainly cultivated in Maharashtra, Karnataka, Andhra Pradesh, Tamilnadu and Uttar Pradesh and to some extent in Gujarat, West Bengal, Madhya Pradesh, Orissa and Punjab.

16.4.1. Climatic Requirement

The crop requires mild cool climate during germination and seedlings growth stages. It requires warm weather from seedling stage upto flowering stage and warm sunny days during flowering to maturity. High humidity accompanied by cloudy weather and rainfall at the time of flowering results in poor seed set. The percentage of linolinic acid decreases with increases in temperature at maturity, however it is a photoinsensitive cop, therefore can be grown throughout the year with some difference in duration viz., kharif 80-90 days, Rabi 105-130 days and spring 100-110 days.

16.4.2. Soil

Sunflower can be grown on wide range of soils and can tolerate some salinity. It comes up well in deep loamy soils with good drainage. The optimum range of soil pH for this crop is 6.5 to 8.5. It's performance is better than Groundnut on heavy black cotton soil.

16.4.3. Time of Sowing (Season)

Sunflower can be grown throughout the year and is not affected by season or day length, that means it can be sown in any month. During kharif it can be sown from June to August, but early sowings always give higher yields. As a Rabi crop, Sowing during 2nd fortnight of September to 1st fortnight of October is better. Summer crop is sown by the end of January to middle of February. No doubt the early sowing always give higher yield however sowings should be adjusted in such a way that peak flowering should not coincide with rainfall.

16.4.4. Cropping System

Sunflower performs well as a pure than as mixed crop. However it can be grown in intercropping systems along with other suitable crops in different regions.

16.4.5. Varieties

Sunflower varieties, differ in the degree of dormancy viz., EC 68414, EC 68415, EC 69874 and BSH-1 shows marked dormancy ranging from 40 to 60 days whereas Morden and APSH-II exhibit no dormancy. The period of dormancy is related to the time of harvest. Earlier harvests results in increases in the period of dormancy and in addition many seeds remain unfilled in the center of the capitulum. Delay in harvest reduces the period of dormancy proportionately but the seed loss increases due to bird attack. Seed dormancy could be overcome by soaking the seed in aqueous solution of 25 ppm ethanol or Gibberellic acid for 24 hours.

Varieties under cultivation

Variety	Height	Duration in days	Oil content
EC 68414	Tall	100-110 days	42
EC 68415	Tall	100-110 days	42
Morden	Dwarf	75-80 days	40
BSH-I	Medium Tall	90-95 days	42
Co-I	Dwarf	65-70 days	38
Surya	Tall	100-110 days	42

The other sunflower hybrids which have given higher yield are:

TNAU SUF-3, TNAU SUF-4, KSF-3, CGP-1, APSH-9, APSH-11, PKVSH-I, PKVSH-4, KBSH-14, MSSH-1,4,5,10,11,12.

16.4.6. Field Preparation

Crop requires well pulverised and weed free seed bed for proper germination and initial growth. One deep ploughing followed by 2-3 light ploughings, cold crushing and levelling are essential. There should be sufficient moisture in the soil at the time of sowing for proper germination.

16.4.7. Seeds and Sowing

Well filled (60/g/1000 seeds) high quality improved or hybrid seeds should be used for sowing after treating with captan or thiram at the rate of 3 g/kg seed before sowing for the control of seed born diseases. Size of the seed and its chemical composition has a great influence on the germination, seedling vigour, final size and yields. Special care is necessary where soil crushing is a problem. Germination and emergence will be inhibited under water logged condition due to lack of oxygen to the young seedlings.

Whenever there is delay in sowing of the crop and insufficient moisture in the soil, soaking the seeds in water for 12 hours and drying them in shade and then sowing helps in better germination and establishment of the crop.

Under favourable moisture conditions 45 cm x 30 cm and for limited soil moisture condition, 60 cm x 30 cm for tall and long duration varieties, whereas for Dwarf varieties 30 to 45 cm inter row and 20 to 30 cm intra row is recommended. A seed rate of 8- 10kg/hactare is sufficient to ensure good crop stand. Generally seeds should be sown at 3-5 cm depth for getting good stand and establishment of the crop.

Thinning is very important operation in sunflower. After emergence of the crop the excess seedlings have to be thinned 10 to 15 days after retaining only healthy seedlings. Gap filling in most instances is found to be waste of time and material unless the gaps are large enough. The late sown plants will not compete with established plants and will mature very late.

Sunflower exhibits remarkable yield, plasticity with densities ranging from 50,000 to 1,25,000--plants per hectare under rainfed condition. However 75,000 plants/hactare under rainfed and about 75,000 to 1,00,000 plants under irrigated condition are optimum. At very high density beyond one lakh plants per hectare, stalks break due to thin stem and at low densities less than 50,000 plants/hectare, plants lodge due to heavy weight of the large heads.

16.4.8. Manures and fertilizers

Sunflower is an exhaustive crop and responds well to Nitrogen, Phosphorus and Potash. Application of 40-60 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha is found to be optimum. However the dose can be changed depending upon soil fertility status. By and large 40 kg N and 20 kg P_2O_5 has been found to be optimum under rainfed conditions where the rainfall has been found to be optimum under rainfed conditions where the rainfall is very much erratic. Nitrogen is essential for vegetative growth whereas phosphorus is necessary to improve the seed size and its proper filling and to increase oil content.

Application of half the recommended dose of N and entire P_2O_5 and K_2O at the time of sowing and remaining N when the crop is 35 to 40 days old is very effective.

16.4.9. Intercultivation

Sunflower is a rapidly growing plant and compete well after 30 days of sowing. First 25-30 days is the most crucial period for control of weeds. Interculture with bullock drawn implements will damage the crop from stem breakage by 10 to 30%and hence hand weedling twice, one between 20 and 25 days and another after a fortnight, is found to be better to control weeds. Hand weeding also provide sufficient aeration to the young growing roots. Weed control by chemicals can also be adopted. Fluchlorine or Lasso as pre-emergence application at the rate of 1.5 kg (a.i.) per hectare have been found to be effective. Grasses can also be controlled by using Fusilade at the rate of 0.5 kg/ha as post emergence spray.

16.4.10. Water management

Sunflower is a crop of medium water requirement. Usually no irrigation is required for kharif crop. However one irrigation should be given in case of uneven distribution of rainfall. Pre-sowing irrigation is necessary for Rabi and Summer crops. bud initiation (20-25 days), button stage (35 to 40th days), flowering (60-65th day) and seed development are very important critical stages in the crop. Moisture stress during these periods should be avoided to obtain higher yields.

16.4.11. Hand Pollination

When the crop is in flowering, on alternate days in the morning hours from 7 A.M. touching the flowers with Palm gently and smearing the heads with pollen one to another is profitable. This operation is to be carried for about 10 days (5 to 6 times hand pollination during flowering). Hand pollination was found to increase the yield to an extent of 20 to 25%. Hand pollination is particularly must during adverse weather conditions and places having low bee activity when open pollinated varieties are taken up.

16.4.12. Harvesting

The crop matures in about 80-110 days depending upon the varieties used. Harvest can be taken up when the back of the head turns to lemon yellow colour. After cutting the heads they are dried for 2 to 3 days and then seeds are separated. The separated seeds are dried again and winnowed and cleaned.

16.4.13. Important Pests and Diseases of Sunflower

A. Pests

1. **Bihar hairy caterpillar** *(Diacrisia oblicua)*
2. Tobacco caterpillar *(Spodoptera litura)*
3. Black hairy cater pillar *(Estigmene lactinea)*

Symptoms: The larvae of the above insects feed voraciously on the leaves causing defoliation.

Control: Spray chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre)

4. Thrips *(Microcephalothrips abdominalis)*

Symptoms : The flower heads of sunflower are infested by the thrips resulting in reduction in yield.

Control : Spray Monocrotophos (1.5 ml/litre) or Dimethoate (1.5 ml/litres).

B. Diseases

1. Leaf spot *(Alternaria helianthi)*

Symptoms : The lesions generally appear on leaves but may appear on stem, sepals and petals.

Control: Spray Dithane M-45 (2.5 g/litre).

2. Rust *(Puccinia helianthi)*

Symptoms : The lower leaves show small reddish brown spots covered with 'rusty' coloured dust. The leaves may turn yellow as the disease spreads.

Control: (a) Spray Dithane M-45 (2.5 g/litre) or calixin (2 ml/litre), (b) Crop rotation and destruction of volunteer seedlings, (c) Growing resistant varieties like Admiral and Advent.

Check Your Progress - 2 & 3

2. What is the advantage of hand pollination in Sunflower?

3. Leaf spot of sunflower is caused by ______________________________

Note:(a) Write your answer in the spaces given below and above.

(b) Compare your answers with those given at the end.

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16.5. SUMMARY

Safflower is mainly cultivated for oil, which is rich in unsaturated fatty acid, which helps in reducing cholesterol in blood. Oil has also got industrial use for making paints, varnishes and linoleum. In India it is mostly grown in Andhra Pradesh, Maharashtra and Karnataka. It is cold season crop grown mostly in Rabi season-1st fortnight of October is optimum time of sowing. It is a drought resistant crop, grown mostly on residual moisture. Row spacing of 45 to 60 cm is recommended with 10 kg/ha seed rate (plant population/ha 90,000 to 1,00,000). Manures and fertilizer doses differ based on preceding crop. In Andhra Pradesh 25-30 kg N and 20-30 kg P_2O_5 is sufficient. Safflower is mostly grown as rainfed but 1-2 irrigations will give 20-25% higher yield. Rosette stage to flowering and grain filling stages are critical for water stress. Duration of this crop is 115-140 depending upon varieties. Manjira, APRP-3 are recommended varieties for Andhra Pradesh. The average yield is 1200-1500. kg/ha.

Sunflower was introduced in India in 1969 as oil seed crop for commercial cultivation. It has certain advantages over others. (a) Can be raised in any season. (b) Under wide range of soil. (c) Drought resistant. (d) Seed multiplication easy. (e) High quality oil with anti-cholesterol properties for cooking purpose. The draw backs in Sunflower cultivation are poor seed filling and bird damage. Major producing countries are Soviet Union, U.S.A. and Rumania. Sunflower can be grown on wide range of soils and can tolerate salinity. Crop requires well pulverised soils. Sunflower can be grown throughout year i.e., June to August in Kharif, September to October in Rabi and January to February in summer. 60 cm x 30 cm for tall varieties, 30 to 45 x 20 to 30 cm for dwarf varieties, 8-10 kg/ha seed. 40-60 kg N, 60 kg P_2O_5 and 40 kg K_2O is optimum under irrigation and 40 kg N and 20 kg P_2O_5 for rainfed. 25-30 days are most critical for crop weed competition. Two hand weedings or Fluchloraline 1-5 kg a.i./ha is recommended. Morden and BSH-I is good variety and hybrid respectively for cultivation. Sunflower requires on irrigation during kharif but in winter or summer 3-4 irrigations are required. Hand pollination increases yield by 20-25%. Duration 80-110 days, yields about 12 to 15 quintals of seed/ha. Early sunflower varieties had dormancy but the latest varieties like Morden is free from dormancy.

16.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The Scientific name of Safflower appid is *Dactynotus carthami.* This can be controlled by spraying Monocrotophos (1.5 ml/litre) or Dimethoate (1 ml/litre).
2. Hand pollination increases the yield to an extent of 20-25% in Sunflower.
3. *Alternaria helianthi.*

16.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give the description of safflower plants along with its usage and distribution.
2. Discuss the fertilizer requirement under different situations.
3. Discuss in brief the climatic requirement of safflower with time of sowing in Andhra Pradesh.

4. Discuss in detail the merits about replacement of Groundnut by sunflower.
5. List out the advantages of growing sunflower as oil seed crop.
6. Discuss the climatic requirement and sowing time of sunflower.
7. Write in Brief about spacing, seed rate and depth of sowing of sunflower.
8. Write in detail about manures and fertilizer requirement of sunflower.

II. Answer the following question in about 10 lines each.

1. Write in brief about seeds and sowing of safflower.
2. Write in detail about water management in safflower.
3. Write a short note on weeding and interculture operation in safflower.
4. Mention in detail about the cropping system to be followed in safflower.
5. Discuss the merits and demerits of growing safflower as pure or mixed crop.
6. Discuss water requirement of sunflower.
7. Write in brief about weed control in sunflower.
8. Write a note on hand pollination in sunflower.
9. Write about dormancy in sunflower.
10. Write the duration, oil content and heights of any 3 varieties.

UNIT - 17: BLACK GRAM AND GREENGRAM

Contents

17.1. OBJECTIVES

After going through this unit you will be able to :

1. describe the climatic and soil requirements of blackgram and greengram,
2. list out the important varieties of blackgram and greengram,
3. describe the method of field preparation and sowing of seeds of blackgram and greengram,
4. list out the manures and fertilisers required for blackgram and greengram,
5. describe the method of intercultivation and harvesting of Blackgram and greengram,
6. list out the important pests and diseases of blackgram and greengram and describe the symptoms caused by them and suggest the control measures.

17.2. INTRODUCTION

Blackgram is one of the important pulse crops and is closely related to green gram and is more extensively grown in India than greengram. It is used mainly as an ingredient in South

Indian breakfast dishes. It is also used as a nutritive fodder specially for mulch cattle. It is also used as green manure. It contains 24% protein, 60% carbohydrate and good amount of phosphoric acid. Black gram is cultivated in Bangladesh, Pakistan, Burma and Ceylon.

Greengram (Moong) in an excellent source of high quality protein as food which contains about 25% protein. Being a leguminous crop, it is also used for green manuring. It can be used as a cover crop which prevents the soil erosion. It is also used as feed for cattle in green or dried condition. As its duration is short it can be accommodated in any type of the intensive cropping programme. Greengram has been cultivated in India since ancient times. Numerous varieties are found in different parts of the country but the plant is not found in wild state. Greengram is supposed to be native of India and Central Asia. It was grown in these regions since pre-historic times. It is now spreading slowly to other Asian and African countries.

17.3. BLACK GRAM

In India it is extensively grown in Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and Tamil Nadu. In area and production Madhya Pradesh stands first followed by Maharashtra. In Andhra Pradesh it is mainly grown in Khammam, Guntur, Nalgonda, Adilabad, Karimnagar, Ranga Reddy and Srikakulam.

17.3.2. Soil

Black gram does well on heavy soils. However it can be grown on all types of soils ranging from sandy loam to heavy clay except alkaline and saline. Loamy or slightly heavy soil with natural pH are best suited. It should be grown on heavy soils where rainfall is scanty and on well drained medium soils in humid regions.

17.3.3. Season

Kharif season: Sowing is done with the onset of monsoon or 2nd fortnight of June to 1st fortnight of July.

Rabi: Second fortnight of September to end of October.

Summer: The sowing could be done from last week of February to 1st week of April. Rice fallows: December month.

This crop is grown in kharif, Rabi and summer in South India, where as in North India it is cultivated in kharif and summer seasons.

17.3.4. Crop Rotation and Inter Cropping

Black gram is grown mixed with jowar, maize, bajra and cotton during kharif season. As an intercrop it is taken in redgram and sugarcane. One or two rows of Blackgram are sown in two rows of Redgram planted 75 cm apart. The black gram will be an additional income without affecting the Redgram or Sugarcane yield.

In command areas black gram is cultivated largely in rice fallows of Guntur, Karimnagar and Nizamabad Districts.

17.3.5. Varieties

The crop is classified into two sub-species. They are : (1) *Vigna mungo* - var. Niger - early maturing, bold and black colour seeds, (2) *Vigna mungo* - var. *Virdis* late maturing, small and green colour seeds.

It is an annual plant attaining a height of 30-100 centimetres. In general appearance, the plant looks like green gram except darker green shade leaves, more hairy with slightly smaller stature. Seeds are generally black or green. The split seed of Black gram is white in colour. Self fertilization is the rule. The varieties recommended for A.P. are given below.

1. T-9: Suitable for all seasons as well as in Rice fallows; duration 70 days, yield 7.5 Q/ha; plant short semi erect, seed is medium, good cooking quality and tasty, suitable for multiple cropping system.
2. L.BG-17: Suitable for Rabi and Rice fallows, duration 75 days, yield 12-14 Q/ha, plants tall, semi spreading, seed bold, with shining coat. Pods are long, bold and green in colour. Resistant to downy muldew fairly tolerant to yellow mosaic virus. Photosensitive, suitable for Rabi and Rice fallows.

17.3.6. Field Preparation

Fields are prepared by ploughing with mould board plough or country plough followed by two to three harrowings and one planking. For rice fallows no preparation is required. For crop after harvest of Rabi crop 2-3 harrowing followed by planking is adopted to ensure good germination. Pre-sowing irrigation is given.

17.3.7. Seeds and Sowing

Before sowing, seeds should be treated with thiram at the rate of 2-5 g per kg of seed. During kharif season 12-15 kg seeds are sufficient per hectare. Vegetative growth of the plant will be more in kharif. A wider spacing of 45 cm is recommended, otherwise 30 cm is optimum. Seed drill could be used for sowing. In rice fallows sprouted seeds are broadcasted. Seeds should be inoculated with suitable *Rhizobium* culture, if Black gram is being taken for the first time in the field or after a long duration. As green manure 25-30 kg of seeds per hectare is used.

17.3.8. Manures and Fertilizers

Being a leguminous crop small quantity of Nitrogen at the rate of 15-20 kg/ha is sufficient. Phosphate and potash fertilizer should be applied based on soil test values or 30-50 kg P_2O_5 and 30 kg K_2O/ha is sufficient. The entire quantity of fertilizer should be applied as basal by drilling 5-7 centimeter below seed. If F.Y.M. is available 5 tons/ha during land preparation may be added.

17.3.9. Intercultivation

One or two hand weedings should be done upto 40 days after sowing depending upon weed intensity, otherwise Fluchlorine at the rate of 1-5 kg a.i. per ha can be used as pre-sowing soil incorporation.

17.3.10. Water Management

Rabi crop and summer crop, require irrigation. The number of irrigations required depends upon soil and climate. From flowering to pod development stage, there is need of sufficient moisture in the field. 3-4 irrigations are sufficient. Blackgram taken in the rice fallows are not generally irrigated. Generally the crop should be irrigated at an interval of 10-15 days.

17.3.11. Harvesting and threshing

Black gram is harvested when most of the pods turn black. Over maturity may result in shattering. Harvested crop is dried on threshing floor for few days. A well managed crop yields about 15-20 grain quintals/hectare.

17.4. GREEN GRAM

It is cultivated presently in Burma, Ceylon, Pakistan, Fiji, China and Africa. In India, it is being grown in almost all the states. The important states that are cultivating this crop are Orissa, Maharashtra, Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan and Bihar. The average productivity of this crop is 330 kg/ha. Out of all the important states that are growing, Orissa has maximum area followed by Maharashtra and are Andhra Pradesh. In Andhra Pradesh it is grown mostly in the districts of Warangal, Karimnagar, Krishna, Khammam, Adilabad, Nalgonda, Guntur and Ranga Reddy.

17.4.1. Climatic Requirement

It is a tropical crop. It requires hot climate and can tolerate drought to certain extent. It can be successfully grown in the areas having an annual rainfall of 60-75 centimeters but heavy rainfall at flowering is not desirable as the fertiliization is adversely affected resulting in poor yield. Green gram is considered to be the hardiest pulse crop. It can be grown from mean sea level to an elevation of 2000 metres.

17.4.2. Soil

Greengram can be grown on variety of soils ranging from red laterite to black cotton soils but comes up best in well drained loamy to sandy loam soils. A saline or alkaline, heavy black soils with poor drainage are not suitable.

17.4.3. Season

It is largely grown as a rainfed crop during Kharif season. In some parts of Maharastra, Andhra Pradesh, Tamilnadu it is cultivated in rabi season also as a second crop after rice, especially in coastal Andhra pradesh. In this area the sprouted seeds are broadcasted in the standing rice crop one week before harvest. The residual moisture in the soil is sufficient for this crop in heavy black or alluvial soil types. In some of the areas of Northern India and Western plains, East and Central Zone it is taken as summer crop under irrigation after wheat and for this purpose short duration, photoinsensitive varieties like Pusa Baisakhi, Mohini, IRG-30 etc., are recommended.

1. **Kharif:** Sowing is done with the onset of South-West monsoon in the second fortnight of June to first fortnight of July.
2. **Rabi:** Sowing is taken up during the months of October and November.
3. **Summer:** Sowing is taken up from second fortnight of April.

17.4.4. Crop Rotation and Intercropping

Greengram is grown as a mixture with Redgram, Jowar, Bajra, Maize, and Crop rotation and Inter cropping cotton during Kharif season. As an Inter crop it can also be cultivated along with Sugar cane, without adversely affecting the sugarcane yield. Sugarcane is planted 90 cm apart. The important crop rotations are:

1. Paddy - Greengram.
2. Paddy - Paddy - Greengram.
3. Greengram - Cotton.
4. Greengram - Cotton.
5. Maize - Wheat - Greengram.
6. Greengram - Wheat.
7. Greengram - Potato.

17.4.5. Varieties

The moong crop can be grouped into four different types based on leaf size, flower colour, pod colour and seed colour etc.

i. Seed colour = Green, Black, Brown or yellow.

ii. Seed surface = Dull or Shining.

iii. Flower colour = Light yellowish olive or olive yellow.

iv. Pod colour = Iron grey, olive grey or snuff brown.

Greengram is a small herbaceous annual plant growing to a height of 30 to 100 cms with a slight tendency to twining in the upper branches. The central stems are more or less erect while side branches are semierect. The leaves are trifoliate with long petiole. The stems and leaves are covered with short hairs and they are smaller than green gram. The crop is self pollinated.

Varieties recommended for Andhra Pradesh

Variety	Season	Duration	Yield Q/ha	Characters
1.Kondaveedu	kharif, Rabi Summer, Rice fallows	60-65 days	10-12	The plant is medium tall and erect, stem is green moderately susceptible to powdery mildew and yellow mosaic virus. Pods are dark brown in colour when fully riped. Number of pods/plant is 12 with 14 seeds. Seeds are dull green in colour and weight of 100 seeds is 2.7 grams.
2. PS-16	Kharif, Rabi, Summer Rice fallows.	60 days	8-10	Plant is semi erect with elongated peduncle, uniform maturity, comes up in single harvest. Recommended for all the districts of the state. Seed is shining with yellowish green (Pacha-Pesalu) in colour.
3. PIMS-4	Kharif, Rabi, Summer Rice fallows.	65 days	11-12	Stem with green colour Pods are dark brown when ripened. Seed is dull green in colour and bold.

Check Your Progress - 1

What is the duration and the yield of the Kondaveedu variety of Greengram?

Note: (a) Write the answers in the spaces given above and below.

(b) Compare your answer with the one given at the end.

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17.4.6. Field Preparation

For pure crop in Kharif season the land is ploughed twice and then harrowed. The field should be well levelled and made free from weeds. For summer crop after harvesting of Rabi crop a light irrigation is given then the field is brought to fine tilth by ploughing, harrowing and planking and finally the field is levelled to minimise moisture loss by evaporation.

Seed can be sown at 30 centimetres away behind the plough or using the seed drill when it is grown as intercrop. The seed rate may be adjusted depending upon ratios. In rice fallows the sprouted seeds are broadcasted. It is also desirable to treat the seed with suitable *Rhizobium* culture as well if the pulse crop is sown in the field for the first time or after a long period. The seed should be treated with thiram or captan at the rate of 2.5 g/kg of seed.

17.4.7. Seeds and Sowing

1. During Kharif 12-15 kgs of seed/ha and for rabi and summer sowings 15-20 kgs of seed/ha are required.

17.4.8. Manures and Fertilizers

The crop is generally grown on residual fertility of the preceeding crop in wet lands. However the crop responds to the application of fertilizers especially phosphorus, since it is a leguminous crop. It does not require high dose of Nitrogen. However a starter dose of 15-20 kg N and 30 to 40 kg P_2O_5/ha is sufficient. Generally no response is noticed for potash application. However if the soil is poor in potash, 25-30 kgs of potash can be applied. The fertilizer should be drilled either at the time of sowing or before sowing 5-7 centimeters below the seed. All the fertilizer should be applied as basal dressing. If available, 8-10 tonnes of F.Y.M. or compost can also be applied.

17.4.9. Intercultivation

Competition of weeds is more during the early stage of the crop growth, especially during Kharif season and if the weeds are not controlled, the moisture and nutrients will be utilized by the weeds, but once the crop is established, it will smoother the weeds. However two weedings should be given to get the higher yield. First hand weeding has to be taken up 20-25 days after sowing, and second 40 days after sowing. Weeds can also be controlled by inter cultivating the crop with tyned hoes. This will not only control the weeds but also forms a soil mulch to conserve the soil moisture. Weeds can also be controlled by using herbicides like Fluchlorine 1.0 kg a.i./ha as presowing soil incorporation or Alachlor 0.5 to 0.75 kg a.i./ha as pre-emergence application.

17.4.10. Water Management

For Kharif crop, irrigation is not necessary but good drainage is essential as the crop is grown during the monsoon.

For Rabi and Summer crop 3-4 irrigations may have to be given. The first irrigation at sowing time, second at flowering and third at grain development stage are necessary. Depending upon the soil type and temperature number of irrigations my have to be changed. In general the irrigation at an interval of 12-15 days has to be given.

17.4.11. Harvesting and Threshing

Shattering of pods is a great Problem with this pulse, therefore picking should be taken up as soon as pods mature. Harvesting should be completed in 2-3 pickings. The pods or whole crop after complete drying should be threshed manually. A well managed crop under rainfed condition gives 5-6 quintals/ha and under irrigated conditions 10-15 q/ha.

17.5. IMPORTANT PESTS AND DISEASES ON BLACKGRAM AND GREENGRAM

A. Pests

1. Gram caterpillar *(Heliothis armigera)*

Symptoms : The insect attacks greengram, blackgram, redgram, bengal gram etc. The caterpillar feeds on leaves, pods etc. At the time of feeding it thrusts its head inside the pod leaving the rest of its body outside. The larvae feeds on the tender foliage and as they grow, they bore into the pods and feed on the seed contents.

Control: Spraying of Endosulfan (1.75 ml/litre) or Fenvalerate (0.5 ml/litre) or DDT 50 WP (3 g/litre).

2. Spotted pod borer *(Maruca tastulalis)*

Symptoms: The insect attacks greengram, black gram, red gram etc. The caterpillars web the flowers together and feeds on them and also bores into pods from one end and eat away the ripening seed.

Control: (a) Spray Endosulfan (1.75 ml/litre) or Carbaryl 50 WP (3 g/litre) at 50% flowering.

3. The pod bug *(Riptortus pedestris)*

Symptoms: It is polyphagous insect attacking greengram, black gram, red gram etc. The nymphs and adults of the brownish long bug suck the sap from the tender shoots and pods and causes heavy yield losses.

Control: (a) Spray Monocrotophos (1.5 ml/litre) or Dimethoate (1 ml/litre).

4. Aphid *(Aphis craccivora)*

Symptoms: It attacks greengram, blackgram, red gram etc. Both adults and nymnphs suck the sap from the tender leaves and shoots and cause curling.

Control: Spray Monocrotophos (1.5 ml/litre) or Dimethoate (1 ml/litre).

5. Stem fly *(Melargomyza phaseoli)*

Symptoms: It causes withering and drying of shoots in green gram, black gram, red gram etc.

Control: Spray chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre).

B. Diseases

1. Powdery mildew *(Erysiphae polygoni)*

Symptoms: The fungus attacks both green and black gram. The infection occurs at any stage of plant growth but severe infection occurs during flowering. White powdery growth appears on leaves initially and spread to stem and other parts of the plant.

Control: Dusting of sulphur at the rate of 10 kg/acre.

2. Cercospora leaf spot *(Cercospora canescens)*

Symptoms: The fungus infects both green gram and black gram. During initial stages of infection water soaked lesions appear on leaves and as infection develops the affected tissues turn brown to reddish brown. Purple borders develop around the well defined spots and centres may turn grey at maturity. In severe cases the infected tissues are killed and the dead portion drops leaving shot hole symptoms on leaves.

Control: Spray Bavistin (1 g/litre) or Dithane M-45 (2.5 g/litre).

3. Anthracnose *(Glomerella lindemuthianum)*

Symptoms: The fungus attacks both greengram and blackgram. The infection may take place at any stage of plant growth on any plant part above the ground. The infection on leaves occur on under surface. The stem and petioles are also affected. The affected plant parts may dry under severe conditions of attack.

Control: Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed helps in eliminating seed-borne infection.

4. Rust *(Uromyces appendiculatus)*

Symptoms: The rust also attacks both green gram and black gram. The fungal infection produces typical pustules on leaf blade and other plant parts. In severe cases the sori may coalesce and cover the complete leaf blade and resulting in withering.

Control: Sulphur dusting at the rate of 10 kg/acre.

5. Dry root rot *(Macrophomina phaseoli)*

Symptoms: The affected plants initially show yellowing of leaves and after one or two days the leaves droop and eventually drop off. After a week of initial symptoms the plants may wilt. The tissues gets weakened and break off easily.

Control: (a) Field sanitation measures helps in checking the soil borne inoculum, (b) Crop rotation.

Check Your Prpgress - 2 & 3

2. Powdery mildew of greengram and blackgram is caused by ______________________

3. Dry root rot of greengram and blackgram is caused by ______________________

Note: (a) Write the answers in the space given above.

(b) Compare your answers with those given at the end.

17.6. SUMMARY

Black gram is mainly used as an ingrediant in South Indian break fast dishes. It is extensively grown in Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and Tamilnadu. In Andhra Pradesh it is confined mostly to Khammam, Guntur, Nalgonda,Adilabad, Karimnagar. Black gram is classified into two sub-species with different durations and seed colour. Black gram requires hot and humid season and can be grown in all three seasons, viz., Kharif, Rabi and Summer. It is generally grown in all types of soils ranging from sandy loam to heavy except alkaline. T-9 and LBG-17 are two improved varieties recommended for Andhra Pradesh. 12-15 kg seeds per hectare are required and are sown 30 cm apart. Being leguminous crop 15-20 kg N, 30-50 P_2O_5 and 30 kg K_2O is sufficient. Weed free upto 6-7 weeks is essential to get good yield. In Rabi and summer 3-4 irrigations are given to get good crop. Duration of crop ranges from 70-90 days. Yield also varies and it ranges from 7-12 Q/ha.

Green gram is an excellent source of high quality of protein. It can be used as a green manure as well as fodder crop. It can also be used as cover crop to prevent soil erosion. It is cultivated mostly in Burma, Ceylon, Pakistan, Fiji, China and Africa. In India, it is grown in almost all the states, especially Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh, etc. In A.P. it is grown in Warangal, Karimnagar, Krishna, Khammam, Adilabad, Guntur. Green gram can be grouped into 4 different types based on leaf size, flower colour, pod colour and seed colour. It is tropical crop, requires hot climate and also tolerates drought. It can be grown on variety of soils ranging from red laterite to black cotton soils. It is grown in all three seasons. During Kharif 12-15 kgs and in Summer 15-20 kgs seeds per hectare are used. For Green manure 25-30 kgs are recommended. The seeds are sown at 30 cm spacing by seed drill. In rice fallow the sprouted seeds are broadcasted. For green gram 15-20 kg N, 30 to 40 kg P_2O_5 is recommended. In Potash difficult areas 25-30 kgs of K_2O is also recommended. Two weedings, one at 20-25 days and the other 40 days after sowing are done or Fluchloraline at the rate of 1.0 kg a.i./ha can also be used. For Rabi and Summer 3-4 irrigations may have to be given for getting good crop. Kondaveedu, PS-16, and PIMS-4 are the improved varieties. Duration of the crop is 60-70 days and yields are about 5-6 Q./ha.

17.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The duration of Kondaveedu variety of Green gram is 60-65 days and the average yield is 10-12 quintals/hectare.
2. *Erysiphae polygon.*
3. *Macrophomina phaseoli.*

17.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write in detail the area and production along with classification of Black gram varieties.
2. Write in detail the used area and production of Green gram.
3. Listout the different types of green gram along with characteristics of any two green gram varieties.

II. Answer the following questions in about 10 lines each.

1. Write the fertilizer recommendation to balck gram.
2. Write the season and date of sowing of black gram.
3. Write noton crop rotation and intercropping in black gram.
4. Write briefly about intercultivation and water management in black gram.

1. Write the fertilizer recommendation to Greengram.
2. Write seed rate for different seasons for green gram.
3. Write the soil and climatic requirement of Greengram.
4. Write a note on crop rotation and inter cropping in Greengram.
5. Write briefly on intercultivation in green gram.

UNIT - 18: REDGRAM AND BENGALGRAM

Contents

18.1. OBJECTIVES

1. describe the climatic and soil requirements of Redgram and Bengalgram,
2. list out the important varieties of redgram,
3. describe the method of land preparation and sowing of Redgram and Bengalgram,
4. list out the manures and fertilisers required for Redgram and Bengalgram,
5. describe the method of intercultivation and harvesting of Redgram and Bengalgram,
6. list out the important pests and diseases of Redgram and Bengalgram and describe the Symptoms caused by them and suggest the control measures.

18.2. INTRODUCTION

Redgram is one of the most widely cultivated pulse crops of India which furnishes part of the daily dietary in South Indian homes. It is extensively used as 'dhall'and considered a perhaps the most important protein food among the people of South India. Its green pods may be used as a vegetable. The husks of the pods and the leaves obtained at threshing time for a valuable cattle feed. Being deep rooted crop, it is also planted as a soil renovator to break-up the hard sub-soil and to check soil erosion. The heavy shedding of leaves adds considerable organic matter to the soil. Stalks are used as fuel.

Bengalgram is commonly known as Gram. It is one of the most important pulse crops grown in our country. It occupies 34% of the area and accounts for 46% production of all pulses grown in India. It is used as dhall, flour and eaten as boiled, fried and parched. Germinated seeds are recommended to cure 'Scurvy'. Malic and oxalic acids collected from green leaves are used for intestinal disorders. The husks of the pods and the dry stems and leaves obtained at threshing time form an important cattle feed.

18.3. REDGRAM

As a cultivated crop Redgram is said to have existed in India from very ancient times although it is claimed that the home of the plant is Africa in the region of Upper Nile and coastal districts of Angola. It is grown throughout the tropical countries of the world as a cultivated crop, especially in the more arid regions of America, Australia, West Indies, Ceylone, India, China, Pakistan etc.

About 90% of the world pigeonpea is produced in India. It is grown in almost every state of the country. In India the crop is cultivated in an area of 2.84 m.ha with a production of 1.93 m.t. Among the different states in India, Maharastra stands first followed by Madhya Pradesh and Uttar Pradesh in area while in production Uttar Pradesh stands first followed by Maharastra and Madhya Pradesh.

Check Your Progress - 1 & 2

1. Which is the highest Redgram producing state in India?
2. Redgram is originated from ______________________ Countries.

Note: (a) Write the answers in the spaces given above and below.

(b) Compare your answer with the one given at the end.

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In Andhra Pradesh the crop is grown in an area of 2.40 lakh hectares producing 0.45 lakh tonnes of grain annually. The area under redgram is maximum in Adilabad district (35,000 ha) followed by Mahaboobnagar (35,000 ha) and Ranga Reddy (19,200 ha). Mahaboobnagar is the maximum producer followed by Adilabad and Ranga Reddy districts.

Table 19.1 Area and production of redgram in different districts of Andhra Pradesh

Sl. No.	District	Area ('000 ha)	Production ('000 t)
1.	Adilabad	35.30	4.60
2.	Mahaboobnagar	35.00	4.90
3.	Ranga Reddy	19.20	4.10

Earlier sowings are preferable if wheat is to be grown during rabi. Care should be taken that flowering and pod formation should not coincide with rains. General sowing periods are:

Kharif : June, July

Rabi : October, November.

During Rabi season most of the varieties developed for kharif will undergo agronomic dwarfing. So, whenever rabi sowings are taken up with there popular varieties like LRG 30, it is necessary to adopt double the seed rate and close spacing for obtaining optimum yield. Further the duration of these varieties will be shortened considerably besides agronomic dwarfing of the plants and will come to harvest within 130 days. Hence more number of plants can be accommodated per unit area to get optimum yield. If these varieties are sown beyond November they will not come to flower but end up with vegetative growth only. Efforts are being made to evolve suitable varieties for rabi by ICRISAT and other research stations. The varieties like C11 and LRG 30 which are already developed are not able to give optimum yields.

18.3.3. Preparation of Land

The crop responds well to good tilth which is a prerequisite for good germination of seed and establishment of optimum plant population. Deep ploughing followed by two or three discings and harrowings are desirable. The field has to be levelled well and weeds are removed. Land preparation is the most difficult job in rice fallows due to lack of sufficient time for land preparation after the harvest of rice crop. ploughing wet soil leads to clody seedbed which results in poor germination of seed resulting in low plant population. Hence the field has to be prepared well by ploughing the soil at optimum moisture.

18.3.4. Varieties

The important varieties, their height, type, duration and yield are given below.

Sl. No.	Name of the variety	Plant height (cm)	Plant type	Days to flower	Days to maturity	Yield (Q/ha)
1.	Hy-1	115	Spreading	80	130	20-22
2.	Hy-5	140	Semi-erect	81	130	23-25
3.	Hy-2	200	Semi-erect	93	150	26-28
4.	Hy-4	170	Semi-erect	85	150	25-28
5.	Hy-3A	235	Erect	120	180	30-35
6.	Hy 3C	220	Semi erect	125	180	30-40
7.	Palnadu	145	Spreading	120	180	22-25
8.	PDM 1	145	Semi-Spreading	120	180	23-26
9.	C 11	136	Semi-spreading	115	170	23-25

18.3.1. Climatic Requirement

Pigeonpea is a tropical crop which is one of the most important heat and drought resistant pulse crops. During the period of vegetative growth, moist weather is favourable and requires comparatively cool and dry weather during reproductive phase. This crop is highly susceptible to fost. Cloudy weather during winter season or excessive rainfall at flowering stage damages the crop to a great extent.

18.3.2. Soils & Seasons

It can be grown in all types of soils except saline, alkaline and soils subjected to water stagnation. Well drained, alluvial and loamy soils are best suited for it. In heavy black cotton soils also redgram gives higher yields. Sowing time is influenced by rainfall pattern of the area and duration of succeeding rabi crops.

18.3.5. Rotations and Mixtures

It is rarely grown as pure corp. It forms a companion crop to maize, sorghum, bajra, ragi, groundnut, greengram, blackgram, cowpea, etc., in varying proportions. It is rotated with cereals.

18.3.6. Seeds and Sowing

(a) **Seed rate:** As a pure crop it requires seed of about 15 kg/ha. But it is seldom grown as a pure crop but grown as mixture with other crops and the seed rate usually depends upon the proportion of this crop, generally 8-10 kg/ha.

(b) **Seed treatment:** The seed has to be treated with *Rhizobium* culture to increase the grain yield by 20-30 per cent. Particularly in the soils when the crop is grown for the first time it is all the more important to treat the seed for obtaining higher yields.

(c) **Sowing:** Sow the seed either behind the plough or with seed drill.

(d) **Spacing:** Plant population depends on: (1) Sowing time, (2) Soil fertility status, (3) Rainfall pattern, (4) Variety and duration.

Extra early and early varieties: 50 x 20-30 cm

Medium varieties : 60-75 x 20-30 cm

Long duration varieties : 75-90 x 20-30 cm

18.3.7. Fertilizer Requirement

Nutrient requirement studies in pigeonpea revealed that application of 30 kg N/ha gave a response of 1.0 Q/ha. Potassium application, however, did not show any response.Results obtained on cultivated fields under rainfed conditions in pigeonpea indicated that four fold increase in pigeonpea yields could be obtained with agronomic management inputs-such as phosphate application, *Rhizobium* inoculation, weed control and plant protection.

Being a leguminous crop, it has the inherent capacity of fixing atmospheric nitrogen and does not need heavy doses of nitrogenous fertiliser. The fertilizer requirement for the pure crop is as follows.

Fertilizer	Dose	No.of doses	Stages
Farm Yard Manure	5 tons/ha	1	Soil incorporation
Nitrogen	25 kg/ha	1	Before sowing
Phosphorous	60 kg/ha	1	Before sowing
Potash	25 kg/ha	1	Before sowing

18.3.8. Water Management ana Drainage

Redgram is mostly a rainfed crop. However, a special type of redgram called 'Pedda Kandi' or 'Kurakandi' grown on garden lands and redgram grown in rice fallows is given light irrigations as and when needed.

18.3.9. Weed Control

Weeds pose a serious problem particularly during rainy season. During the early growth stages, weeds not only compete for the nutrients and moisture but also give shelter to the pests.

It is, therefore, essential to keep the crop free from the weeds particularly during the early growth states. In a pure crop of redgram intercultivation between the lines will be done with an implement called 'Danti' or 'Blade harrow'. It is worked twice between rows to uproot the weeds and to provide good milch to the crop. In an intercropping system, the plants grow very slow till the main crop is removed. After the main crop is harvested, the land is ploughed or worked with a harrow between redgram rows and then onwards the growth of redgram is very quick and vigorous. Pre-emergence application of Lasso at the rate of 1.5 litre a.i./ha is effective when it is grown as pure crop.

18.3.10. Harvesting and Threshing

As soon as all the pods mature and start drying the crop should be harvested. If the crop is allowed in the field for complete drying, the operations like preparation of the field and sowing of wheat will be delayed. Hence the harvested crop is removed from the field and kept at one place in small bundles. When bundles are completely dried, threshing is done by beating with sticks or trampled by bullocks.

The grains after cleaning generally disposed off as it is difficult to preserve the same. Grains requireo for personal use of the farmer are stored in earthern pots covered at the top with a layer of sand or mixed with ash, red earth, neem leaves etc.

18.3.11. Yield

In a mixed crop the yields range from 500 to 600 kg/ha and in pure crop the yields range from 1000 to 1500 kg/ha and under irrigated conditions the yield may go upto 1500-1800 kg/ha. In rabi, the grain yields obtained were ranging from 2000-3000 kg/ha.

18.4. BENGALGRAM

Gram seems to have originated from some where in South West Asia i.e., countries lying to the North-West of India, Afganistan and Persia. It is said to be one of the oldest pulses known and cultivated from ancient times both in Asia and in Europe. This pulse is grown in many countries like Italy, Greece, Rumania, Russia, Egypt, North Africa, Rhodesia, East Africa, Iran and Turkey and in Parts of Australia. In India, it is mainly grown in Uttar Pradesh, Himachal Pradesh, Rajastan, Haryana and Madhya Pradesh. It is cultivated in India in 7.2 m.ha. with a production of 5.1 m.t. Madhya Pradesh stands first both in area and Production followed by Rajastan and Uttar Pradesh.

In Andhra Pradesh, gram is grown in 48.7 thousand hectares and yield is 18.3 thousand tonnes. Medak stands first in area followed by Kurnool and Nizamabad, while in production Kurnool stands first followed by Medak and Guntur districts.

18.4.1. Climatic Requirement

Gram is a winter crop in India and it is generally grown in dry tract. It is best suited to areas having low to medium rainfall and a mild cold weather. Excessive rain soon after sowing or at flowering causes heavy damage to the crop. Severe cold is injurious and is very harmful. Early summer shortens the growing period, hastens maturity and reduces the yield.

18.4.2. Soils & Seasons

Clay soils are best suited. In Northern India, the crop is grown on light alluvial soils which are rather poor for wheat. In Central and South India, it is cultivated in clayloams and black cotton soils. It grows with the help of moisture stored in the retentive black cotton soils and of the dews which are heavy in the months following the rainy season.

Normally grown during rabi season and suitable time for sowing is middle of October and this helps in minimising the damage caused by gram wilt to the crop. Early sowing results in excess vegetative growth, poor setting of pods and also damage caused by rains occurring late.

18.4.3. Land Preparation

There is a common saying that gram requires clodded and rough seed bed. This gives a well drained and well aerated sphere for root growth which is essential for gram. Thoough preparation of land is necessary to make soil loose and well aerated. Two to three ploughings followed by cross ploughing and working with blade harrow to break the clods and level the land provide necessary tilth. In low rainfall areas, deep ploughings in July and August help in the removal of weeds and conservation of moisture. Manures and fertilizers are applied before the last ploughing and covered by working a cultivator.

18.4.4. Varieties

Some of the important varieties of Bengalgram, their Reracters and yield are given below.

Sl. No.	Name of variety	Duration	Yield (Q/ha)	Characters
1.	Jyothi	110 days	15-18	The plant is semi-spreading with bold attractive seed and posses good cooling quality having 3.3% more protein than local. It is resistant to drought and wilt disease.
2.	C-214	125-130 days	20-23	This variety has slightly bold seeds and bears a large number of pods per plant. Its grain colour is attractive yellow brown. It is resistant to wilt, frost and drought and thus gives good yield in years of adverse climate conditions.
3.	G-130	125-130 days	24-26	Recommended for cultivation under irrigated conditions. It has erect growth and upright leaves. Its grains are yellowish brown. It branches profusely and bears good number of pods.
4.	JG-62	120-125 days	20-25	It is a double podded variety. It has dark green foliage and erect plant type. Seed colour is light yellowish brown and protein % is 19.2.
5.	G-543		14-16	It passes high degree of resistance to gram blight and foot blight. Seeds are brownish yellow in colour and contain more ash percentage, thus giving palatable saltish taste to the cooked dishes. This variety is highly suitable for the humid and disease prone conditions.

18.4.5. Seeds and Sowing

(a) **Seed rate:** It ranges from 45 to 75 kg/ha depending upon the size, spacing and variety.

(b) **Sowing:** A heavy drill is used for sowing the seed. It is also sown in plough furrows behind desi plough keeping row to row distance of 30 cm.

(c) **Seed-treatment:** Seed treatment with an efficient strain of *Rhizobium* specific to the crop enhances the grain yields between 20-30 per cent on an average.

(d) **Spacing:** Seed is placed 8-10 cm apart within the row and with an inter-row spacing of 30 cm.

18.4.6. Fertilizer requirement

In some parts of the country (Madhya Pradesh, Delhi and Maharastra) gram is not directly manured but gets the benefit from the manurial and fertilizer residues of the preceeding crop in double cropped lands. In loamy soils of Uttar Pradesh, Bihar, West Bengal, Gujarat and black cotton soils of Andhra Pradesh, the crop receives compost of farmyard manure at the rate of 12-15 tonnes/ha. Response of gram to nitrogen is not encouraging. However, it was emphasized that there is a need for 10-15 kg N/ha as a starter dose to gram. With the use of 40-50 kg P_2O_5/ha, increase in yield has been recorded in Chickpea. In places where soil is deficient in potash, additional supply of Potash may be given through the use of muriate of potash at the rate of 30-40 kg/ha. In case of P_2O_5 and K_2O deep placement at 12- 15 cm depth in band is recommended. Work on Rhizobium in the all India Co-ordinated Pulse Improvement Project indicated that in Chickpea where there was significant increase in yield due to *Rhizobium* inoculation has also been obtained. Similarly, no response was noted due to *Rhizobium* where N application also did not improve the yield.

18.4.7. Rotations and Mixtures

Gram when grown as pure crop, it is rotated with jowar, bajra, wheat, coriander, cotton and occasionally rice. Gram is grown after rice in wet lands.

Gram is grown either alone or mixed with wheat, barley, linseed, safflower or mustard. In mixed crops, gram does well when rainfall is low while other crops fare better when rainfall is more. When gram is taken along with wheat, a seed rate having 2/3 wheat and 1/3 gram seems to be economical.

18.4.8. Irrigation

Gram is generally grown as a dry crop, however, re-sowing irrigation ensures good germination and better establishment of the crop. One light irrigation in the middle of December or at secondary branching stage helps the crop growth and reduces plant mortality from wilt. Second irrigation, if necessary, should be given at pod-filling stage. Care should be taken to irrigate lightly and avoid water stagnation.

18.4.9. Weed Control

The crop is generally not weeded since it is supposed to be highly competitive and suppresses the weed growth. However, weed control in early stages either mechanically or chemically was found to increase the yields.

18.4.10. Harvesting, Threshing & Yield

In about 3-31/2 months the crop matures and good portion of the leaves become reddish brown and dry and shed on the field. Harvesting is done usually in mornings to prevent the pods from dehiscing and shattering the seeds, plants are cut by sickle close to the ground or pulled out. The plants are dried and cattle threshed. The threshing is also done by beating the plants with sticks.

The average gram yield under rainfed conditions ranges from800- 1000 kg/ha. Under ideal conditions, the yield may go upto 1800- 2000 kg/ha.

18.5. IMPORTANT PESTS AND DISEASES ON RED GRAM AND BENGAL GRAM

18.5.1. Pests of Redgram & Bengalgram

1. Pod borer *(Heliothis armigera)*

Symptoms: This attacks both red gram and Bengal gram. At the time of feeding it thrusts its head inside the pod leaving the rest of its body outside. The larvae feeds on the tender foliage and as they grow, they bore into the pods and feed on the seed contents.

Control: Spray of Endosulfan (1.75 ml/litre) or Fenvalerate (0.5 ml/litre) or DDT-50 WP (3g/litre).

2. Plume moth *(Exelastis atomosa)*

Symptoms: The larvae bores into the pods and feeds on seed. It also feeds on flower buds at flowering and cause heavy damage to flowers.

Control: (a) Collecting and destroying the larvae, (b) Spray Thiodan (1.78 ml/litre) or carbaryl (2.5 g/litre).

3. Pod fly *(Melanagromyz obtusa)*

Symptoms: The maggot bore into the pods and feed on the seeds. The larvae first enter the pod by boring through epidermis into the seed without rupturing the seed coat. Then larvae bores into cotyledons and feed.

Control: (a) Spray Endosulfan (1.75 ml/lit) or Carbaryl (2.5 g/lit), (b) Advance the sowing time in endemic areas.

4. Spotted pod borer *(Maruca testulalis)*

Symptoms: The larvae webs together the flower buds and feed on them. They bore into pods and feeds on the seeds.

Control: Spray Thiodan (1.75 ml/lit) or carbaryl (2.5 g/lit).

5. Etiella pod borer *(Etiella zinckenella)*

Symptoms: The larvae feed on the floral parts and newly formed pods and seeds.

Control: (a) Spray Thiodan (1.75 ml/lit) or carbaryl (2.5 g/lit).

6. Green plant bug *(Nezara virudula)*

Symptoms: The nymphs and adults suck the sap from the plants and leave the plants pale. The sucking of sap from the green pods results in the loss of weight.

Control: (a) Spray Thiodan (1.75 ml/lit) or Carbaryl (2.5 g/lit).

18.5.2. Diseases of Redgram

1. Powdery mildew *(Leveillula taurica)*

Symptoms: The fungus attacks the leaves on both the surfaces. The symptoms are characterised by powdery whitish growth on both surfaces. In serious cases of infection premature defoliation is also noticed.

Control: (a) Sulphur dusting at the rate of 10-12 kg/acre.

2. Leaf spot *(Cercospora indica)*

Symptoms: Small brown spots are developed on the under surface of the leaf. The lesions enlarge to become angular and are bound by veins. The infection may lead to premature defoliation.

Control: (a) Spray Dithane M-45 (2.5 g/lit) or Bavistin (1 g/litre).

3. Wilt *(Fusarium odum)*

Symptoms: The characteristic symptom of the disease is the wilting of seedlings and adult plants as though they are under going drought stress even when the soil is with plenty of moisture. The leaves of the infected plants turn yellow prematurely and the foliage droops followed by wilt.

The earliest branches which wilt early arise from the discolored parts of the stem.

Control: (a) Incorporation of heavy doses of green manure in between the rows reduces the soil borne population of the fungus.(b) Long crop rotation. (c) Growing resistant varieties like NP 15 and NP 38.

18.5.3. Diseases of Bengal gram

1. Foot rot *(Operculella padwickii)*

Symptoms: Water soaked lesions are developed on leaves initially which later develop into roundish spots, with brown margin and grey centre. The stem infection may lead to girdling and eventual death of the plants. In some cases the lesions may coalesce and result in the blighting of leaves.

Control: (a) Field sanitation, (b) Crop rotation.

2. Blight *(Ascochyta rabiei)*

Symptoms: Water soaked lesions are developed on leaves initially which later develop into roundish spots, with brown margin and grey centre. The stem and pods may also be affected. The stem infection may lead to girdling and eventual death of the plants. In some cases the lesions may coalesce and result in the blighting of leaves.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed. (b) Incorporation of green manure.

3. Wilt *(Fusarium orthoceros)*

Symptoms: The initial symptoms in the field is wilting and drooping of the plants followed by death. The leaves may become yellow and drop prematurely.

Control: Incorporation of green manure and other organic manures.

4. Rust *(Uromyces ciceris - arietinii)*

Symptoms: The fungus initially produces small oval brown powdary lesions on both surfaces of leaves. With the advancement of diseases the lower surface may be completely covered with rust pustules.

Control: (a) Sulphur dusting at the rate of 10-12 kg/acre.

Check Your Progress - 3, 4 and 5

3. The Scientific name of spotted pod borer is____________________________.
4. Wilt of Redgram is caused by ______________________________.
5. Bengalgram blight is caused by ______________________________.

Note: (a) Write your answers in the spaces given above.
(b) Compare your answers with those given at the end.

18.6. SUMMARY

About 90% of the world redgram is produced in India. Redgram is extensively used as 'dhall' and it adds protein in the diet of South Indian people. In India, Maharastra stands first in area, while Uttar Pradesh stands first in production. Pigeonpea is a tropical crop and one of the most important heat and drought resistant pulse crops. Though it can be grown on all types of soils, well drained alluvial and loamy soils are best suited for it. Rabi redgram requires close spacing and double the seed rate as it undergoes agronomic dwarfing. Redgram varieties suitable for Kharif are : ICPL-1-6, Hy-3A, Hy-3C, PDM-1, Hy-1, Hy-2 etc. Redgram varieties suitable for rabi season are C-11 and LRG-30. It is rarely grown as pure crop and forms a companion crop to cereals in inter cropping systems. Seed rate for pure crop in Kharif is 15 kg/ha but for mixed crop the seed rate depends on the proportion of this crop. General spacing is 60-75 x 20-30 cm. Optimum fertilizer requirement is 25 kg N + 60 kg P_2O_5 + 25 kg K_2O/ha and should be applied before sowing. Yield ranges are Mixed crop : 500 - 600 kg/ha; Inter crop : 800 - 1000 kg/ha; Kharif pure crop : 1500 - 2500 kg/ha; Rabi Redgram : 1500 - 2000 kg/ha. The important pests are pod borer, plume moth and pod fly.

Bengal gram occupies 34% of the area and accounts for 46% production of all pulses grown in India. Germinated seeds of Bengal gram are recommended to cure "Scurvy" and Malic and Oxalic acids collected from green leaves are used for intestinal disorders. In India, Madhya Pradesh stands first both in area and production of Bengal gram. Gram is a winter crop but severe cold is injurious and very harmful. This crop grows with the help of residual soil moisture and hence moisture retentive black cotton soils are best suited. The most suitable variety for Andhra Pradesh is "Jyothi". Seed rate ranges from 45 to 75 kg/ha and sowing is done by drilling keeping row to row distance of 30 cm. Fertilizer requirement is 10-15 kg N + 40-45 kg P_2O_5 + 30-40 kg K_2O/ha. Fertilizers should be applied in bands before sowing. Gram is grown either alone or intercropped with wheat, barley, linseed, safflower or mustard. The average grain yield under rainfed conditions ranges from 800- 1000 kg/ha. Under ideal conditions the yield ranges from 1800- 2000 kg/ha. The important pest is pod borer and disease is wilt.

18.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Madhya Pradesh is the highest Redgram producing state in Andhra Pradesh.
2. Afganisthan and Persia
3. *Maruca testularis*
4. *Fusarium odum*
5. *Ascochyta rabici*

18.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write in detail the cultivation aspects of redgram crop.
2. Write in detail the 'Package practices' for bengal gram crop.
3. Briefly discuss about the important pests and damage caused by them in redgram and bengalgram crops and their control measures.
4. Write in detail about the diseases of redgram and bengalgram and their control measures.

II. Answer the following questions in about 10 lines each.

1. Write about the economic importance of redgram and bengalgram.
2. Write about the seasons for Redgram crop.
3. Write about seed rate, spacing and fertilizer requirement for redgram and bengalgram crops.
4. Write briefly about the water management for redgram and bengalgram crops.
5. Write briefly about the varieties of redgram.

UNIT - 19 : SUGARCANE

Contents

19.1. OBJECTIVES

After going through this unit you will be able to :

1. describe the climatic and soil requirements for sugarcane,
2. list out the early maturing, midseason maturing and late maturing varieties,
3. explain the planting season, preparation of seed canes, types of seed material, seed treatment, seed rate, spacing and methods of planting.

4. list out the manures and fertilizers required for sugarcane at different periods and describe the method of application,
5. describe the different methods of inter-culture practices,
6. describe the method of harvesting and the process of jaggery making,
7. list out the important pests and diseases of sugarcane and describe the symptoms caused by them and suggest the control measures.

19.2. INTRODUCTION

Sugarcane is one of the most important commercial crops of India. It is being cultivated since ancient times and it is the main source of sugar in the world, as it is contributing nearly 60% against 40% by sugarbeet. The average per capita consumption of sugar in the developed countries, U.S.A., U.K., U.S.S.R. and Japan is 45 kg or more, while it is 15 kg including jaggery in India.

It is believed that it has been originated from India. Out of 74 countries that are growing these crop, India, Brazil, Cuba, U.S.A., Indonesia, U.S.S.R., Japan and Taiwan are important. In India it is being cultivated in all the states except in Jammu and Kashmir. The area under this crop in India is 3.36 million hectares with a total production of 189.1 million tonnes of cane. Andhra Pradesh stands 6th in area 3rd in production, while Uttar Pradesh stands first both in area and production. The highest average cane yield is obtained in Karnataka, with very low yield in Uttar Pradesh. Next to the textile industries in India sugarcane factories are providing gainful employment to a large number of people.

19.3. SOILS

Sugarcane is grown under varied soil conditions. Major sugarcane growing soil groups are alluvial, black and red soils. In Indo- Gangetic plains, it is cultivated on loam and clay loam soils, while in South India it is grown on brown, reddish loams, laterites and black cotton soils. The red soils are not very deep, generally sandy loam to loam in texture. The most common types are alluvial or clay soils. Well drained loamy soils are suitable. The black soils of delta areas of Andhra Pradesh crack deep in summer, causing lodging. Soils with pH range of 7.5-8.0 are most suitable for high yields. High level lands without water stagnation even in monsoon months are ideal. In alkaline soils (pH 8.0), the growth and tillering will be poor than in neutral soils, but better than in acid soils. In alkaline soils the quality of juice is poor.

19.4. CLIMATIC REQUIREMENT

Sugarcane is considered essentially a tropical plant, but it is also grown under sub-tropical climate. Temperature, light and moisture are the principal climatic factors that control crop growth. Temperatures above 50°C arrests its growth and below 20°C slow down the growth markedly. The crop will not be able to withstand severe frost conditions. The crop grows well in the tropical regions receiving a rainfall of more than 750 mm. For ripening it needs a cool dry season but prolonged at ripening period affects the quality of juice. Warm and moist conditions at ripening period, are not congenial. It is not advisable to grow, crop where typhoons and hurricanes are expected as they cause crop lodging.

Abundant light promotes tillering. Plants that grow in full sunlight have thicker and shorter stalks, greener and broader leaves and a higher percent of sucrose. In coastal area of Andhra Pradesh rapid growth was observed from June-October due to congenial temperatures and high humidity. In North India, the grand growth period is comparatively shorter due to prolonged winter resulting in low cane yields. Since the temperature in coastal districts are not very low, the quality of cane (Sucrose %, % Purity) is not as good as in the districts of Nizamabad, Chittoor and Anantapur, where the temperatures are congenial. Rainfall increases the relative humidity in atmosphere which helps in increased cane growth.

19.5. VARIETIES

In a given climatic conditions variety plays the key role in respect of cane yield or sugar production because of its genetic potentiality. There are varieties that suit different kinds of soil and other environmental conditions. The response of varieties to adverse or favourable conditions varies with their genetic composition.

Varieties have been grouped for the purpose of their cultivation with reference to their time of maturity or juice sucrose content at a particular period of harvest. The various groups are as follows:

19.5.1. Early Maturing Varieties (10 months)

These varieties have not less than 16% juice sucrose with 85% purity at the age of about 10 months in November or December. The yield potential is 100-106 ton's/ha. The early maturity varieties are;(i) CO-A-7701, (ii) CO-7508, (iii) CO-6907, (iv) CO-A-8201, (v) CO-T-8201, (vi) CO-C-671, (vii) CO-997, and (viii) CO-A- 711.

19.5.2. Mid-Season Maturing Varieties (11-12 months)

These varieties have about 18% juice sucrose with 85% purity at the age of about 11-12 months in the period January-March. The yield potential is 120 t/ha. The mid season maturing varieties are (i) CO-975, (iii) CO-A 7602, (iii) CO-62175, (iv) CO-6304, and (v) CO-7602.

19.5.3. Late maturing varieties

There varieties have not less than 14% juice sucrose with 85% purity at the age of about 13 months or above during March or later on. The yield potential is 142 t/ha. The late maturing varieties are (i) CO-22175, (III) CO-719 and (iii) CO-419.

Early maturing varieties can serve for opening of cane mills in any sugar factory. The sugar recovery in these varieties are least affected by seasonal varieties in different years. Early maturing varieties are generally poor in cane yield than mid- season and late varieties. However, the sugar yield per unit area and time was higher in early maturing varieties.

Sugarcane is generally planted throughout India from January- March. In Andhra Pradesh, the optimum date of planting is the 3rd week of January.

19.5.4. Adsali Crop

In Maharastra and parts of Nizamabad district in Andhra Pradesh adsali crop is grown. The varieties that are planted will be kept in the field for 18 months or more and normally this crop is planted from June to September in an year. Planting has to be taken up as early as possible in fields that are liable for water stagnation during monsoon season. Variety CO-R-8001 released from Rudrur was found to be promising for growing as an adsali crop as this variety was found to give an yield about 160 tons per hectare.

Check Your Progress - 1

Give three examples of late maturing varieties of sugarcane.

Note :(a) Write the answers in the space given below.

(b) Compare your answer with the one given at the end.

....

....

19.6. PREPARATORY CULTIVATION

Crop requires fine tilth. Ploughing with country or iron plough is common for preparing the land and also breaking of clods and pulverisation of soil. Tractor ploughing in some parts have become common. After field preparation, furrows are formed for planting cane. In East and West Godavari districts cane is planted on the flat beds and subsequently shallow channels are made adjacent to the cane rows.

In some places trenches of 20 cm deep and 40 cm wide made at 60 cm apart are made for planting sugarcane. The cane yields are higher in trench planting than planted in shallow furrows. These trenches are prepared with human labour or using a tractor drawn implement, namely Ridge Mar. Trenches are made directly without any initial preparation of the land. The advantages of trench planting are as follows:

1. Cost of cultivation is less
2. Pulverisation is done simultaneously
3. High moisture can be maintained
4. Shoot borer attack is less
5. Higher yields can be obtained
6. Ratoon crop yields are better.

It is not desirable to make deep trenches in saline soils, alkaline soils, and also in shallow soils. presence of higher salt concentration in saline soils and murram in shallow soils at lower layers are detrimental to germination of buds.

In soils, where hard pans or impermeable horizons exist in the subsoil, it is necessary to disturb these layers to encourage deep rooting. In regular soils of Nizamabad district of Andhra Pradesh, deep ploughing upto 40 cm is done to break hard pans in sub-soil.

19.7. SUGARCANE PLANTING

Sugarcane is a vegetatively propagated crop. Young canes usually 6-9 months age is generally selected for seed. The whole cane can be used for seed purpose, because the buds on the immature portion germinate better than those on the mature part of a cane. In case of old (mature) canes only the top portion of the cane is used for seed because of higher percentage of germination, and the sugar content in the top portion was also less. Therefore, when top portions from mature cane are used for planting, less sugar is wasted than when bottom (lower) portions of the cane material. In the matured cane, the lower buds (eyes) on the stem will become hardened because of long exposure to environment, and the older leaves situated on the lower nodes are likely to dry up resulting in exposure of buds and are likely to be desiciated. The buds on the mature cane take longer time to germinate because of high sugar content. Ratoon crop should not be used for seed purpose because there is danger that cane may carry the diseases of previous crop. So healthy seed material free from diseases and having high viability is required for raising a good crop.

19.7.1. Planting season

Sugarcane requires about 60°-100°F temperature for good germination. On this basis, first fortnight of March is the best time for cane planting in Punjab, February-March in Uttar Pradesh, and Janurary-February in Bihar. In Tamilnadu and Andhra Pradesh, Maharastra and Karnataka cane planting can be done between December to February.

19.7.2. Preparation of Seed Canes

This includes stripping of the leaves. If the seed canes are to be carried to long distances, leaves should not be removed. During transportation, cane bundles should be covered with a thick layer of paddy straw or sugarcane trash moistened with water. If planting is delayed by any reason, the harvested canes should be heaped under shade be heaped under shade and covered with moist cane trash or paddy straw. There after, water should be sprinkled periodically to keep the cane fresh. In North India, before planting, setts are kept in water for 8-10 hours which improves greatly the germination.

19.7.3. Types of seed material

Budded setts: The top 1/3 portion of the cane at harvest is taken and cut into 3 budded setts. In areas, where irrigation is uncertain, planting of mature cane setts, with sound buds is desirable, as they resist drought better. Three budded setts are most commonly used throughout the country. Two budded setts are planted in Punjab and in some parts of Andhra Pradesh. Studies indicated no significant variation in cane yields due to number of buds for each set. The number of buds on each set range from 2-4 or more.

Short nursery crop: Six to seven month aged cane provide immature seed setts. By raising nursery, it is possible to eliminate diseases or pests.

Spaced transplant method: This is one of the methods used to develop seedlings from single budded setts. Single budded setts are prepared by cutting at the centre of the internodal portion. Raised beds are prepared with dimension of 35-40 cm width and about 6 metres length. Channels of 30 cm wide are prepared between beds and irrigated. Setts are planted erect on beds at finger width distance between two setts (450-550 buds per square yard). Mulching is necessary. The buds sprout and develop shoots and the nursery will be ready for planting within 4-5 weeks. Twenty square metres of nursery is needed to plant a hectare.

Sprouting or setland method: Setts are planted shallow with wide spacing in heavily manured well drained soil. Frequent irrigations are given to promote profuse tillering. Soon after developing root system at nodes they are separated by cutting the cane at internode and planted separately.

Bud chip method: Buds from entire stalk is removed along with a portion of the cane by using small machine evolved and perfected at the workshop of Andhra Sugars. These bud chips are planted directly in the main field or can be transplanted after raising the nursery. Half of the bud should be buried in the soil. The buds can also be sown in a nursery leaving 1 meter between the rows. Nitrogen is applied 4 weeks after sprouting at the rate of 25 to 40 kg N/ha and the seedlings will be ready for planting in 5-6 weeks. The advantages of this method are:

1. Seed material can be treated better.
2. Saving in cost of seed material.
3. After removing buds the seed cane can be used for milling.

19.7.4. Seed Treatment

To prevent the setts from fungal diseases, they should be dipped in 0.25 per cent Agallol or 1 kg of parenox dissolved in 400 litres of water. Where termites are a problem, one kg of gamma- BHC in emulsion form diluted in 300 litres of water may be sprayed over the cut setts.

Treatment of setts in hot water at 52°C for half an hour is a standard practice in Vuyyuru (Krishna district). Hot water treatment keeps grassy shoot, ratoon stunting (Virus diseases) and smut diseases under check, if not completely eliminate them.

19.7.5. Seed Rate & Spacing

Based on the row spacing and the soundness of the buds 25,000- 30,000, three budded setts are required to plant one hectare area. By weight 1500-3000 kg of cane depending on thickness is required/ha of land. The seed rate for bud chips is 0.75 t/ha. If planting is delayed, seed rate should be increased and row spacing should be made closer to accommodate more number of setts per unit area.

Field trials revealed that planting setts at a distance of 80-100 cm between rows and 45-60 cm within the row was best to obtain optimum cane yield.

19.7.6. Methods of planting

Sugarcane setts should not be planted not more than 5 cm depth. There are three methods of sugarcane planting in India (1) Flat planing (2) Furrow planting and (3) Trench planting.

Flat Planting: After thorough preparation of the field, 8-10 cm deep furrows are opened by country plough at 75-90 cm apart. The setts are planted end to end and covered with 4 to 5 cm of soil. Thereafter field is levelled up with a beam. Irrigation is given by border strip or by basin method.

Furrow planting: Furrows are made with ridger about 15-20 cm deep. Setts are placed end to end and covered to a depth of 4-5 cm with soil. Thereafter, water is let into furrows. In some places first water is let into the furrows to soak the furrow bed and cane setts are placed in the furrows and pressed into the mud 3-4 cm below by foot. In monsoon planting, as a precaution against the stagnant water in the furrows damaging the beds, setts are placed inclined (slant) on the side of furrows.

Trench planting: Trenches are dug 20-25 cm deep, 40 cm wide with 60 cm apart by manual labour by a tractor drawn ridger. Water is then let into the trenches. Cane setts are planted end to end and pressed by feet to 3-4 cm deep into the mud.

19.8. GAP FILLING

Gap filling should be done as early as possible and not later than 30 days after planting.

19.9. MANURES AND FERTILIZERS

Sugarcane is a heavy feeder. A seventy tonnes crop removes from the soil 85 to 110 kg of nitrogen, 180 to 330 kg of phosphoric acid, 60 to 190 kg of potash and 70 to 80 kg of calcium. Adequate manuring is therefore essential for sustained high yields.

Bulky organic manures like Farm yard manure or compost at 25 t/ha has to be applied in the furrows about 4 to 6 weeks prior to planting cane. If no bulky organic manure is available, green manure crops like sunhemp or *Sesbania speciosa* may be raised on the ridges between furrows. The seed (Sunnhemp 15 kg/ha or *Sesbania speciosa* 10 kg/ha) has to be sown at the time of planting of sugarcane itself. After 50 to 60 days, depending on the rate of growth of green manure crop, the plants may be pulled out, spread between furrows and covered with soil. The incorporation of intercropped legumes could save the fertilizers to the extent of 20 to 25%.

The damage of nitrogen recommended for various tracts in Andhra Pradesh are as follows:

I. Coastal districts	Rate of N application
Srikakulam and Visakhapatnam	112 kg N/ha
East, West Godavari and Krishna	168 kg N/ha
II. Rayalaseema region	224 kg N/ha
III. Telangana region	
Nizamabad district	- Eksali crop 250 kg N/ha
Nizamabad district	- Adsali crop 400 kg N/ha
Medak district	- Eksali crop 112 kg N/ha

The application of phosphate and potash can be made normally at the rat of 125 kg each per hectare.

In some areas of Chittoor, East and WestGodavari and Nizamabad districts deficiency symptoms of iron are noticed. Spraying of 2% $FeSO_4$ solution at the rate of 5 kg/ha twice is recommended to correct the deficiency. In Medak district manganese deficiency was observed. This can be corrected by foliar application of 6-25 kg Mn SO_4/ha.

19.9.1. Time of Fertilizer Application

In coastal and Rayalaseema districts, the fertilizer N has to be applied at 45 and 90 days after planting in two equal splits. In Telangana districts the fertilizer for Eksali crop is to be applied in two equal instalments at 60 and 1150 days after planting. Application of a part of the fertilizer before 45 days when irrigation facilities are uncertain strengthens the root system and enables the plant to tap moisture even from the lower depth of the soil. The entire dose of phosphorus and potash fertilizers have to be given as basal dressing at the time of planting the setts.

19.9.2. Method of Application

Placement of N, P and K was found to be more efficient. Significant differences were not observed between different forms of nitrogen, and foliar spray on crop yield.

19.10. INTERCULTURE

Effective cultural practices carried out at proper time helps in keeping the field clean but also encourages healthy growth which is favourable for optimum production. proper coverage of setts in the soil is desirable. The sets exposed to the sun have to be pressed down in the moist soil immediately the next day after planting.

19.10.1. Hoeing

There is a practice of hoeing the newly planted soils in coastal districts when the soil moisture is optimum. This is known as blind hoeing because setts should have not germinated by this time. This is desirable in areas where water supply is scarce and where the soil is likely to encrust which prevents easy sprouting of sugarcane setts. Generally 2 to 3 hoeings have to be given to the crop during the early stages. By this method not only the soil is loosened but also the weeds are controlled.

19.10.2. Earthing Up

Earthing up is done before the start of the monsoon to prevent the lodging to the cane.

19.10.3. Mulching

Covering the soil with trash (sugarcane leaf trash or any other trash material) is practiced in some areas for conservation of soil moisture as also to suppress the weeds, especially in the very early stages of crop after planting. Application of about 3 tons of trash/ha on the next day after planting proved to be beneficial.

19.10.4. Weed Control

Weeds reduce cane yield and also in some cases the juice quality. It is impossible to keep the field weed free for entire season, as it is neither economical nor feasible. The first three months after planting is considered as critical period for weed control. So, controlling of weeds either by hoeing, or by intercultivation by implements or by using herbicides seems to be essential. In addition, some of the cultural practices like trash mulching, earthing up practices will also control the weed growth.

Normally first weeding cum hoeing is carried out within 10 days after planting. After germination weeding cum hoeing should be done after each irrigation. Thus 2 to 3 hoeing cum weedings are carried out within first 3 months after planting. Due to high cost and non-availability of labour in time excess soil moisture or too dry a soil condition might not permit hoeing or intercultural operation in time. In such cases the chemical weed control can be practised. Herbicides (chemicals used for weed control) can be applied at different periods of crop growth depending on the convenience of the farmers. They are effective in suppressing the growth of weeds for a period of 6 to 12 weeks depending upon the type of herbicide and dosage.

Herbicides recommended

Time of application	Herbicide	Dose kg a.i./ha
1.Pre-planting incorporation (Incorporating the chemical in the soil before the cane is planted)	Simazine Atrazine + 2,4-D	0.5-1.0 0.25-1.0
2. Pre-emergence application (application of chemical after planting but before emergence of cane plant. Usually applied two to three days after planting)	Simazine, Atrazine	1-2
3. Early post emergence application (Applied after emergence of cane plants but before 30 days of sowing/planting)	Paraquat Diquat	0.5-1.0 0.5-1.0
4. Post emergence application (Twice a 30 and 60 days after planting)	2,4-D Glyphosate	1.0 3-4

The common weeds infesting sugarcane fields are *Sorghum haleoense* (Johnson grass), *Cynodon dactylon* (Burmuda grass), *Cyperus rotundus* (nut grass), *Ipomoea asiatica* (Morning glory). The important parasitic weeds are *Striga* spp. (Witchweed) and *Aegintia indica*.

19.10.5. Wrapping

This is the process of twisting the bottom leaves round the cane stem, so that cane is completely covered. This ensures clean cultivation, protection of the stem from direct exposure to the sun which prevents the splitting of cane. During the crop period, 5-7 wrappings are generally given.

19.10.6. Propping

The cane is supported by bamboos to prevent the plant from lodging due to heavy winds or when the soil is too wet. Lodging may cause yield losses to the extent of 25%. As the cost of bamboos has increased tremendously, the farmers are adopting either trench method of planting or trash twist propping.

19.10.7. Trash Twist Propping

The trash twist method of propping will reduce the cost of bamboos and keep the cane in erect position.

In this process two or three canes from the adjacent rows are involved. Some dry and green leaves are twisted and spun in the form of a rope at a height of 150 cm. Two or three clumps are involved in the loop. Another tier is formed after 100cm of further growth of crop. Thus 2-3 tiers are formed depending upon the growth.

19.11. IRRIGATION

The total water requirement for sugarcane varies from 200-300cm depending upon the soil type, rainfall distribution, weather conditions, variety grown, method of planting and rate of manuring. The frequency of irrigation depends on the stage of development of the cane. The formative stage is the most critical stage as for as irrigation is concerned. Irrigation water applied at 25% depletion of available soil moisture (6-7 days interval) after planting and during tillering is beneficial in ensuring uniform emergence and an optimal number of tillers per unit area. During grand growth period, the crop has to be irrigated at 50% depletion of available soil moisture. As the cane approaches maturity, irrigations have to be restricted to reduce the rate of vegetative growth and dehydration of the cane, to force the conversion of reducing sugars to sucrose. At maturity phase (last 3 months of a 12 month crop), irrigations have to be given at 75% depletion of available moisture.

For sugarcane furrow method of irrigation was ideal. In some areas of North India, the crop is irrigated by flooding the fields.

The quality of water also affects the yield. Sodium salts, if present in irrigation water adversely affects the physical condition of the soil and ultimetely the productivity. Irrigation water having E.C. (electrical conductivity) of more than 2mm mhos/cm are not suitable for raising sugarcane.

19.12. DRAINAGE

Provision of drainage is as important as that of irrigation, other wise water stagnation impairs root function and consequently cane yields are lowered. The keeping quality of jaggery from such crops was found to be inferior to that from normal crops. In areas where drainage is a problem, cane planting should be done at the earliest (on or before 15th February). Younger crops suffer more than older ones. Variety CO-975 was found to withstand poor drainage condition followed by CO-419. Drainage channels of 45 cm deep, 60 cm wide and 24 meters apart have to be provided at the time of field preparation itself for draining excess water.

19.13. RIPENING

The maturity of the cane is judged by, the lower leaves gradually withering up, leaving progressively fewer green leaves at the top. A ripe cane cut across with a sharp knife shows against sunlight a slight sparkling appearance in its flesh in contrast to the more watering cut surface of an unripe cane. The farmers judge the ripeness of the cane, if good hard jaggery is made without difficulty. Ripeness can also be tested with hand refractometer. Few drops of juice collected from the middle of the cane is placed on the refractometer and if the brix reading is 20 or more, the cane is considered to have reached maturity.

19.14. HARVESTING & YIELD

Stalks are cut at ground level by manual labour. Then the leaves are stripped off and the stalks are cut at the top of most mature internodes where the stalk can break easily. The sugar recovery is in the range of 8-10%.

Generally the yields in South India are higher than in North India because of favourable growing conditions besides sugarcane is grown under assured irrigated conditions; where several suitable varieties were developed. In North India most of the area is under rainfed conditions.

19.15. JAGGERY MAKING

About 50-55% of the total cane produced is converted into jaggery in India. Andhra Pradesh about 60% of the total cane produced is made into jaggery. The juice extracted from cane by crushing is slightly acidic in nature and contains collodes. For reducing the acidity and flocculating the colloids, filtered lime sucrate (1:5 lime water) is added. Then the juice is subjected to boiling. The temperature of the juice by boiling has to be increased gradually so that flocculated colloids will be removed before suice started boiling. At the temperatures of 118 to 124^{o}C the juice has to be cooled and poured into moulds before it solidifies.

Check Your Progress - 2

What do you do for reducing the acdity in the sugarcane juice during jaggery making?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

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19.16 INTERCROPPING

Blackgram, Groundnut, Bhendi etc can be sown as intercrops at the time of sugarcane planting

19.17. RATOON CANE MANAGEMENT

Reduction in cost of production and early maturity are the important advantages of ratooning. In general, more than one ratooning is not recommended. Another advantage in ratooning is that under limited irrigation facilities fresh planting is difficult and requires more irrigation water.

After harvest of the crop, for raising a ratoon crop, the trash is burned and the stubble should be given an irrigation. Therefore, interrows should be ploughed to a depth of 12-15 cm for loosening the soil to enable formation of fresh roots and tillers. Gap filling and early manuring is due for better yields. Ratoon crop need 112 kg N/ha more than plant crops to give similar cane yields at those of plant crops.

19.18. CROP LOGGING

Crop logging is the periodical study made during the life cycle of the crop in order to get an insight into the relative effects of different factors on the ultimate crop performance. Among several factors tested plant moisture as reflected by moisture in leaf sheaths (3-6) during the first four months (formative phase) after planting appear to exert the most dominating influence on cane yields. For realising higher cane yields, moisture (3-6) in the formative phase should be maintained at or above 85%. This can be achieved by providing irrigations at weekly intervals and completion of the recommended level of nitrogen fertilizer within 3 months after planting. Phosphorus content of 0.08% and potash content of 1.99% in 3-6 leaf sheaths (on sugar free dry weight basis) are found to be optimum for realising satisfactory cane yields.

19.19. IMPORTANT PESTS AND DISEASES ON SUGARCANE

A. Pests

1. Early shoot borer *(Chilo infuscatellus)*

Symptoms: The larvae enter the stem just above the ground level by making a hole and feeds on central whorl and as a result the central shoot wilts and dries out. This type of damage is called 'dead heart'. The affected whorl can be easily pulled out and it emits foul smell.

Control:(a) Destruction of egg masses, (b) Trash mulching helps in reduction of pest, (c) Planting the crop in deep trenches reduces infestation, (d) Early planting in November December reduces infestation, (e) Spray Endosulfan (1.75 ml/litre) or apply Endosulfan granules or Sevidol at the rate of 1.5 kg a.i./ha.

2. Top shoot borer *(Tryporyza nivella)*

Symptoms: The larvae first bores into the midribs of leaves leaving red markings on the second to fifth leaves. From the midrib it makes a hole into central core of leaves and enters the shoot. It feeds on the growing points which eventually results in 'dead heart'. The dead heart in this case can not be easily pulled out.

Control:(a) Collection and destruction of egg masses, (b) Spray Endosulfan at the rate of 1.75 ml/litre, (c) Release of either egg parasite *Trichogramma minutum* or *Isotima javensis*, larval parasite.

3. Stem borer or Internode borer *(Chilo sacchariphagus indicus)*

Symptoms: The larvae makes entry into the stem by boring at he nodal region and feed the inner contents and as a result the tissues turn red.

Control : (a) Collection of egg masses and their description by burning, (b) pray Endosulfan (1.75 ml/litre), (c) Release the egg parasite, *Trichogramma australicum.*

4. Sugar cane scale *(Melanaspis glomerata)*

Symptoms : The insects infest the crop at the time of formation of internodes. The scales appear as shiny mass at the lower nodes of the plant and extends upto the middle. The nymphs and adults suck the sap from the stem and leaves. The infested cane gets shriveled and the internodal length gets reduced.

Control:(a) The setts should be drenched in 0.1% emulsion malathion or Dimethoate for 15 minutes, (b) Apply Disulfaton granules at the rate of 20 kg/acre as placement at the base of the plant at 5" deep, (c) Grow resistant varieties like CO-70 and A-11 in endemic areas, (d) Spray malathion or Dimethoate (1 ml/litre) after the removal of leaf trash of basal leaves, (e) Release predators like *Pharoscymnus hornii* or *Chilocoris nigrites.*

5. Mealy bugs*(Saccharicoccus sacchari)*

Symptoms : Beneath the leaf sheath, colonies of mealy bugs develop and both adults and nymphs suck the sap from the cane. The population of the bugs increases under drought conditions.

Control :(a) Detrash the leaves and spray malathion (1.5 ml/litre) or Fenitrothion (1 ml/litre), (b) Destruction of crop rescues after harvest, (c) Selection of pest free seed material.

6. Leaf hoppers *(Dictyophora pallidae)*

Symptoms: The nymphs and adults suck the sap from the lower surface of leaves. The infested plants appear sickly and shows blighted appearance.

Control: (a) Spraying Monocrotophos (1.5 ml/litre) or Phosphamidon (1 ml/litre) or Dimethoate (1 ml/litre), (b) Trash should be burnt after harvest, (c) Collection and destruction of eggs.

7. White grub *(Holotrichia consanguinea and H.serrata)*

Symptoms: The grubs feed on the roots and root hairs and kill the entire plant. The affected plant completely dries up.

Control: (a) Application of phorate or carbofuran granules in two equal splits, one at the time of planting and the second one month after planting, (b) plough the field deep in summer after harvest to expose the grubs.

8. Mites *(Paratetranychus indicus)*

Symptoms: Nymphs and adults suck the sap from the under surface of leaves. The affected leaves show yellowing initially and later develop into red patches.

Control: Dust sulphur at the rate of 10-12 kg/acre or spray Dicofol at the rate of 5 ml/litre.

B. Disease

1. Ring spot of Sugarcane*(Leptosphaeria sacchari)*

Symptoms: The initial symptoms start as purple spots on both surfaces of leaves. The spots are elongated irregularly and scattered over the whole or part of the leaf blade. In severe cases of infection the leaf dries up and withers prematurely.

Control: Grow resistant varieties like B.O. 32, CO-245, 312, 324, etc.

2. Sett rot *(Ceratocystis paradixa)*

Symptoms: The fungus mainly affects the sugar cane setts. The diseases setts may rot before germination or the shoots may die after growing to a height of about 15-30 cm. The Central portion of the stem becomes red and emits typical pineapple smell.

Control:(a) Healthy setts to be planted, (b) Treat the seeds with Thiram or Ceresan or Agallol, (c) Hot water treatment.

3. Smut *(Ustilago scitaminea)*

Symptoms: The infected plants are stunted and central shoot is replaced by whip like black shoot, several feet in length and curved.

The early stages the whip is covered by a thin silvery white film. At maturity the film ruptures releasing black powdery spores. The spores can be easily blown out even by little wind.

Control: (a) Avoid planting of setts from smutted canes, (b) Disinfect setts by treating with Agallol (0.25%) for 5 minutes or Formalin (1%) for 5 minutes, (c) Removal of smutted whips from the field and destructing them, (d) Discourage the practice of ratooning, (e) Plant resistant varieties like CO-285, 356, 385, 449, 523 etc.

4. Red rot *(Collectotrichum falcatum)*

Symptoms: The young leaves are discolored initially and margins and tips of the leaves wither and droop. In later stages the canes get shrivelled, the rind sinks and becomes longitudinally wrinkled. The leaves of the infected plants show symptoms in the form of dark red lesions in the midrib, which may elongate and turn blood red with dark margins and later with straw coloured centres.

Control: (a) Selection of healthy setts from disease free crop, (b) Treating the setts in Bordeax mixture, (c) Discourage ratooning, (d) Crop rotation, (e) Growing resistant varieties like CO 244, 285, 301, 349 etc.

5. Wilt disease *(Cephalosporium sacchari)*

Symtoms: Stunting and gradual withering is the initial symptom. The leaves of the infected clumps turn yellow and withers. The affected canes become light and hollow and dries up. A typical disagreeable doou is also associated with the infected canes. Gradually the pith becomes hollow and hollowed portions show mycelial growth bearing large numbers of conidia.

Control: (a) Select healthy setts and treat with Agallol before planting, (b) Grow resistant varieties like CO 356, 370, 343 etc.

6. Red stripe *(Xanthomonas rubilineans)*

Symptoms: The lesion starts with red stripes of 0.5 to 1 mm in breadth and several mm in length. As the disease advances several of the lesions may coalesce causing wilting and drying of leaves. The growing points of the affected shoot are yellow and later turn reddish with dark brown stripes. The affected canes show cavities in the pith region and the vascular bundles show dark red discolouration. The diseased and rotting shoots can be easily pulled out.

Control: Removal and destruction of affected plants.

7. Mosaic

The disease is caused by Sugarcane Mosaic virus.

Symptoms: Pale patches or blotches in the green tissues of the leaf will appear first. Small areas of th leaf are paler green colour than the rest. The patches are not uniform. The areas are oval or elongated. The unfolded leaves show mottling.

Control: (a) Use of healthy setts as seed, (b) Roguing of infected plants, (c) Elimination of weed hosts.

Check Your Progress 3,4 and 5

3. The Scientific name of Top shoot borer of Sugarcane is ________________________

4. The smut of Sugarcane is caused by ______________________

5. *Colletotrichum falcatum* causes ______________________ disease of Sugarcane.

Note: (a) Write your answers in the spaces given above.

(b) Compare your answers with those given at the end.

19.20. SUMMARY

Sugarcane is the main source of sugar in India. Sugarcane factories provide gainful employment to a large number of people. Well drained loamy soils with pH range of 7.5 to 8.0 are most suitable for high cane yields. Temperature, light and moisture are the principal climatic factors, which influence the crop growth. Areas receiving more than 750mm rainfall are ideal. Warm and moist conditions at ripening period are not congenial. Early maturing varieties are generally poor in cane yield than mid season and late varieties, but the sugar yield per unit area and time was higher in early maturing varieties. The crop requires fine tilth. The setts should not be planted more than 5 cm depth. The optimum sowing period is from January to March for early, medium and late season varieties, and June to September for Adsali crop. Planting is done either in furrows, trenches or on flat beds. Healthy seed material free from diseases and having high viability are used for raising a good crop. Three budded setts from young canes of 6-9 months age or the top setts of mature canes are generally used for seed purpose. Sugarcane is a heavy feeder of nutrients. So, adequate manuring is essential for obtaining high yields. The fertilizer nitrogen is to be given at 45 and 90 days after planting, whereas the entire dose of phosphorus and potassium fertilizers are to be applied as basal at the time of planting the setts. The crop planted by trench method is less prone to lodging. Wrapping and propping prevents the cane from lodging and also protects the cane from direct exposure to sunlight and wild animals. Earthing up is done before the start of the monsoon to prevent lodging of the cane. The total water requirement varies from 2000 to 3000 mm. The formative stage of crop growth is most sensitive for moisture stress. Ripeness of the cane is judged based on the hard jaggery made from cane juice. The ripeness can also be tested with hand refractometer. Early maturity and reduction in cost of production are important advantages of ratoon cropping of sugarcane. After reducing the activity, the juice is to be boiled at temperature of 118 to 124^{0}C and cooled for making jaggery. Incidence of pests and diseases can be kept under check by selecting resistant varieties, early planting of disease-free seed material after treating with chemicals, besides following crop rotation, avoiding ratoon cropping and by destroying the crop residues.

19.21. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The late maturing varieties of Sugarcane are (a) CO-62175, (b) CO-7219, (c) CO-419
2. The acidity of sugarcane juice during jaggery making is reduced by adding filtered lime sucrate.
3. *Tryporyza nivella*
4. *Ustilago scitaminea*
5. Red rot

19.22. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Explain, how the various climatic factors influence the crop growth, yield and quality of cane?
2. Discuss the various types of seed materials used for sugarcane planting.
3. Describe the three methods of sugarcane planting in India?
4. Write about the minuria and fertilizer requirement of sugarcane with special reference to dosage and time of application recommended for various tracts in Andhra Pradesh?
5. Give a detailed account of irrigation aspects of sugarcane crop?
6. Write the symptoms of Ringspot, Sett rot, Smut, Wilt and Mosaic diseases in sugarcane crop?

II. Answer the following questions in about 10 lines each.

1. Describe the salient features of early, mid season and late maturing varietal groups?
2. Give a brief account of the soils of sugarcane growing areas?
3. Explain, briefly, the management aspects of ratoon sugarcane.
4. Describe, in brief, the process of jaggery making?
5. Write about crop logging in sugarcane.
6. Write the nature of damage (symptoms) of Early shoot, Top shoot and stem borers on sugarcane?

UNIT - 20 : COTTON

Contents

20.1. OBJECTIVES

After going through this unit you will be able to:

1. list out the cotton regions of Andhra Pradesh and describe each one of them,
2. list out the species of *Gossypium* included in old world cotton and new world cotton,
3. describe the climatic and soil requirements for cotton,
4. describe the method of preparation of land and the process of sowing the seeds of cotton,
5. list out the manures and fertilizers required for cotton at different periods and describe the method of application,

6. describe the after cultivation practices,
7. list out the Important pests and diseases of cotton and describe the symptoms caused by them,
8. describe the method of harvesting of cotton and estimate the yields,
9. evaluate the quality of cotton produced.

20.2. INTRODUCTION

Cotton is most important commercial crop of the world which is often referred to as 'white gold'. It plays a significant role on socio-economic life as it links the cultivation, the industrialist and the shop keeper in a chain of production, processing and marketing. It is foremost among the fibre crops, providing the most essential requirement of mankind, the clothing. Although cotton faces a tough competition with synthetic fibres in the market, it is being preferred for its softness and moisture absorption properties which give more comfort over synthetics. It supplies the basic raw material for cotton textiles industry which is the oldest industry. It is the largest industrial segment in the country in terms of value of output and labour employed directly or indirectly. There are 688 cotton textile mills in India, providing direct employment to 9 lakh workers and indirect employment to 25 lakh people through powerlooms, handlooms charkas etc.

Cotton is cultivated in about 60 countries of the world but ten countries, viz., the U.S.S.R, USA, China, India, Brazil, Pakistan, Turkey, Egypt, Mexico and Sudan contribute nearly 85 per cent of the total production.

India ranks first in acreage but occupies fourth position in production. The average lint yield is 160 kg per hectare which is the lowest in the world.

The reason for low yields of cotton in India can be listed as follows:

(a) About 76 per cent of cotton area is under rainfed conditions which is subjected to vagaries of weather conditions.

(b) A considerable area of cotton is still occupied by desi cottons *(G. arboreum* and *G. herbacium)*which are low yielders.

(c) Most of the rainfed cotton is grown in soils having less fertility with out proper management practices including fertiliser application.

(d) Fish yielding and better quality American and Egyptian type *(G. hirsutum & G. barbadense)*are being grown without proper plant protection measures which are most susceptible to pest attack.

In India cotton is being grown from the sub-Himalayan Region in the north to the extreme. South tip. The major cotton growing area is confined to peninsular India comprising Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Punjab and Rajasthan and Northern India.

In Andhra Pradesh it is grown in an area of about 4.43 lakh hectares with a production of 5.89 lakh bales of cotton. Andhra Pradesh ranks 6th both in acreage and production in the country. The important districts growing cotton in terms of acreage are Adilabad, Guntur, Kurnool, Prakasam and Anantapur

20.3. COTTON REGIONS OF ANDHRA PRADESH

The state of Andhra Pradesh is divided into 3 cotton regions. They are: (1) Northern Region,

20.3.1. Northern Region

It comprises mainly of Adilabad district bordering Maharastra State. In this region two distinct agro-climatic areas exists.

(i) The high plains locally called " Ghat area" are characterised by fairly assured rainfall of 1000 mm and above from June to October. *G.hirsutum* (American) cottons are cultivated. L 147 and Buri 1009, DHY-286 are the popular varieties. The soils are fairly deep and retain moisture for long periods. The total area of 0.4 lakh hectares is under this ghat area.

(ii) the plains the soil is deeper than in ghat area but the rainfall is less and also not assured and is ill distributed. *G. arboreum* (Gaorani) is the cotton variety grown in this area covering 0.3 lakh hectares. Gaorani cottons which have strong fibre and fine quality lint are in great demand by the mills. Gaorani 6 and Saraswathi are the recommended varieties for this tract.

20.3.2. Central Region

Cotton is grown mainly under rainfed conditions and is spread over mainly in Kurnool district. The total area in this region is 1.75 lakh hectares which can be classified into five distinct areas as follows:

(a) **Mungari region:** The soils are light and the cotton *(G. arboreum)*is cultivated in early Kharif (Mungari) season in about 0.4 lakh hectares. At present a non-descript variety, Pandarpuri is grown. Srisailam is now recommended for this tract.

(b) **White Northerns:**This was the important cotton area in the past.*G. arboreum* was predominantly cultivated but with the advent of *G. hirsuttum* and area under this particular type of cotton has dwindled considerably and now occupies only 0.2. lakh hectares as against 0.6 lakh hectares. The soils are very deep and highly moisture retentive. Sowings are possible only by the end of August or early September. Eventhough 650 mm rainfall is received, it is unpredictable both in intensity and distribution. Nandicum and Mahanandi are the recommended varieties for this tract.

(c) **Rainfed Americans:** In the black cotton soils, American cottons (Laxmi, Hampi and Mahalaxmi) are cultivated in 0.80 lakh hectares under rainfed conditions. In years of good rainfall the yields are assured but in years of inadequate and ill distributed rainfall the yields suffer very much.

(d) **Westerns:** This area is mostly confined to about 0.2 lakh hectares of black cotton soils of Western taluks of Kurnool district. Varieties, Western-I and Jayadhir are largely cultivated as they had the ability to withstand drought better than all other cottons. The farmers therefore grow both westerns *(G.herbaceum)* and also American cotton. The fibre of Westerns is coarse and short staple type.

(e) **Irrigated cottons:** Of late in abut 0.1 lakh hectares American cottons specially the hybrids like H-4 and DCH-32 are being cultivated under irrigation. The yields are fairly good. In rabi season also some area is under American cottons. Though the area at present is very limited, it is expected to increase in future.

20.3.3. Eastern Region

This is the major quality cotton producing region, and has come to occupy top place in our country. It comprises Nagarjuna Sagar Project area of Guntur and Prakasam districts with an acreage of 1.2 lakh hectares. To some extent in Nalgonda and Krishna districts also, these long staple cottons are being cultivated. The area in other adjacent districts is estimated to be 0.2 lakh hectares. Again under Nagarjuna Sagar Project, there are two distinct regions (1) black soil area and (2) the light-red soil area. With the extension of irrigated area to lighter soils, the acreage under cotton is likely to touch 2 lakh hectares in the near future. Both extra long and superfine cottons are produced in this zone. The varietal composition is 75% MCU, 5% Hybrid-4 and 20% Varalaxmi and Suvin.

Besides the above area where cotton is grown in kharif season, cotton is also grown in rabi season in rice fallows in about 0.08 lakh hectares. With improvement in irrigation facilities it is likely that this area will increase in future.

20.4. SPECIES COMPOSITION

In India all the four cultivated species of cotton are grown. The four species of Gossypium are divided into 2 groups-1. old world cotton and 2. New world cotton.

20.4.1. Old World Cotton (Desi cotton)

1. *Gossypium arboreum*
2. *Gossypium herbaceum*

These are diploids having 26 chromosomes (2n). The fibre is coarse and short-stapled.

20.4.2. New World Cotton

3. *Gossypium hisutum* (American or upland or Cambodia cotton); These are tetraploids having 52 chromosomes (2n). Fibre is fine and long stapled.
4. *Gossypium barbadense* (Egyptian or Sea Islands or Andrews); These are tetraploids having 52 chromosomes (2n). Fibre is fine and extra long stapled.

Gossypium hirsutum is the predominant species covering 50% of the cotton area in India followed by *Gossypium arboreum* with 29 per cent and *G.herbaceum* with 21 per cent. The area under *G.barbadense* is negligible and covers only a few thousand hectares. Efforts are being made to increase the area under *G.hirsutum* by replacing the old world species which are low yielders and having short fibre length. In USA *Gossypium hirsutum* occupies 99 per cent and one per cent of *G.barbadense*. In U.S.S.R. 92 per cent of the area is occupied by *G. hirsutum* and *G. barbadense* occupies the remaining eight per cent.

Check Your Progress 1 & 2

1. Write the names of three cotton regions of Andhra Pradesh?

2. What are the species of *Gossypium* that are included in New world cotton?

Note:(a) Write the answers in the space given below

(b) Compare your answers with those given at the end.

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20.5. VARIETAL IMPROVEMENT PROGRAMME

In place of desi cotton, earlier attempts were made by the East India company to introduce *hirsutum species* from America, Egypt, Brazil, Peru etc. Improvement in the varieties was achieved through the breeding programme of hybridization and selection. Varieties suitable to the different regions were released. India has the distinction of developing and releasing hybrid in cotton for commercial cultivation on a large scale by employing manual labour. So far male sterile line in cotton for commercial exploitation by natural crossing is not available. Some of the varieties and hybrids recommended for cultivation in different parts of the country are MCU 5,9, Varalaxmi, Bhagya, Mahanandi etc.

New Hybrids

1. Savitri hybrid (Inter specific hybrid)-Irrigated area of Maharastra.
2. Godavari hybrid (Inter *hirsutum* hybrid)-Rainfed areas of Marathwada in Maharastra.
3. Suguna (Inter *hirsutum* hybrid)-Rainfed and irrigated areas of Tamil Nadu, Andhra Pradesh, and Karnataka.
4. DCH-32 (Dharwar cotton hybrid)-Inter specific hybrid. Suitable for irrigated tracts of Andhra Pradesh and Karnataka.

20.6. CLIMATIC REQUIREMENT

Cotton is essentially a tropical and subtropical crop thriving well under hot and humid climates. The minimum temperature required for germination is 15^{o}C. The optimum temperature range for vegetative growth is 21-27^{o}C. It does not grow well when temperatures are below 21^{o}C but it can tolerate high temperature upto 43^{o}C. During the period of fruiting, warm days and cool nights with large diurnal variations are conducive for fibre development and better yields, lack of sufficient sunshine hours will prevent ripening of boll to full maturity. For getting good quality produce, bright sunny days are essential.

It can be grown under rainfed conditions in regions receiving a minimum annual rainfall of 500 mm with 200 mm of rainfall well distributed over the growing season. It requires sufficient rainfall during the early stages of its growth. Continuous rains or a long spell of dry weather may affect the germination or retard the crop growth. During vegetative growth, moderate rainfall is required. Heavy rains at flowering and fruiting time may cause heavy shedding of buds and young bolls. A dry period is essential for bolls to ripen and burst properly.

20.7. SOILS

Cotton is grown in a variety of soils. It requires well drained soils as it can not tolerate water logging. It is mainly grown as a rainfed crop in black cotton soils of central India and light black soils of the Deccan plateau and as an irrigated crop in alluvial soils of the Punjab, Haryana, Rajasthan and Uttar Pradesh and red lateritic soils of Tamil Nadu, Kerala and Assam. It can be grown in soils having pH values ranging from 5.5 to 8.5.

20.8. SOWING SEASON

The sowing season of cotton varies considerably from tract to tract because of differences in climate, soils and varieties grown. There is practically no month in the year when sowing do not take place in some part of the country or other. In major cotton growing tracts of the country viz, Maharastra, Gujarat, M.P., Punjab, U.P., northern districts of Andhra Pradesh, parts of Karnataka and Bihar it is grown as kharif crop with the onset of the monsoon in the month of June-July. The irrigated crop in these areas is sown during April-May. In the districts of Baroda, Broach and Surat of Gujarat and also in M.P. and Maharastra, farmers take up dry sowing in the last week of May or early June in anticipation of rains. Such dry sowing gives early start to the seedlings resulting in higher yields.

In north Karnataka and southern districts of Andhra pradesh, Tamil Nadu which receives rainfall both from S.W. and N.E. monsoon, cotton sowings are taken up in the month of August both for rainfed and irrigated cotton. In the districts of Thanjavur and Tiruchinapalli, it is sown as an irrigated crop in February.

The soil must contain a considerable amount of moisture at the time of sowing. Cotton seed will not germinate unless it absorbs water equivalent to 1/2 or more of its seed weight.

20.9. PREPARATION OF LAND

Proper preparation of land is important for providing ideal conditions for seed germination and plant growth. For rainfed crop in black cotton soils alternate-year deep ploughings to a depth of 20-25 cm followed by two to three blade harrowings help in eliminating hard pan and increasing the moisture storage capacity of the soil. In alluvial and red soils for irrigated crop two to three ploughings are generally given followed by harrowings. Land is brought to fine with and leveling is done by running wooden plank before sowing. F.M.Y. or compost at the rate of 8-10 tonnes/ha should be applied uniformly before land preparation.

20.10. SEED AND SOWING

Selection of good seed is important in any crop. It is advisable to use certified seed.

20.10.1. Seed Treatment

The cotton seed is covered by short fibres called 'fuzz'. The fuzz makes the seeds to cling together, thus hampering their free passage through seeds drills. The seeds are generally treated by rubbing with solutions of mud or mixture of ash and fresh cow dung. By this treatment the fuzz of the seed get pasted on the seed itself and seeds no longer cling together. After this, the seeds are dried in shade for two to three hours.

The latest and more beneficial method is the use of concentrated sulphuric acid for delinting cotton seeds. Two Kgs of cotton seeds are taken at a time in a bucket, concentrated commercial sulphuric acid is slowly applied at the rate of 100 ml/kg of seed, stirring the seed with a wooden-stick till the fuzz gets scorched and the seed attains Coffee brown colour. The time required for this treatment is one to two minutes depending upon the variety. The seeds are immediately washed four to five times by pouring water into the bucket. The damaged and immature seeds float on the water and they are removed. The seeds are then dried in shade and treated with capton or thiram at a rate of 5 g/kg of seed or Vitavox at a rate of 2 g/kg of seed or Bavistin and a rate of 1 g/kg of seed. The seed treatment has to be done two to three days before sowing. Acid delinted seeds are proved to be advantageous in the following ways.

a) Acid delinting helps to eradicate the pathogens present on seed surface.

b) Seed treatment with fungicides effectively done in acid delinted seeds.

c) Acid delinting facilitates the seeds to absorb moisture quickly and,improve the germination percentage.

20.10.2. Seed Rate and Spacing

The optimum number of plants and distance between row to row (inter row) and between plants in a row (intra-row) depend upon growth characteristics of the variety, conditions of soil, fertility status and soil moisture conditions. The recommended seed rate and spacing for different varieties grown under rainfed or irrigated conditions are given in the table 20.1. Seed more than one year old should not be used for sowing.

Table 20.1. Seed rate and spacing for different species of cotton.

Variety	Seed rate Kg/ha	Spacing (cm)
a) Rainfed		
1. G.*arboreum*	8-12	Drill sowing. with 45 cm inter row spacing.
2. G.*herbacium*	8-12	Drill sowing with 60 cm inter row.
3. G.*hirsutum*	12-16	75 - 90 x 30 - 45
4. hybrids	3	90 - 120 x 90
b) Irrigated		
G.*hirsutum*	8-12	90 x 45 - 60
G.barbadense	,,	90 x 45 - 60
hybrids	3	90 - 120 x 90 - 120

20.10.3. Sowing

Cotton is sown either by drilling or by dibbling. The former is generally practiced under rainfed conditions for desi cottons. American cottons both under irrigated or rainfed conditions and hybrids are sown by dibbling. In case of varieties two to three seeds per hill are sown and after 3 weeks of sowing thinning is adopted. For hybrids due to high cost of the seed only one seed is dibbled and gap filling is done with seelings grown in polythene bags. The depth of planting depends on soil type and moisture conditions. In light soils, when there is enough moisture the seed is usually sown at 2 to 3 cm deep. In heavy soil it is sown at a depth of 5 cm.

20.10.4. Paired Row Planting

In this method the row spacing is reduced to form a pair of two rows and increase the space between the two pairs so that it can accommodate short duration legume or cereal or oil seed crop to augment the monetary returns of the farmer. For example if the inter row spacing is 75 cm. it is reduced to 60 cm within the pair and 90 cm in between the pairs. Under limited water supply conditions irrigation can be given within the pair skipping inter space between the pairs. This results in considerable saving in irrigation water without adversely affecting the yields of the cotton crop.

20.11. FERTILIZER RECOMMENDATIONS

Cotton is not a soil exhaustive crop. The average removal of nutrient by cotton crop producing 560 kg of lint per hectare excluding cotton stalks and other parts left in the field was 40, 16 and 17 kg N, P_2O_5 and K_2O per hectare respectively. Application of Farm yard manure of compost at the rate of 10 tonnes per hectare before the last ploughing is recommended wherever possible. In table 21.4 the recommended quantity and time of fertilizer application for the different cotton regions of Andhra Pradesh is furnished.

Table 20.2: Quantity and time of application of fertilizers.

Variety	Total Quantity Kg/ha			basal dose Kg/ha			Top dressing Kg/ha		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Rainfed									
1. North Zone	40	40	40	40	40	40	-	-	-
2. Central zone	20	20		20	20	-	-	-	-
Irrigated									
East zone	120	50	50	60	50	50	-	60	-
Rice fallows	120	40	40	60	40	40	-	60	-
Hybrids	150	60	60	75	60	60	-	75	-

20.12. AFTER CULTIVATION

For planting hybrid cotton seed, it is advisable to sow 2 to 3 redgram seeds along with hybrid seeds to facilitate the easy emergence of cotton seedling. The redgram seedlings should be removed 15 days after sowing. In case of varieties where 3 to 4 seeds are sown per hill, thinning is done 20 to 30 days after sowing leaving only one plant per hill. Intercultivation is done with bullock drawn blade harrow followed by hand weedings at 20- 25 days and again at 15 days at square formation stage before top dressing the fertilizer. When sufficient labour is not available for carrying out timely hand weedlings post emergence application of Diuron at a rate of 1.5 kg/ha or mixture of Diuron and Ansar- 529 can be applied at a rate of 750 g and 1 litre respectively.

Shedding of young buds and bolls is a common phenomenon in cotton which affect the cotton production adversely. it has been estimated that nearly 10 to 60 per cent of total flowers produced are shed due to physiological disorder. Adverse climatic factors or imbalance of nutrients or growth-regulating substances may be the case for boll shedding. Application of plant hormones like planofix i.e., NAA (alpha naphthelene acetic acid) at a concentration of 30 ppm at flower initiation followed by 20 ppm spray, 15 days after the first spray result in retaining 35 per cent more bolls and increase the seed cotton yield by 3 q/ha.

20.13. IRRIGATION

Cotton, though drought tolerant responds well to irrigation. It is highly sensitive to soil moisture conditions. A planned moisture regime that will restrain vegetative growth without adversely affecting the yield is essential. The plant should complete its vegetative phase by the time of full flowering. This can be achieved by moisture regime that promotes regular and rapid but not excessive development of the young plant. The water use per day by cotton plant at different phases of crop is as follows:

1. Upto first flower — 3.8 mm of water/day
2. Upto peak bloom — 8.9 mm of water/day
3. At the last bloom and harvest — 5.1 mm of water/day

Flower initiation stage, peak flowering stage and boll development stage are three critical stages when moisture should not be limiting factor. Moisture stress at flower initiation reduces the growth and number of boll retention, boll weight, seed index and lint index. Moisture stress at boll development reduces the number and size of bolls. Irrigation after too much moisture stress results in boll shedding.

Rainfed cotton because of ill distribution of rainfall may often face excessive moisture conditions or moisture stress conditions at one or other stages of the crop growth. Ridging with every interculture or lying ridges before last rains have been found to be advantageous to counteract the above situations. Wherever possible one or two protective irrigations in the post flowering period would increase the response of fertilizers and enhance the yield.

20.14. IMPORTANT PESTS AND DISEASES ON COTTON

A. Pests

1. Jassid *(Amrasca biguttula)*

Symptoms: Nymphs are seen in huge numbers on the under surface of leaves sucking the sap. They move diagonally. The infested leaves turn yellow and curl at the tips with reddish patches. They turn to brown patches and when the damage is severe, stunting is also observed.

Control: Spraying of Methyl dematon (2 ml/litre) or Monocrotophos (1.5 ml/litre).

2. Cotton aphid *(Aphis gossypii)*

Symptoms: The nymphs and adults suck the sap from the lower surface of leaves and shoots and results in the curling of leaves.

Control: Spray Monocrotophos (1.5 ml/litre) or Dimethoate (1 ml/lit) or phosphomidon (1 ml/litre) or Acephate (1 gm/litre).

3. White flies *(Bemisia tabaci)*

Symptoms: The nymphs and adults suck the sap from the lower surface of the leaves and this results in premature boll drop and improper opening of bolls. The insect is a vector of leaf curl virus.

Control: Spray Monocrotophos (3 ml/litre) or Dimethoate (2 ml/litre) or Phosphomidon (2 ml/litre).

4. Cotton thrips *(Thrips tabaci)*

Symptoms: Nymphs and adults suck the sap from the leaves and flower buds. The affected leaves get curled up and show uneven surface with bronzed appearance.

Control: Spray Methyl dematon (2 ml/litre) or Monocrotophos (1.5 ml/lit) or Dimethoate (1 ml/litre).

5. Red cotton bug *(Dysdercus congulatus)*

Symptoms: The nymphs and adults suck the sap from the tender parts of leaves, shoots, flower buds, immature bolls, and developing bolls.

Control: Dust BHC 10% or Spray Chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre)

6. Spotted boll worm *(Earias vittella and E. insulana)*

Symptoms: The larvae enter the developing shoots and feed inside and as a result dropping of leaves is observed. In the later stages the larvae bore into buds, flowers and bolls and cause damage by migrating from one part to another. Heavy shedding of flower buds in the early stages and at later stages occurs. The affected bolls drop off prematurely and this results in severe yield losses.

Control: (a) Spray Monocrotophos (1.5 ml/litre) or Fenvale rate (0.5 ml/litre) or Decamethrin (1 ml/litre), (b) Destruction of alternate host plants.

7. American boll worm *(Heliothis armigera)*

Symptoms: The larvae bore into the bolls and feed upon them by keeping the head inside and the body outside. The infestation leads to immature boll drop.

Control: Spray Monocrotophos (1.5 ml/litre) + DDT (2.5 g/litre)

8. Pink boll worm *(platydera gossypiella)*

Symptoms: The larvae enter inside the boll and eat away the inner portions.

Control: Spray Monocrotophos (1.5 ml/litre) or Endosulfan (1.75 ml/litre) of Fenvalerate (0.5 ml/litre) or Decamethin (1 ml/litre).

9. Tobacco caterpillar *(Spodoptera litura)*

Symptoms: The larvae scrape the lower epidermis of the leaf and eat the leaves by making holes. At later stages the larvae extensively feed on the leaves and defoliate. The larvae also feed on the developing bolls by making holes.

Control: (a) Spray Monocrotophos (1.5 ml/litre) or Chloripyriphos (2.5 ml/litre) or Fenvalerate (0.5 ml/litre) or Decamethrin (1 ml/litre), (b) Destruction of alternate host plants, (c) The insecticidal application should coincide with the hatching of eggs.

B. Diseases

1. Anthracnose *(Colletotrichum capsici)*

Symptoms: The disease initiates as reddish circular spots on the cotyledons and primary leaves. The infection on collar region may result in girdling causing seedlings to wilt and die. In the matured plants the stem splits and sheds the bark.

Control: (a) Treat the seed with conc. H_2SO_4 to eliminate seed borne infection, (b) Removal of collateral weed hosts.

2. Wilt *(Fusarium oxysporum f.sp. vasinfectum)*

Symptoms: Young seedling show yellowing or browning of cotyledons. The infected seedlings wilt and it results in their death. If the plants are affected later, the leaves become turgid and it results in drooping and wilting of the leaves. There may be complete defoliation.

Control: (a) Ploughing during summer months to expose the resting spores, (b) Application of heavy doses of FYM and Green manures reduces build up, (c) Growing resistant varieties like Jayadhar, Jarila, Vijay Pratap etc.,

4. Verticillium wilt *(Verticillium dahliae)*

Symptoms: The characteristic symptom is the mottling of leaves with pale yellowish irregular areas at margins and in between the main veins.

Control:(a) Using acid delinted seed helps in reducing seed borne inoculum, (b) Treating the seed with vitavax or Ceresan at the rate of 3 g/kg of seed, (c) Crop rotation.

5. Root rot *(Rhizoctonia bataticola)*

Symptoms: Sudden and complete wilting of the affected plants is the main symptom. The affected roots show rotting and decay. The affected main root is sticky and moist with the bark shredded and woody tissues showing yellowing.

Control: (a) Crop rotation, (b) Mixed cropping with Sorghum and *Phaseolus aconitifolius* reduces the disease intensity.

6. Black arm *(Xanthomonas campestris pv. malvacearum)*

Symptoms: The bacterium attacks all the above ground plant parts. The seedlings show water soaked circular lessions on the cotyledons which enlarge to become water soaked circular lesions. The leaves of the mature plants show water soaked lesions and become irregular black patches which wither and dry up. The bacterium may infecte bolls, stems etc.

Control: (a) Spray 500 ppm of Streptomycin sulphate, (b) Soak the seeds overnight in 1000 ppm of streptomycin sulphate before sowing.

Check Your Progress - 3 & 4

3. The Scientific name of white flies that attack cotton is ______________________

4. Black arm of cotton is caused by ______________________

Note: (a) Write the answers in the space given below

(b) Compare your answers with those given at the end.

20.15. HARVESTING & YIELD

In countries like USA and USSR where holdings are large and labour is scarce the picking of cotton is carried out with harvesting machines. in India cotton is entirely hand picked. Cotton harvesting is a costly and prolonged affair since it is picked three to five times as and when cotton bolls open. The opened bolls, if kept on the plant for long, get spoiled due to excessive moisture, trash and other contaminants which are difficult to remove during ginning and reduce the quality of seed cotton. Later pickings of cotton will be lower in grade than those harvested early. Cotton is usually picked by both hands with bags slung on their shoulders or backs. The picked seed cotton (Kapas) is dried in shade to reduce the moisture content and then stored. A few un-opened bolls which still remain on the plant after last picking can be collected and dried in the sun. When they burst, the cotton can be taken out from them. Cotton stalks should be removed immediately after the last picking to avoid the carry over of posts.

The yields vary widely from tract to tract and from season to season depending upon the climatic conditions. The average yields of seed cotton (Kapas) are as follows.

Rainfed desi cotton	:	300-400 kg/ha
Rainfed American cotton	:	400-800 kg/ha
Irrigated cotton (improved *hirsutum* variety)	:	1500-2000 kg/ha.
Irrigated hybrid cotton	:	2000-3000 kg/ha.

20.16. CROP ROTATION

It is always advisable to grow crops in rotation instead of continuous cropping with a particular crop on a given piece of land. It helps to maintain soil fertility besides keeping the insects and disease organisms under check. Growing cotton after leguminous crops in rotation has been found to give higher yields of cotton. Cotton succeeding groundnut gave 15 to 20 per cent more yield than followed by wheat or sorghum. The common rotations followed in different cotton growing regions are as follows.

20.17. INTERCROPPING

Intercropping both under rainfed and irrigated conditions is beneficial. It ensures better utilizations of resources like land, soil moisture and fertilizers. Cotton is commonly intercropped with korra or ragi or groundnut in Rayalseema region of Andhra Pradesh and Karnataka. It is intercropped with blackgram or coriander or bengal gram in Tamilnadu. The other common intercrops or mixtures grown in association with cotton crops are maize, sorghum, ambadi sesamum in central and northern parts of India.

20.18. COTTON QUALITY EVALUATION

The quality of seed cotton is generally judged by the following characteristics.

(1) Ginning percentage (2) Fibre length (staple length) (3) Fibre fineness
(4) Fibre strength. (5) Fibre maturity (6) Spinning quality
(7) Colour and (8) Trash content.

20.18.1. Ginning Percentage

It is the out turn of lint to seed cotton by weight and is expressed in percentage. Ginning percentage ranges from 24 to 44.

20.18.2. Fibre Length or Staple Length:

It is one of the most important characteristics for deciding quality and market price of cotton. It is the average length of individual cotton fibres. The longer the staple length the better the quality. The cotton is classified into the following five

Group	2.5 span length (mm)
1. Extra long staple	33.0 and above
2. Long staple	29.5 to 32.5
3. Medium staple	25.0 to 26.0
4. Short staple-A	20.5 to 24.5
5. Short staple-B	20.0 and below.

20.18.3. Fibre Fineness

Next to staple length, fineness is important and it affects the spinning quality. Fibre finess is usually expressed in terms of weight per unit length of fibre. The micronaire value recording 5 or more micrograms per inch of fibre is considered coarse fibre. The values recording less than 4 are fine and the values between 4 to 5 as average.

20.18.4. Fibre Strength

It is usually measured by subjecting to stretching stress in length wise direction on a single fibre or on a bundle of fibres. The values are expressed in terms of breaking strength in pounds per milligram weight of fibre bundle. In metric system the values determined by stelometer are expressed as tenacity in terms of grams per tex where tex donates weight in grams of one kilometre of the fibre.

20.18.5. Fibre Maturity

It is the index of the extent of development of fibres. The maturity can be determined by different methods. In the procedures commonly adopted, the fibres are swollen in 18 percent caustic soda and examined under microscope. Based on the ratio of diameter of lumen (L) to the wall thickness of swollen fibres (W), they are classified into the following groups.

$\frac{L}{W}$	Less than 1	= Mature
"	1 - 2	= Half mature
"	greater than 2	= Immature.

20.18.6. Spinning Auality

Lint cotton is first spun into yarn by spinning. Price of cotton depends upon the spinning quality which is usually expressed as the highest standard count (HSC) to which cotton can be spun. A count is the number of hanks (each hank is 840 yards length of yarn) found in one pound of yarn. For example 50 counts would indicate that one pound of yarn would contain 50 hanks of 940 yards each. Spinning quality depends upon staple length, fineness and strength.

20.18.7. Colour of Cotton

The colour of cotton varies reddish tint to bright shining white. The brighter the colour the better the quality. In the laboratory, colour is estimated by using the Nikerson Hunter Colorimeter. In this instrument the total amount of light reflected and degree of yellowness from sample is estimated.

20.18.8. Trash Content

Spinning performance and yarn appearance are affected by higher percentage of trash content. It is estimated in the Laboratory by Shirley Analyser. In this instrument, a known quantity of cotton is passed through a set of rollers and opened out. The trash and lint are collected separately and their percentage is determined.

20.19. SUMMARY

Cotton is the most important among the fibre crops, supplying the basic requirement of man, the clothing. It is being grown all over the world. The major cotton growing area in India is confined to Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Punjab and Rajasthan. All four cultivated species i.e., *Gossypium hirsutum, G. herbaceum, G. barbadense* and *G. arborium* are grown in India. India has the distinction of developing and releasing hybrids in cotton for commercial cultivation on a large scale by employing manual labour. It can be grown under rainfed conditions in regions receiving a minimum rainfall of 500 mm annually. It requires dry climate with bright sun shine during boll development and ripening. As a rainfed crop it is mostly grown in black cotton soils and as an irrigated crop in a variety of soils. As a rainfed crop it is mostly grown with the commencement of monsoon in June-July. In regions where rainfall is received from both S.W. and N.E. monsoon rainfed crops are sown in August. As an irrigated crop it is sown in April-May. Use of Acid delinted seed is advantageous for increasing the germination percentage. The seed rate required for hybrids is 2.5 kg/ha and for varieties 8-12 kg per/ha. The spacing for desi cotton ranges from 45-60 x

15-30 cm and for hirstutum and barbadense types 75- 90 x 45-60 cm and for hybrids, 90-120 x 90-120 cm. The fertilizer recommended for desi cotton is 40 : 40 : 40 Kg N, P_2O_5 KO_2/ha and for *hirsututum* and *barbadense* types 120 : 50 : 50 kg N, P_2O_5 K_2O/ha and for hybrids 150 : 60 : 60 kg N, P_2O_5, K_2O/ha. Intercultivation with bullock drawn blade barrow followed by hand weeding twice at 20-26 and 45-30 days age of the crop has to be attended. Adverse climate factors or imbalance of nutrients or growth regulating substances are the probable reasons for ball shedding in cotton. Jassid in early stage and boll worms at later stages are the major pests in cotton which needs to be controlled by regular plant protection measures. Flower initiation, peak flowering and boll development stages are the critical stages for irrigating cotton. The average yield of seed cotton (Kapas) under rainfed conditions for desi cotton is 300-400 kg/ha and for American cotton 400-800 kg/ha and Irrigated cotton *(hirsutum)* type is 1500-2000 kg/ha. Cotton quality is mostly judged by fibre length, fibre fineness and fibre strength which influence the spinning performance of lint cotton to yarn.

20.20. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The three cotton regions of Andhra pradesh are (a) Northern Region (b) Central Region and (c) Eastern Region.
2. The species of *Gossypium* that are included under new world cotton are *G. hirsutum, G. barbadense*
3. *Bemisia tabaci*
4. *Xanthomonas compestris* P.V. malvacearum

20.21. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe soil types of different cotton regions of Andhra Pradesh along with species and important varieties of cotton that are grown in each region.
2. Give a brief account of soil and climatic requirements and sowing seasons of cotton.
3. Give the seed rate, spacing, manurial and fertilizer schedules and yield of different species and hybrids of cotton under rainfed and irrigated conditions.
4. Describe the symptoms caused by different pests of cotton along with control measures.
5. Discuss in brief the characteristics of fibres for evaluating the quality of cotton.

II. Answer the following questions in about 10 lines each.

1. Why is seed treatment in cotton necessary ? Explain different types of seed treatments.
2. Give a brief account of shedding of young bunds and bolls in cotton.
3. Mention two important diseases of cotton along with their symptoms and control measures.
4. Describe control measures of three important pests of cotton.
5. What are the critical stages of irrigation in cotton? How water requirement of cotton vary at different stages of crop growth.
6. Write a brief account of areas under different species of cotton in India and in other countries.

UNIT - 21 : CHILLI

Contents

21.1. OBJECTIVES

After going through this unit you will be able to:

1. describe the climatic and soil requirements of Chillies
2. list out the recommended varieties,
3. describe the method of preparation of main field and the process of transplanting
4. list out the manures and fertilisers and describe the time and method of application
5. describe the method of intercultivation practices
6. suggest the method of controlling flower drop,
7. list out the important pests and diseases and the causal organisms and suggest the method of controlling them,
8. describe the process of harvesting and drying of chillies by different methods,

21.1. INTRODUCTION

Chilli known as red pepper is a native of South America. Though exotic in origin has become an indispensable in every Indian house. Black pepper wa in use prior to the introduction of this crop. The conditions for successful cultivation of black pepper are restricted to a limited area. Chilli is an annual crop and can be grown over a wide range of climatic, soil and cultural conditions. This crop had therefore rapid spread throughout the country.

It can be used both in the green state and dried form. Besides the pungency due to capaicin, it is a source of vitamin A and C.

It is grown in most parts of the world i.e., South and Central America, South, Central and East Africa and Asiatic countries. Less pungent types are grown in the U.S.A. In India chilli occupies an area of 7,91,800 hectares with a production of 5,18,000 tonnes of dry chillies (1982-83). Leading chilli producing states are Andhra Pradesh, Maharastra, Karnataka, Orissa and Tamil Nadu. In Andhra Pradesh it is grown in an area of about 1699 lakh hectares with a production of 1983 lakh tonnes of dry chilli (1982-83). Andhra Pradesh ranks first both in area and production for chillies, contributing 37.5% of the country's production.

21.3. CLIMATIC REQUIREMENT

The crop thrives well under tropical and subtropical climate. For optimum vegetative growth and development of fruits, the temperature range of 18 to 38^{o}C is required. It can not grow well when temperature falls below 12^{o}C or in high rainfall regions of more than 1500 mm. Moderate rainfall of 550-900 mm is congenial for this crop. It can grow well from mean sea level upto 1100 metre elevation.

21.4. SOILS & SEASONS

It requires a well- drained medium to heavy soil with sufficient organic matter. For rainfed crop, moisture retentive black soils are best suited. For irrigated crop alluvial soils or red loams are best suited.

The crop is generally first raised in the nursery and then transplanted in the main field after 1-1/2 months. The following are sowing and transplanting times of rainfed and irrigated chillies.

Rainfed crop	:	Sowing Nursery - June - July Transplanting - August
Irrigated crop	:	Sowing Nursery - June - July Transplanting - August - September
Irrigated (Green chillies)	:	Sowing Nursery - June or August or December Transplanting - July or Sept. or January.

The duration of the crop (seed to seed) is 7 to 8 months for rainfed and 8 to 9 months for irrigated crop

21.5. RECOMMENDED VARIETIES IN ANDHRA PRADESH

The different varieties that are recommended for Andhra Pradesh, their average yields and their characteristics are given below.

Sl. No	Varieties and their parentage	Average Dry Chillies Yields in Q/ha Rainfed	Irrigation	Ave. green chillies yield Q/ha	Characteristics
(1)	(2)	(3)	(4)	(5)	(6)
1.	G-3 (N. P-46 A)	10-12	25-30	-	It is cosmopolitan in habit and comes up well both under irrigated and rainfed conditions. Ideal for foreign export. Recommended for all the districts. Fruits are medium in size with 44% seed to pod. Calyx cup shaped and persistent.
2.	G-4..(CA-766-1-3) Bhagya-lakshmi	12-13	30-35	-	It gained extensive spread throughout the state particularly under irrigated areas. Fruits are medium with olive green colour turning to bright red on ripening. Recommended for all the districts under irrigation.
3.	Sindhur (CA-960 Hot Portugal)	12-14	30-35	250	Early in bearing by two to three weeks. Plants tall growing. Fruits long and stout with cup shaped calyx and blunt tip. Pericarp light green turning to bright red on ripening. Seed content 38% and pungency is mild. Recommended for green chilli production in Cuddapah, Anantapur, Kurnool, Prakasam and Krishna Dists. Recommended for dry chillies in Krishna, West Godavari, Warangal and Karimnagar dists. Where there is liking for stout and mildly pungent types.
4.	Aparna (CA-1068)	12-14	30-35		Plants tall growing and late in bearing by two weeks when compared to other strains. Fruits yellow in colour on ripening. Fruits medium long and stout with semi cup shaped calyx and blunt tip. Seed content 42%. Recom- mended to yellow chilli zone of East Godavari, Visakhapatnam, Vijayanagaram and Srikakulam Districts. It is tolerant to salinity and can withstand drought as well as high moisture conditions.

Sl. No	Varieties and their parentage	Average Dry Chillies Yields in Q/ha Rainfed	Irrigation	Ave. green chillies yield Q/ha	Characteristics
(1)	(2)	(3)	(4)	(5)	(6)
5.	X-196 (G-3 x Nadikudi)	8-12	-	-	Plants tall growing. Fruits long and stout with blunt tip and attractive red colour. seed content 40% and mild in pungency. Good for pickles. Resistant to Cucumber mosaic virus. Suitable to Warangal and Karimnagar dists.
6.	X-197..(G-3 x..B-71 Assam)	12-15	-	-	Fruits long and thin with cup shaped Calyx and pointed tip. Seed content 42% tolerant to thrips. Suitable for rainfed and irrigated areas in all the dists.
7.	X-235 (G-4 x Y.A.M.)	15-20	-	-	This variety is characterised by compact plants with short internode, small leaves and flowers with yellow anthers. Pods are olive green (5-6 cm. long) with high degree of pungency. Fairly tolerant to sucking pests like thrips, mites and aphids. The yellow anther colour which is a rare character serves as a marker gene in maintenance-of-purity. Recommended to all the dists.
8.	Jwala	10-12	25-30	250	Similar to N.P. 46 A, but pods are longer (10-12 cm). Suitable for green chillies production round about Hyderabad to catch the market of Hyderabad city.

21.6. SEED RATE AND RAISING OF SEEDLINGS

The seed rate is 1 kg/ha for transplanted crop and 6.25 kg/ha for direct sowing crop. The following precautions are to be taken when raising the seedlings.

1. Seedlings should be invariably raised on raised beds. On flat beds, development of roots and growth of seedlings are poor and damping off disease occurs.

2. Raised beds of 1 metre width and 30 metres long in one of more bits according to the availability of space surrounded by drainage channels of 30 cm width are to be formed.

3. Sowing of seeds uniformly using 550 g per bed of 30 sq.m.

4. Application of 100 g of Disulfotan granules per 30 sq. metre area.

5. Seed treatment with Agrosan G.N., or Captan or Dithane M-45 at 3 grams per one kg of seed.

6. Spraying copper fungicide on 12th day and 19th day of sowing to prevent, damping off disease.

7. Organic manures only are to be applied.

8. Topping seedling one week prior to transplantation.

9. Six weeks old seedlings are to be used for transplantation.

21.7. PREPARATION OF MAINFIELD

The main field is well prepared by ploughing twice followed by two to three harrowings.

21.8. MANURES AND FERTILIZERS

A basal dose of 10 tonnes of farm yard manure per ha is to be applied in June-July.

Sheep penning 2500-3000 sheep per ha can be done if available. Neem cake at 3-4 quintals/ha preferably mixing with fertilizers at the time of final ploughing should be applied. Green manuring can be practiced by sowing pillipesara or cowpea or sunhemp with early rains and incorporating it after 40 days growth.

Chilli responds well to heavy doses of fertilizers. Balance dose of N.P.K fertilizers is necessary to get good yields and quality produce. For a rainfed crop 60 kg N, 30 kg P_2O_5 and 50 kg K_2O/ha are to be applied as a basal dose at the time of last ploughing. Wherever green manure crop is raised, the phosphatic fetilizers can be applied at the time of sowing green manure crop. Depending on the rainfall a top dressing of 20-30 kg N per hectare is to be applied in two split doses by placement.

For an irrigated crop, a basal dose of 60 kg N, 60 kg P_2O_5 and 30 kg K_2O is to be applied per hectare at the time of final ploughing. After 45 days of planting three split doses of 20 kg N plus 10 kg K_2O each at 15 days interval followed by irrigation should be adopted. Later on two more split doses of N alone at 20 kg N per hectare are to be given. Foliar application of 1% urea along with insecticidal or fungicidal spray can be given and at each time only 8 to 10 kg of Urea may be required. Urea can be mixed with all insecticides and fungicides but not with carbaryl.

In the soils where Zinc deficiency is noticed, Zinc sulphate at the rate 25 kg per hectare can be applied to the soil. Zinc sulphate can also be sprayed at the rate of 2 grams in one litre of water using 1250 grams of zinc sulphate per hectare. This is to be repeated twice at 10 days interval.

21.9. TRANSPLANTING

Transplant 40-45 days old seedlings preferably on a cloudy day. For cold weather crop transplantation is to be done during the first fortnight of September.

The spacing is to be followed as given below.

Rainfed crop	=	56 x 15 cm (56 cm between rows and 15 cm within the row with one seedling per hill.)
Irrigated crop	=	56 x 56 cm or 60 x 60 cm or 90 x 69 cm Depending upon soil fertility with two to three seedlings per hill.

21.10. DIRECT SOWING

1. Recommended for a rainfed crop under retentive black soils which are free from weeds with good drainage.
2. Seeds are to be drilled by the end of July or first week of August by using 6.25 kg per ha.
3. Seed is to be treated as in the case of nursery before sowing.
4. After 30-40 days of sowing thinning and gap-filling are to be done preferably on a cloudy day.
5. Plant to plant distance is to be maintained at 15 cm in the rows of 56 cm apart.

21.11. INTERCULTIVATION

Chillies require frequent inter-cultivation. In the direct sown crop blade harrow to be worked starting from the 30th day of sowing. Four intercultivations are needed at 10 days intervals alternated with blade harrow and tyned harrow or Junior-hoe. Final inter-cultivation is to be given by the country plough. For an irrigated crop, intercultivation is to be given either by Junior-hoe or light plough after each irrigation. Inter cultivations to be followed by hand weeding to check the weed growth.

21.12. IRRIGATION

Chilli cannot withstand heavy moisture. Hence, irrigation should be given only when it is necessary. Frequent and heavy irrigation induces vegetative growth and causes flower shed. The number of irrigations and interval between irrigations depend upon soils and climatic conditions. If the plants show symptoms of drooping leaves at 4.00 p.m., it is an indication that irrigation is needed.

21.13. FLOWER DROP

Flower drop is natural in chillies. Only 30 to 40% flowers set into pods. Flower drop will be high during cloudy days. To minimise flower drop and to increase pod set Napthaline Acetic acid (Planofix or Wardhak) 15 ppm. is to be sprayed thrice at fortnightly intervals starting from November.

21.14. INTERCROPPING

Chilli is mainly cultivated as a mono crop. In Gollaprolu tract of Guntur district it is cultivated with cotton or onion crop. After every 14 rows of chilli one row of cotton is grown. In Karimnagar region maize crop is grown in June-July and Chilli is transplanted in September-October as a relay crop in the same field.

Check Your Progress - 1

What do you spray to minimise the flower drop in chillies?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

....

....

21.15. IMPORTANT PESTS AND DISEASES ON CHILLIES

A. Pests

1. Thrips *(Scirtothrips dorsalis)*

Symptoms: The nymphs and adults harbour the leaf tissues and suck the sap. They also flower buds and flowers besides growing tender shoots. The feeding results in curling of leaves in cup-shape.

Control: Spray Monocrotophos (1.5 ml/litre) or dust BHC 10% or Carbary 1.5% 25 kg/ha.

2. Chilli pod borer *(Spodoptera litura or Heliothis armigera)*

Symptoms: *Spodoptera litura* bores the chilli pods and feeds inside by causing irregular holes. *H. armigera* also makes holes and feeds on the rind and seed.

Control: Spray Monocrotophos (1.5 ml/litre) or Chloripyriphos (1.5 ml/litre) or Fenvalerate (0.5 ml/litre) or Decamethrin (1 ml/litre).

3. Chilli aphids *(Aphis gossypii and Myzus persicae)*

Symptoms: Nymphs and adults of both the insects suck the sap from the leaves and growing points. The infested plants are stunted and flowers and tender parts are shed.

Control: Spray Monocrotophos (1.75 ml/litre) or Phosphomidon (1 ml/litre) or Dimethoate (1 ml/litre).

4. Chilli mites *(Polyphagotas soncmuslatus and Tarsonemus translucence)*

Symptoms: The mites are found in large numbers on the lower surface of leaves and nymphs and adults suck the sap. The affected leaves show elongation of petiole and curling down of the leaf blade in the form of inverted boat shape. The affected leaves become dark green and can be easily broken.

Control: Spray Dicofol (5 ml/litre) or dust sulphur at the rate of 10-12 kg/acre.

B. Diseases

1. Damping off *(Pythium aphanidermatum)*

Symptoms: The infected seedlings become pale green and brownish water soaked lesions are seen at the basal portion of the stem. The lesion girdles the stem and the affected tissues rot and collapse.

Control: (a) Soil sterilization by burning trash on the surface of nursery, (b) Provision of free drainage to the beds, (c) Spraying of Dithane M-45 (2.5 g/litre) or Bavistin (1 g/litre).

2. Cercospora leaf spot *(Cercospora capsici)*

Symptoms: The initial symptoms start as small chlorotic lesions, angular to irregular in shape and they later on turn greyish brown. Severely affected leaves may drop off prematurely resulting in severe yield losses.

Control: (a) Seed treatment with Bavistin at the rate of 3 g/kg of seed. (b) Spray Dithane M-45 (2.5 g/litre) or Bavistin (1 g/litre).

3. Altermaria leaf spot *(Alternaria solani)*

Symptoms: The lesions start as small water soaked areas and become irregular after a few days. The lesions may coalesce in course of time and cover large areas of the leaf blade resulting in the blight. The leaf spots are characteristic with concentric rings.

Control: (a) Seed treatment with Bavistin at the rate of 3g/kg of seed, (b) Spray Dithane M-45 (2.5 g/litre).

4. Anthracnose *(Colletotrichum capsici)*

Symptoms: The disease generally appears on ripened fruits and results in fruit rot. The lesions are circular and sunken with black margins. With the advancement of disease the spots spread and form concentric markings with dark fungal fructifications. under severe conditions the fruits drop prematurely and result in heavy yield losses. The fungus some times attacks fruit stalk and spread to the stem and causes die-back.

Control: (a) Seed treatment with Thiram or Ceresan at the rate of 3 g/kg of seed, (b) Spray Dithane M-45 at the rate of 2.5 g/litre.

Check Your Progress - 2 & 3

2. Anthrocnose disease of chillies is caused by ____________________

3. Dampring off of chilli seeding is caused by ____________________

Note: (a) Write the answers in the spaces given above.

(b) Compare your answers with those given at the end.

....

....

21.16. HARVESTING

On an average flowering occurs at about 80-85 days age of the crop and the first green fruit harvest can be started after 115- 130 days from the date of nursery sowing. The first red fruit harvest can be undertaken after 160-165 days of nursery sowing. Generally six pickings are taken from a rainfed crop and ten pickings from irrigated crop. Only well riped fruits are picked at each time and dried separately.

21.17. DRYING OF CHILLIES

Sun drying is the common practice in India. The preparation of the drying floor differs from tract to tract. In places where sand belts are available they are used for drying chillies. Sand is also carted and spread as a thin layer on the drying floor to get uniform and quick drying. In places where sand is not available, the drying floor is prepared by working a blade harrow or a spade. The grass patches are removed and the land is leveled and compacted, if necessary, after sprinkling water. The pods are spread on such drying yards in layers of 8-10 cm. From fifth day onwards the pods are turned on alternate days so that the pods in the bottom layers are brought up to ensure quick and uniform drying.

Sun drying of chillies expose the pods to dust and foreign matter, apart from affecting pod colour. The results of experiments conducted at the Agricultural Research Station, are found quite encouraging. Chilli pods can be dried within a period of 18 hours with the aid of air blown drier, keeping temperature at 44-46^{o}C. This method not only saves time and avoids watch for 10-15 days but also imparts deep red colour and glossy texture to the fruits which are liked in the foreign markets and fetch higher premium than that of the sun-dried procedure. The cost of mechanical drying was worked out to be 25 paise per kg of dry fruits.

Packing is done after the removal of defective and decolourised pods in gunny bags or jute borahs or palmyrah baskets.

21.18. YIELDS

The yields in rainfed and irrigated areas are given below.

Rainfed	Green chillies = 100 quintals/ha.
Crop	Red dry chillies = 6 to 8 quintals/ha.
Irrigated	Green chillies = 250 to 300 quintals/ha.
crop	Red dry chillies = 10 to 15 quintals/ha.

21.19. SUMMARY

Chilli both in green or dry state the most important condiment which is being used in every Indian house. It is being grown in most parts of the world. In India, Andhra Pradesh, Maharashtra, Karnataka, Orissa and Tamil Nadu are the leading states growing chilli. It grows well within temperature range of 18 to 38^{o}C. Its growth is curtailed when the temperature is below 12^{o}C or annual rainfall if more than 1500 mm. For rainfed crop moisture retentive black soils are suitable, and for irrigated crop alluvial soils or red loams are suitable. Generally the crop is first raised in the nursery in raised beds during June-July and then transplanted after 1-1/2 month in the main field. The seed rate required for transplanted crop is one kg/ha and direct sown crop 6.25 kg/ha. The spacing for rainfed crop is 56 x 15 cm with one seedling per hill, for irrigated crop 56 x 56 cm with two to three seedlings per hill. For rainfed crop the fertilizer recommendation is 100: 30 : 50 and for irrigated crop 120 : 60 : 30 kg of N, P_2O_5 and K_2O/ha respectively. Nitrogen is to be given in two to three split doses. The crop is intercultured four times from 30th day of transplanting at 10 days interval. The crop should be irrigated when it shows symptoms of drooping. Excessive irrigation induces more vegetative growth and causes flower shed. Flower drop is common in chillies. Spraying of Napthaline acetic acid thrice at 15 days interval would minimize the flower drop. Thrips, aphids, mites and pod borer are the major pests in chilli. Spraying of monocrotophos at regular intervals should be done to protect the crop from thrips damage. The crop is ready for first picking of green chillies at 115-130 days and that of red fruits at 160 to 165 days from the date of nursery sowing. Generally six pickings from the rainfed crop and 10 pickings from the irrigated crop are taken. Sun drying of red chillies is the common practice in India. Mechanical drying of produce at temperature of 44 to 46^{o}C in the air blown drier for 18 hours would impart deep red colour and glossy texture to the fruits. The yield of the dry chilli for the rainfed crop is 600- 800 kg/ha and for irrigated crop is 1000-1500 kg/ha.

21.20. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Napthaline acetic acid is sprayed to minimise the flower drop of Chillies.
2. *Colletotrichum capsici.*
3. *Pythium aphanidermatum.*

21.21. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Name the different varieties of chilli grown in A.P. with their characteristic features.
2. Discuss the raising of chilli seedlings in the nursery and mainfield preparation to transplant the seedlings.
3. Give a brief account of seed rate, spacing and manurial and fertilizer schedules and yields of rainfed and irrigated chilli. Describe one popular variety used in rainfed and irrigated conditions in your tract.
4. Discuss about the important pests and diseases of chillies and damage caused to the crop and control measures.

II. Answer the following questions in about 10 lines each.

1. Discuss the improved methods of drying of chilli.
2. Describe the symptoms of important pests of chilli.
3. Describe the control measures of important diseases of chilli.
4. Give the soil requirement, sowing seasons, and transplanting time for rainfed and irrigated chilli.

UNIT - 22: TURMERIC, GINGER AND CORIANDER

Contents

22.1. OBJECTIVES

After going through this unit you will be able to:

1. describe the climatic and soil requirements for turmeric, ginger and coriander,
2. list out the important varieties of turmeric, ginger and coriander,
3. describe the method of preparation of land for all the three crops,

4. describe the intercultivation practices,
5. list out the important pests and diseases and describe the symptoms caused by them in all the three crops and suggest the control measures,
6. describe the method of harvesting of all the three crops,
7. describe the process of curing and bleaching of ginger,
8. describe the process of storage of seed material.

22.2. INTRODUCTION

Turmeric *(Curcuma longa L.)* is one of the important commercial crops grown for underground rhizomes. The cured turmeric is one of the common spices used in many culinary preparations. It is used in drugs and cosmetic industries. It is directly applied as a toilet by Hindu women in South India. It is exported to other countries for the manufacture of some dyes.

Raw ginger is commonly known as green ginger and is extensively used as condiment. Dry ginger is used in many drugs and is being exported to foreign countries.

Coriander seed powder is one of the common condiments used in all preparations and is the main ingredient in Indian curry powder. The green leaves are used to flavour curries, chutneys and salads. Coriander seed is also brown for its medical properties.

22.3. TURMERIC

India is the largest turmeric producing country in the world. Andhra Pradesh is the leading state with an area of 23,000 hectares producing 60,000 tonnes, which accounts for 50 percent of the century's production. The other turmeric growing states are Tamil Nadu, Bihar, Orissa, Maharashtra and Kerala. In Andhra Pradesh it is mainly cultivated in Krishna, Guntur, Cuddapah, Kurnool, East and West Godavari, Nizamabad, Karimnagar, Srikakulam and Visakhapatnam districts.

22.3.1. Climatic Requirement

It is a tropical crop and thrives well in humid warm weather. Hence there is a practice of providing shade to the crop by inter-planting castor. It can be grown from mean sea level upto an altitude of 1200 m.

22.3.2. Soil

The crop can be grown on a variety of soils ranging from red loams to clay loams. The crop cannot withstand water logging or alkalinity in the soils. Fertile loamy soils having irrigation and drainage facilities are ideal for this crop.

22.3.3. Varieties

(a) Long duration varieties (9 months)

(i) Mydukar: The finger rhizomes are long and stout. The epidermis is dirty brown in colour, outer core lemon yellow and the inner portion deep yellow. This is popular in cuddapah district.

(ii) CLL-326: It is a selection from Mydukur type. Rhizomes are long, stout, smooth and hard with pale yellow colour. The curcumin (colour) content is 1.46 per cent. The yield ranges from 25 to 37 tonnes of raw rhizomes per hectare with curing percentage of 19.3. It is the highest yielder in all zones of the state and resistant to leaf blotch.

(iii) CLL-327: It is a selection from Tekurpet but resembles Mydukur type. Curcumin content of rhizomes is 3.0 per cent. It gives equal yields to that of CLL-326. Curing percentage is 21.8 and it is resistant to leaf blotch disease.

(iv) Duggirala: This variety is popular in Guntur and Krishna districts. It is known for its fast yellow coloured rhizomes. The average yield is about 25 tonnes per hectare.

(v) Armoor: Popular in Nizamabad district. Rhizomes are known for fast yellow colour. Its yield ranges from 12-18 tonnes per hectare.

(b) Medium duration varieties (8 months)

(i) CLI 317: It is a selection from Amruthapani Kothapeta type. Rhizomes are medium long, thick with narrow constriction. Curcumin content is 3.8 per cent. Yield ranges from 25 to 35 tonnes per hectare and curing percentage is 19.6. It is resistant to leaf spot but susceptible to leaf blotch.

(ii) Kesari: This variety is popular in Cuddapah and Kurnool districts. Rhizomes are moderately long and thick and wrinkled. It's yield ranges from 15-25 tonnes per hectare. It is susceptible to leaf spot.

(c) Short duration varieties (7 months)

(i) CD 69 *(Curcuma aromatica):* It is a selection from Dindrigam type of Orissa. The plant grows to a height of 50 cm with dark green foliage. Rhizomes are long and thin with shiny skin and aroma. Curcumin content is 1.46 per cent. Its yield ranges from 15 to 20 tonnes per hectare. Curing percentage is 26.7. It is tolerant to leaf spot and resistant to leaf blotch disease.

(ii) Kasturi: It is popular in Agency, and Godavari districts. The finger rhizomes are long and thin with characteristic aroma. The epidermis is brown in colour with pink tinge and the core in rich yellow. Its yield ranges from 15-20 tonnes per hectare.

Check Your Progress - 1

What are the two medium duration varieties of Turmeric?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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22.3.4. Seasons

There is only one season for this crop. Planting commences in June and continues upto early part of August. The duration of the crop is 7 to 9 months and it is harvested in February March.

22.3.5. Preparation of Land

The land is prepared with the receipt of rains and brought to fine tilth by giving 4 to 6 ploughings. Before last ploughing, farm yard manure at the rate of 25 tonnes per hectare is applied.

22.3.6. Planting

Seed material preserved from the previous crop is used for planting. Both central mother rhizomes and finger rhizomes are used for planting. It has been found that finger rhizomes yield better crop than mother rhizomes. Mother rhizomes are cut into two longitudinal pieces before planting. Finger rhizomes of 7 to 8 cm long with sprouting buds are selected for planting. They are dipped in 0.3% Agallol Solution for 30 minutes and subsequently air dried.

About 2500 kg of rhizomes are required per hectare. They are dibbled behind the country plough at 15 cm apart in the plough furrows spaced 30 cm apart. In low lying areas or clay soils where drainage is a problem, planting is done in raised bed of 20 cm high 1.2 meter wide and 8-10 meters long with 30 cm wide channels in between them. In red soils of Cuddapah a green leaf much is spread in plots soon after testing for securing good germination and moisture retention. After 1 1/2 months the twigs are shaken and removed. The leaves gradually get decomposed and mixed up in the soil.

22.3.7. Fertilizer Schedule

Turmeric is an exhaustive crop and required heavy manuring, Farm yard manure at the rate of 25 tonnes a hectare should be applied at the time of last ploughing. Besides F.Y.M., crop requires 180 kg N, 60 kg P_2O_5 and 120 kg K_2O per hectare. Entire phosphorus, 1/3 nitrogen and 1/2 potassium should be applied as basal dressing at the time of planting. Two months after planting top dressing with 60 kg N/ha is given before hoeing and weeding. Again at the end of the 4th month a third dose of 60 kg nitrogen per hectare and the remaining 1/2 potassium is applied.

22.3.8. Intercultivation

Three to four harrowings followed by hand weedings are necessary in light soils. The plants have to be earthed up immediately after weeding. In black soils where ridge and furrow methods of planting are adopted country plough can be worked to remove the weeds and earthing up.

22.3.9. Irrigation

The number of irrigations given depends on the climatic conditions and type of the soil. About 25 to 40 irrigations are required at 8 to 10 days interval. In light soils 40 irrigations are needed with 6 to 8 days interval and in clay loams 25 irrigations are required with 8 to 10 days interval. At the time of rhizomes development and maturity frequent irrigations are necessary.

22.3.10. Important Pests and Diseases

A. Pests

1. Rhizome fly *(Callobata albimana)*

Symptoms: The maggots of rhizome fly attack both turmeric and ginger. They feed inside the rhizomes and cause severe damage and yield losses.

Control: Application of carbofuran at the rate of 25 kg/acre in two equal splits.

2. Thrips *(Panchaetothrips indicus)*

Symptoms: The larvae and adults suck the sap from the under surface of leaves and cause curling and drying from the tips. The insects infest only turmeric.

Control: (a) Spray Monocrotophos (1.5 ml/litre) or Dimethoate (1 ml/litre) or Phosphomidon (1 ml/lit).

3. Turmeric lac wing bug *(Stephantis typicus)*

Symptoms: The nymphs and adults suck the sap from the upper surface of leaves and cause yellowing of the leaves. In severe cases the leaves dry up and fall off.

Control: (a) Spray Monocrotophos (1.5 ml/litre) or Methyl dematon (2 ml/litre) or Malathion (1.5 ml/litre).

B. Diseases

1. Leaf blotch *(Taphrina maoulans)*

Symptoms: The lesions appear on both the surfaces of leaves and cover the major portion of the leaf area under severe cases. The infected leaves become reddish brown as compared to the golden yellow colour of healthy leaves.

Control: (a) Spray Bavistin (1 g/litre) or Dithane M-45 (2.5 g/lit).

2. Leaf spot *(Colletotrichum capsici)*

Symptoms: The lesions develop on both young and old leaves in different sizes as oblong spots with grey centres. Large number of spots develop and cover major portion of the leaf blade. The matured lesions appear as oblong brown spots with typical black concentric rings.

Control: (a) Spray Bavistin (1 g/litre) or Dithane M-45 (2.5 g/lit).

3. Rhizome rot *(Pythium sp)*

Symptoms: This attacks both turmeric and ginger. The tips of leaves change to yellow and chlorosis proceeds downwards resulting in the death of the leaves. The foot of the plant and rhizomes turn pale and the portion a little above the ground level becomes watery and soft. The rhizome slowly get decomposed and changes to decaying mass of tissues.

Control: (a) Use of healthy seed-pieces, (b) Drench the soil with Bordeaux mixture, (c) Foliar spray may be given with Fytolan (2 g/lit) or Dithane Z-78 (2.5 g/litre).

Check Your Progress 2 and 3

2. Leaf batch of turmeric is caused by____________________________.
3. Rhizome rot of turmeric is caused by____________________________.

Note: (a) Write your answers in the spaces given above.

(b) Compare your answers with those given at the end.

23.3.11. Harvesting

The crop comes to harvest in 7 to 9 months depending on the variety. The maturity is indicated by complete drying up of the plants. The dried leaves are cut and preserved for use as fuel in curing rhizomes and storing the seed material. A country plough is worked carefully by the side of the rows so that rhizomes are lifted and thrown to a side without damage. In Rayalaseema region the rhizomes are dug out with pick axe or crow bar. The average number of fingers produced per plant is 10. The finger rhizomes are separated from the mother rhizome (round) and prominent adhering roots are removed. The seed requirement is set apart and stored.

22.3.12. Curing

Curing of turmeric is taken up within 3 to 4 days after harvest. The mother rhizomes and finger rhizomes are cured separately. The rhizomes are boiled in water till frothing takes place and white fumes appear emitting a characteristic odour. The boiling appliance consists of iron pan of square shape 1.5 X 1.5 metre with a depth of 75 cm to take in four cubical immersions of the iron buckets with nine perforations of each side. A lid is placed on the pan at the time of boiling. Frothing commences after one hour of boiling and shortly after white fumes appear pushing up the lid. The lid is removed at this stage and after emission of characteristic turmeric flavour boiling is stopped. The rhizomes would be soft after cooking and allow the broomstick to be easily pushed through which indicates the end point of curing. The material is then removed and finger and round rhizomes are dried separately in the sun for 10-15 days till the material becomes hard and stiff. The dried rhizomes are polished by rubbing against the hard surface of drying floor or shaking them mixed with stones in long narrow gunny bags or by rotating them in polishing drum. During the process of drying and polishing the adhering scales and root bases get separated. The outturn of cured product to fresh rhizomes is 25%. The proportion of rounds to fingers is 1 to 4. The average yield of the cured products is 5000 kg/ha.

22.3.13. Colouring

The rhizomes are some times made attractive by resorting to colouring. This is done in two ways, dry colouring and wet colouring. In the former method, a yellow dye stuff known as the middle chrome is slightly dusted on a small heap of polished rhizomes and well mixed in water and the coloured solution is sprinkled over small heaps of rhizomes and rubbed well. The produce is then dried for a week. Wet colouring gives a better appearance for the produce which will fetch a higher price in the market. In some places turmeric powder itself is used for this purpose. This is a better practice than using colours which are injurious to the health of the consumer.

22.3.14. Storage of Seed Material

From the time of harvest in March till the time of planting in June/July the fresh rhizomes are carefully preserved for planting. The material is stored under the shade of the tree in loose heap covered over with a layer of dried turmeric leaves. The heap is generally left undisturbed till planting season. In some places, the heap is removed after 1 1/2 months and spoiled rhizomes if any are removed and again reheaped. If there are no rains in summer, water is sprinkled once over the heap during April-May.

22.4. GINGER *(Zingiber Officinale Rose)*

This is grown in India, China, West Indies, Jamaica, North and West Africa. It is cultivated to some extent in all the states of India particularly in Kerala, Gujarat and Bihar. In Andhra Pradesh is grown in Visakhapatnam, Godavari, Nellore districts and Zahirabad area of Medak district. The area in other districts is highly localised and grown for green ginger.

22.4.1. Climatic Requirements

It is a tropical crop and comes up well in warm and humid weather. It thrives well from mean sea level upto 1600 metre elevations. It requires well drained soils. It needs enough moisture for its growth. In all states of India it is grown under rainfed conditions. It is tolerant to shade and is grown as an intercrop in coconut gardens, citrus orchards and banana fields. However, shade is not essential for its growth.

22.4.2. Seasons & Soils

Planting season is from April-May to middle June. Duration of the crop is 7 months. Crop comes to harvest in December-January.

Ill drained soils, heavy clay soils and soils with impervious layer are not suitable. Loamy soils are best. It is grown in light red soils and sandy loam soils.

22.4.3. Varieties

1. Siddipet local: Suitable for Telangana region.

2. Tuni, Narsipatnam : Suitable to coastal areas.

These two varieties are low in fibre content, average in crop yield, and susceptible to disease. They possess good quality.

3. Rio de jenero (Brazil) : High in fibre. It can be used as a fresh ginger. Susceptible to diseases.

4. Maran and Bhyri: High in fibre. Susceptible to disease.

22.4.4. Fertilizer Recommendations

120 N + 80 P_2O_5 + 120 K_2O/ha. Farm yard manure at the rate of 50 tonnes/ha and 60 kg P_2O_5/ha should be applied as basal dressing. At 40 days after sowing nitrogen and potassium at the rate of 30 kg each should be given as top dressing. At 80th day 60 kg N/ha and 50 kg K_2O/ha should be given and the final dose of 30 kg N and 30 kg K_2O should be given at 120th day followed by earthing up of the crop.

22.4.5. Land Preparation and Sowing

The land is prepared to good tilth by ploughing 4 to 6 times depending on soil type. The land is laidout in flat beds with alternate irrigation and drainage facilities. The material for planting should be free from disease. About 1000 kg rhizomes are required per hectare for planting. The rhizomes are cut into pieces of 10 to 25 g and they are treated with 0.25% wettable ceresan for half an hour. Sprouted pieces should only be planted at inter row spacing of 45 cm apart with 10 to 15 cm intra row spacing. Cowpea can be sown along with ginger to provide shade and removed after 60 days.

22.4.6. Mulching

Soon after planting, the beds are covered with thick layer of forest leaves to serve as mulch to protect the crop against dashing rains and to reduce evaporation losses and to suppress the weeds. The mulching is done twice or thrice. The undecomposed twings are removed and the crop is given weeding before next month. The crop is thoroughly weeded before final earthing at 120 days after sowing.

22.4.7. Irrigations

Irrigations are given at 4 days interval in summer and 6-8 days interval in post monsoon period. During rainy season it may not be necessary to irrigate ginger crop if there is more than 2.5 cm rain in 12 days. During heavy rains care should be taken to see that there is no stagnation of water in the field after the rain.

22.4.8. Important Pests and Diseases on Ginger

A. Pests

Rhizome fly: These maggots are white in colour and stay in decayed Rhizomes. Good cultivation practices should be adopted to avoid decaying of Rhizomes. Proper drainage should be ensured.

Skippers: These larvae fold the leaves and feed on the chlorophyll.

Control: Spray Carbaryl 50% W.P. at the rate of 2 g. per litre of water once in 10 days depending on necessity. 500 lts. of spray fluid is required per hectare.

Shoot borer: These larvae bore on shoots, resulting in the death of the central shoot.

Control: Spray Endosulfan 35% EC at the rate of 2 ml. in one litre of water. About 625 litres of spray fluid is sufficient for one hectare.

Root grubs: At the time of germination these grubs cut away the growing shoots.

Control: Dusting of BHC 10% dust at the rate of 25 kg/ha.

B. Diseases

Soft rot: Symptoms like drying up of the shoot and decaying of Rhizomes will be noticed.

Control: Treat the seed with Thiram 0.25% (2.5 g in one litre of water). Afterwards, spraying on the main field can also control the disease to some extent.

Check Your Progress - 4

How do you control the shoot borer of Ginger?

Note: (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end.

....

....

22.4.9. Harvesting

The crop gets ready for harvest by the beginning of December, when leaves start withering. In line sown crops the rhizomes are lifted by working a plough by the side of the rows. Digging out the produce with a crow bar or pick axe or digging fork is largely adopted. The rhizomes are then cleared free of mud and roots.

The average yield of fresh rhizomes is 10,000 to 15,000 kg/ha. The bumper yield upto 40,000 kg/ha can be obtained under favourable conditions.

22.4.10. Curing and Bleaching

The outer skin on the surface of rhizomes are removed by scraping with bamboo pieces sharpened like a knife and the cleaned rhizomes are dried in the sun. The loss of weight in drying ranges from 75 to 80 per cent.

The rhizomes cured by the above simple process give a product that is not attractive in appearance. When a better produce is aimed at, the fresh rhizomes are first soaked in water and the skin is removed thoroughly or by trampling in cement tubs in standing water during soaking time. The water is frequently changed during the process of trampling. The peeled rhizomes are washed well and soaked in clear lime water for some time. The rhizomes are then dried in the sun for about a week, turning the drying material frequently to facilitate even drying. In some places after soaking in lime water, they are spread in bamboo trays and fumigated for 12 hours with sulphur di-oxide by burning sulphur and then dried in the sun. The dried ginger is rubbed on coarse gunny pieces to remove any portion of outer skin adhering to the rhizomes. If the ginger is not bleached and white enough, it is again washed in lime water and redried. Thereafter the rhizomes are sorted out according to colour and size.

22.4.11. Preservation of Seed Material

During harvest, healthy rhizomes are selected for use as seed for the next year's crop. A pit is dug in shade or in Verandahs of houses. A layer of sand or paddy husk is spread at the bottom and rhizomes are filled. The mouth of the pit is closed with a wooden plank providing some empty space over the ginger. The pit is scaled with a mud plaster. The pit is opened at the time of sowing by which time rhizomes are ready for planting with sprouts.

22.5. Coriander *(Coriandrum Sativum L.)*

It is grown in Russia, turkey, palestine and Morocco. In India it is grown in all states. In Andhra Pradesh it is cultivated in an area of about 1 lakh hectares contributing about 32% of the area and 42% production in the country. It is cultivated on extensive scale in Kurnool, Ananthapur, Guntur, Prakasam, Krishna, Medak, Adilabad and Ranga Reddy districts.

22.5.1. Climatic & Soil Requirement

Cool climate with low temperature and good amount of dew fall are favourable for the crop.

It is confined mostly to moisture retentive clay, clay loams and black cotton soils. Excessive saline or alkaline soils with water stagnation are not suitable for this crop. it is grown to a less extent in sandy soils with irrigation.

The best season for coriander is Rabi. Depending upon the rainfall and soil moisture availability, it is sown in October- November months.

22.5.2. Recommended Varieties in Andhra Pradesh

The different varieties tht are recommended to Andhra Pradesh, their duration and average yield are given below

	Variety	Duration in days	Average yield kg/ha	Remarks
1.	CS-2 (Mid season grain purpose)	110	1300-1400	Cosmopolitan variety.
2.	CS-4 (late dual purpose)	120	1400-1500	Cosmopolitan variety.
3.	CS-6 (Early type)	80	800-1200	Escapes from powdery mildew incidence.
4.	CS-5 (Small grained)	100	1000-1200	
5.	CS-7 (Late mainly for leaf and also grain)	130	800-1000	More for leaf. Bushy type.

22.5.3. Fertilizer Recommendation

In the last ploughing 10-15 tonnes of F.Y.M. along with 30 kg N/ha as a basal dose should be applied in black cotton soils. In light soils it is cultivated under irrigated conditions. Besides

F.Y.M., 45 kg N, 30 kg P_2O_5 and 30 kg K_2O have to be added. All phosphorus and potassium and 1/2 nitrogen should be applied in the last ploughing. The remaining half nitrogen should be given 30 days after the sowing.

22.5.4. Land Preparation and Sowing

The land is brought to fine tilth by two to three ploughings followed by harrowings. The quantity of the seed required per hectare is about 12-15 kg. The seeds are drilled with inter row spacing of 30 cm. The seeds are sown as split or whole seed.

22.5.5. Intercultivation

The seed germinates in about 12 days. Thinning is done if necessary. The field is kept free from weeds by intercultivating with bullock drawn tyned harrow followed by hand weedings.

22.5.6. Pests and Diseases

1. Coriander aphid *(Hyadaphia coriandri)*

Symptoms: The nymphs and adults suck the sap from he shoot and inflorescence and secrete honey dew.

Control: Spray Monocrotophos (1.5 ml/litre) or Phosphomidon (1 ml/litre) or Dimethoate (1 ml/litre).

2. Stem galls of coriander *(Protomyces macrosporum)*

Symptoms: The fungus initiates tumour like swellings on leaf veins, stalks, stems and on fruits. The tumours are at first glossy and later rupture and become rough. In severe cases of infection the affected plants may be killed.

Control: (a) Use of clean and healthy seeds. (b) Field sanitation and rotation.

22.5.7. Harvesting

The crop comes to flowering in about 45-60 days and matures in 100-130 days depending upon the variety. The crop is sown using heavy seed rate with purpose of periodical thinning and sold as green plants before flowering in places nearby cities. The crop is harvested when 70 percent seeds mature and turn to straw yellow colour. Harvesting is done by pulling out the whole plants. These are kept in the field for 2-3 days and dried in partial shade to get good colour and aroma from the grain. After threshing, the seeds are cleaned, dried and stored in gunny bags. The average yield of coriander is about 800-1000 kg/ha.

22.6. SUMMARY

Turmeric is useful in many ways as a spice culinary preparations, as a drug and also as a toilet in cosmetic industries. Ginger and coriander are used as condiments. Turmeric and Ginger thrive well in warm and humid weather. Coriander requires cool climate. They require well drained soils. Loamy soils are best for turmeric and Ginger. Moisture retentive clay and black cotton soils are best for unirrigated coriander. There are short, medium and long duration varieties in turmeric ranging from 7 to 9 months. The duration of Ginger crop is 7 months and that of coriander ranges from 3 to 4 months. Turmeric and Gingers are sown in the month of June. The coriander crop is sown in the month of October- November. For turmeric the recommended spacing is 30 X 15 cm and 45 X 15 cm for ginger. Coriander crop is sown by drilling at inter row spacing of 30 cm. In some localities soon after planting, the turmeric and ginger fields are spread with forest leaves to serve as mulch. Application of 25 tonnes of F.Y.M. 180 kg P_2O_5

and 120 kg K_2O per hectare is recommended for turmeric. For Ginger crop 50 tonnes of F.Y.M. 120 kg N, 60 kg P_2O_5 and 120 kg K_2O per hectare is recommended. Coriander crop require 10 tonnes F.Y.M. plus 45 kg N, 30 kg P_2O_5 and 30 kg K_2O per hectare in light soils under irrigated conditions. Turmeric and Ginger rhizomes are lifted by running country plough by the side of rows or by crow barring. Corinander is harvested by pulling the plants. The fresh turmeric rhizomes are subjected to curing process by boiling them in iron pans for about one hour till frothing takes place and white fumes appear emitting a characteristic turmeric flavour. Then they are dried in the sun for 10-15 days till they become hard and stiff. Turmeric rhizomes are polished by rubbing against the hard surface or in polishing drum. During the process of drying and polishing, scales and adhering roots get separated. In some places colouring of polished rhizomes is done either by dry colouring or wet colouring. In turmeric, the out turn of cured rhizomes is 25% of fresh weight of rhizomes. The yield of cured turmeric is 5000 kg/ha. In case of Ginger the average yield of fresh rhizomes is 10,000 to 15,000 kg/ha. Ginger rhizomes are subjected to curing and bleaching by removing outer skin by scraping with sharp bamboo stick and soaked in lime and then dried in the sun. The yield of dried rhizomes would be 20 to 25 per cent of fresh weight. In case of turmeric and Ginger since there is a gap of 3 to 5 months from harvesting to the sowing of next crop, the fresh rhizomes are carefully preserved under shade. The average yield of coriander seed is about 800 to 1000 kg/ha.

22.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The two medium duration varieties of Turmeric are CLI-317 and Kesari
2. *Taphrina maculans*
3. *Pythium sp*
4. Shoot borer of Ginger can be controlled by spraying Endosulphan.
5. *Protomyces macrosporum*

22.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the different varieties of Turmeric that are grown in A.P.
2. Write briefly about the different pests and diseases which attack Turmeric.
3. Give a detailed account of the curing and colouring of turmeric.
4. Write an essay on the cultivation of ginger. Add a note on the pests and diseases which attack it .
5. Write a brief account of the cultivation of Coriander and add a role on the pests and diseases that attack it.

II. Answer the following question in about 10 lines each.

1. What are symptoms of the diseases caused to turmeric? How do you control them?
2. Write briefly about the colouring process of turmeric.
3. Write about the climatic and soil requirements of ginger.
4. What are the important pests and diseases of ginger? Write about the causal organisms, symptomatrlogy and control measures.

UNIT - 23: TOBACCO

Contents

23.1. OBJECTIVES

After going through this unit you will be able to:

1. describe the climatic and soil requirements of tobacco crop,
2. list out the different varieties used in Andhra Pradesh
3. describe the method of raising the nursery and the preparation of main field,
4. describe the process of interculture, topping and desuckering,
5. suggest the different methods of weed control,
6. describe the method of harvesting and differnet methods of curing the tobacco
7. list out the important pests and diseases, the causal organisms and describe the symptoms caused by them and suggest the different methods of control,

23.2. INTRODUCTION

Tobacco is one of the important narcotics crop grown in India. This crop is grown for its leaves, which are used after curing. The cured leaves are used for smoking pipe, cigar, cigarette or hukka, used as snuff or chewed in many forms. It was reported that the discovery of narcotic qualities of tobacco was accidently made by Christopher Columbus in the course of voyage from Persia to Spain in 1492.

Columbus and his men also tried this themselves and were pleased with the intoxication and took some seed and leaves with them to spain and that is how the tobacco was introduced in Europe. Tobacco said to have been introduced in India by Portuguese in the begining of the 17th Century A.D. As else where in the world, here too, it has thrived inspite of considerable neglect and social disapproval. Its cultivation is now extends to all parts of the country, and it is one of the most valued crops of India, though the area under this crop is only 0.3% of the total sown area.

Tobacco is grown under a very wide range of conditions, extending from tropical zone to sub-tropical and temperate zones. In India, its cultivtion is widely distributed. The total production of India is about 594 million kilograms of leaf, from an area of 4.5 lakh hectares. This producitn is second largest in the world, next only to united states of America. It earns annually an excise revenue of 350 crores and foreign exchange of about 230 crores. In India it is mainly grown in Andhra Pradesh, Gujarat, Tamilnadu, Karnataka, Bihar, West Bengal, Uttar Pradesh, Orissa, Punjab and Kerala. Andhra Pradesh ranks first in area with 1.7 lakh hectares and second in produciton with 93 million kilograms of leaf. At present 2/3 quantity produced in India is exported. Tobacco ranks third among the excisable commodities and ninth among the exportable commodities

23.3. SOILS

The type, grade and quality of tobacco produced are considerably influenced by the soil characteristics, particularly the texture of the soil. Light soils (sandy loams) tend to produce large leaves, light in weight and colour, mild in strength and weak in aroma, where as leaves produced on heavy sois is usually thick and heavy, dark coloured, strong and aromatic, However, certain beedi tobaccos are not influenced by light and hevy soil characteristics. In general tobacco grows best on sandy loam surface soil with aeration, and high moisture retentive eapacity. In India flue cured virginia (FCV) tobacco cultivtion is confined to black clay soils, sandy loams and red soils. The area under black soil is to an extent of about 60% of the total area under FVC tobacco. In the districtrs of Prakasam, Guntur, Krishna, East and West Godavari, the FCV tobacco is extensively cultivated.

In addition to these soils, the FCV tobaco is also grown on river beds of Khammam and East Godavari, where the soils are alluvial silty loams with high fertility status. The FCV is also grown on sandy loams (light soils) with irrigation in Karnataka and Gujarat. Beedi tobacco is grown on alluvial soils in Gujarat, black clay soils of Karnataka and Maharashtra. Cigar and Cheroot tobacco's are grown on light soils in Tamilnadu. Chewing Tobacco is grown under varying soil conditions. The hukkah tobacco is grown on alluvial soils of Bihar, Uttar Pradesh and West Bengal. The tobacco growing soils of India, in general are low in organic carbon and nitrogen, hence these require about 20 to 40 kg N/ha.

The black soils of coastal districts of Andhra Pradesh are highly clayey with a moderately alkaline pH (7.4-8.7). They are calcareous with 4.5 to 5.0 per cent free calcium carbonate. Their water holding capacity is very high, of the order of 70 per cent, which enables growing of tobacco in winter on the moisture conserved from the monsoon but these soils are characterised by poor drainage.

Moderately deep well drained red sols of Prakasam, Nellore and Parts of West Godavari, having moderate waterholding capacity produces leaf of very good quality. The soils are neutral in pH (6.7-75), free from any harmful soluble salts and are low to medium in fertility staus.

Natu tobacco is grown in West Godavari, Krishna, guntur, Prakasam, Khammam, Kurnool and Anantapur districts. Visakhapatnam and Srikakulam disticts also grow Natu tobacco for cheroot and chewing purposes. The soils growing Natu tobacco range from heavy black clayey soils as in Guntur to sandy and sandy loam soils of West Godavari and Srikakulam. Lanka tobacco exclusively grown on alluvium soils of Godavari, which are characterized by high soil moisture retention. Burley tobacco is grown on black soils of Guntur and Prakasam districts. Burley is also grown on red soils (Chalkas) of Warangal, Karimnagar, Nizamabad, Hyderabad, Medak and Nalgonda districts under rainfed conditions. These soils are poor in organic matter, low in water holding capacity and fertility status. The leaf produced from these soils are of high quality.

23.4. CLIMATE

The climatic factors like rainfall, temperature, relative humidity, wind and sunlight influence growth and flowering of tobacco plants. It can be grown in regions where the mean temperatures of 70-90^{o}F prevails for a period of 80 to 120 days. In Andhra pradesh this crop is grown in winter period (September- February), when the temperatures are suitable. This crop is highly sensitive to flooded or water logged conditions of soil because of lack of oxygen in soil, essential for the development of root system. Light soil, can be used for taking rainfed crop, provided the rainfall is not heavy and the distribution is normal in the crop growing season. Light showers in the early stages of crop after transplanting are beneficial, but light showers when the crop is about to mature results in poor quality both in respect of grade and chemical composition of leaf. The crop is susceptible to hail and storm. Relative humidity influences the quality of tobacco, paricularly that of F.C.V. and cigar wrapper types. The fine, thin and elastic leaf is a product of high relative humidity at the time of leaf maturation. The day time variations in relative humidity and temperature from morning to mid-day influence the crop growth and quality.

23.5. VARIETIES

There ae about 60 species of tobacco, but only *Nicotiana tabacum* and *Nicotiana rustica*are cultivated. In India, both species are grown, but the largest area is under *Nicotiana tabacum*.As *Nicotiana rustica* requires cooler climate, it cultisvation is mainly confined to the northern and and north eastern areas of the country such as Punjab, Uttar Pradesh, West Bengal, Bihar, and Assam. The *rustica* varieties known as Vilayathi and Calcutta have short plants with round puckered leaves with yellow flower. The varieties of *Nicotiana rustica* are used for hookah, chewing and snuff. They are not suitable for cigarette or cigars or bidies. The varieties of *Nicotiana tabacum*, called as desi types have tall plants with long broad leaves and usually have pink flowers. Specific varieties in *Nicotiana tabacum* are available for cigarette, cigar and cheroot, bidi, hookah, chewing and snuff tobacco. Out of the total cultivable area under tobacco, 25% area is under FCL, 31% Bidi, 26% chewing and hookah, 7.5% Natu, 10.5% cigar, cheroots, Lanka and Burley tobaccos.

In Andhra Pradesh mainly cigarette tobacco, Natu tobacco, Burly tobacco, Bidi tobacco are grown.

Cigarette types

The important cultivated varieties are: (i) Flue cured virginia special (ii) Central tobacco research institute (CTRI) special (iii) Kanakaprabha, (iv) Dhana dayi (v) Delcrest (vi) Virginia Gold (vii) White gold (viii) 16/103, and (ix) GSH-3.

Natu tobacco types

The common cultivated varieties are: (i) Thoka Aku (N-I) (ii) Karravithanam (N_2), (iii) Neeti, (vi) Kandukuripedda (v) Surakathi, (vi) Japalan, (vii) Enugu chevi, (viii) Kanusumeda vithanam, (ix) Gorrekommu, (x) DG-3, (xi) NG-2 AND (xii) DR-I.

Burley tobacco types

Most comonly grown varieties are; (i) Burely-21, (ii) KY-8, (iii) KY-16, and (iv) HDBRG.

Bidi tobacco types

The widely adopted varieties are: (i) Anand-2, (ii) Anand-23, (iii) Anand-119, (iv) Andad-3 and (v) K-20.

Suitabily of Cigarete types for vairous regions of Andhra Pradesh

Region	Varieties recommended
Coastal Andhra Pradesh Black clayey soils with normal or deficit moisture	CTRI Special, Kanakaprabha, FCV Special, Dhanadayi, GSH-3.
Guntur and Krishna districts - Black clayey soils with high moisture.	Kanakaprabha, 16/103.
East and West Godavari and Khammam districts northern light soils.	16/103.
Prakasam and Nellore districts - Southern light soils.	CTRI Special, FCV Special, GSH-3.
Riverside lankas	CTRI Special, FCV Special.

Suitability of Natu tobacco types for vairous regions of Andhra Pradesh

Region	Varieties recommended
Guntur, Nalgonda, Mahaboobnagar and Kurnool-black clay soils.	Thokkaku, Karravithanam, DG-3, DG-4 and NG-2.
Krishna, West Godavari and Khammam-Red sandy loam soils.	Neeti, Kandukuri Pedda.
Visakhapatnam and Srikakulam all soils.	Enuguchevi, Kansumedavithanam, Gorrekommu.
Godavari and Krishna districts - River beds.	Lanka tobacco.

Suitability of burley tobacco types for various regions of Andhra Pradesh

Region	Varieties recommended
East Godavari and Telangana districts of sandy loam soils.	Burley-21.
Guntur black soils	KY-8, KY-16, HDBRG.

Suitability of cheroot and chewing tobacco types for vairous regions of Andhra Pradesh

Regions	Type	Varieties recommended
Kakinada	Cheroot	Baru, Mattasam, Kuracha
Vijayanagaram	Chewing	Kurupam, Tangajapanam, Kanusumeda
Visakapatnam	"	
Godavari West	Cheroot	Lanka
Guntur	Cheroot	Chebrole
Warangal	Cheroot	Nujivid, Desi, Natu.

23.6. NURSERY

Tobacco seedlings ae raised on nursery beds and planted in the mainfield after 6-8 weeks. The aim of nursery raisifng is to get good number of healthy and vigorous sedlings. Well drained light soils situated at high level should be selected for raising nursery. The soil should be thoroughly prepared to get fine tilth. Raised seedbeds of 15 cm height are prepared with 1.22 m wide and 10.0 m length. If the bed width is more, weeding and waterifng to seelings become difficult. There should be about 0.5 m wide channel for drainng out excess water. It is also used irrigating the seedbeds and as a pathway for pot watering the seedlings. The tobacco seedlings cannot withstand water logged condiitons even for short period.

The normal practice is to use a combination of organic and inorganic manures. Application of groundnut cake at 80 kg/ha along with 30 tonnes of FYM/ha as a basal dose suplemented with inorganic nitrogen of 50 kg N/ha as top dressings in split doses are recommended. Application of 80-100 kg P_2O_5/ha as basal dose is found to be more beneficial. The 50 kg N/ha has to be given in five splits at intervals of three to four days starting from tenth day after sowing. Seedlings should not be pulled out at least for a week after top dressing. The optimum time for sowing is second fortnight of August. The seed rate is 2 to 4 kg/ha. The seed is small in size, so is to be mixed with sand for even distribution at the time of broadcast in the nursery bed. Before sowing, the seed can be soaked in 50 ppm Gibberlic Acid solution or in water for overnight to soften the seed coat which ensures good germination. It is allways better to drench the seedbed before sowing with freshly prepared Bordeaux mixture to avoid damping-off and other soil borne diseases in the early stages of seedling growth. Afgter sowing, the seed beds are covered and compacted by pausing a stone roller. Watering of nursery beds is to be done carefully till the germination is completed. The beds should always be kept moist but not wet. To minimise dislocation of seed from the bed, rose cans can be used for watering. In the initial stages 6-8 waterings are needed per day and then can be cut down to four as the seedlings grow. The beds will be covered with paddy straw or any other material to keep the beds moist and cool. This cover also protect tender seedlings from strong sunlight and beating rain action. Covers are graduaslly thinned or removed after germination. Normally the seedlings are ready fo planting at the end of 7th week. No watering is done 3-4 days before pulling to harden the seedlings.

It is desirable to change nursery site every yer to minimise the incidence of diseases, pests and weeds. If for any reason, it is not possible to change the site, the old site can be sterilized by burning it with any available waste material like tobacco stalks, paddy husk etc. This will control the soil borne disease causing organisms, pests and the weed seeds.

23.7. MAINFIELD PREPARATION

In most of the tobacco growing areas of Andhra Pradesh, the field is kept fallow till September. In some areas a number of ploughings are given with country plough followed by harrowing to keep the soils in fit conditions to store maximum amout of moisture. Experiments involving tillage operations indicated that excessive tillage operations do not help in either improving the yield or quality. One or two ploughings either with mould board plough or wooden plough, and 3 to 4 harrowings are adequate.

In deep black soils, which crack deep in summer and become very sticky with onset of rains, deep ploughing during summer by heavy duty tractors soon after the removal of tobacco stalks from the field at the end of the season resulted in increased yield and quality. Huge soil clods get inverted, backed in hot sun leading to the destructin of weeds and pathogens. The clods disintegrate to fine powder during rainy season. From June to August the land is ploughed to break the soil clods. Two to three ploughings followd by harrowing are sufficient in the fields that have been deep ploughed in the summer.

23.8. METHOD OF PLANTING

The position of plants in the main field is marked by running a marker in cross wise direction. At the intersecting points the seedlings are planted carefully. Sufficient moistre at the time of planting is maintained for estblishment of seedlings. The planting spots (Intersecting points) are pot watered just before or prior to planting the seedlings, if there are no rains.

23.9. SEASONS

FCV	:	Middle of October to middle of November in Andhra Pradesh.
Bidi	:	Middle of August to middle of September.
Cigar and Cheroot	:	October to Ist week ot November.
Hookah	:	Punjab - March. Bihar - September to October. Bengal - October to November.
Snuff and Chewing	:	Madras - October to November Kerala - September to October

23.10. SPACING

The tobacco seedlings are always planted in rows. The spacing varies with the type of tobacco.

FCV : Black soils 90 X 60 cm

Light soils : 60 X 30 cm

Natu : 80 X 80 cm

Cigar and cheroot : 75 X 50 cm

Chewing : 75 X 75 cm.

Bidi : 100 X 75 cm (Gujarat)

105 X 45 cm (Karnataka)

60 X 45 cm (West Bengal)

Gapfilling : Gaps have to be filled within 10 days of planting.

23.11. INTERCULTURE

The object of various inter cultural operations adopted for successful cultivation of the crop is to keep down the weeds, create mulch and prevent cracking of the soil thereby to conserve the soil moisture and also to aerate the soil.

1. Flue cure tobacco

(a) Traditional black clayey soil: Three to four intercultures starting about 3 weeks after planting will be sufficient.

(b) Northern light soils: First interculture is done with tyned harrow after the seedlings are well established.

(c) Southern light sols: Interculture has to be taken up after each rain to prevent hardening of the soil.

(d) Karnataka state transition belt: Two intercultures with tyned harrow have to be given 3-4 weeks after planting.

II. Natu tobacco (Rainfed) : After the establishment of seedlings, interculture is carried out 4-6 times either with tyned or blade harrows.

III. Beedi tobacco : Five to eight intercultures have to be given.

IV. Cheroot tobacco (Lanka tobacco) : Three to four intercultures starting after 3 weeks from planting will be sufficient.

23.12. TOPPING AND DESUCKERING

The operation of topping consists of removal of the terminal bud just before or soon after the emergence of the flower head. Following topping axillary buds become active and put forth shoots known as suckers. Removal of these suckers is called desuckering. The object of topping and desuckering is to divert the nutrients of the plant to the leaves instead of flowers and seeds, with the resulting gain in the size and body of the leaf, thus increasing the yield and quality of the tobacco.

Maximum cured leaf weight was obtained under normal topping at the opening of 1st flower compared to low topping (done at the same time but two more leaves removed) or no topping. However, FCV tobacco grown in light soils is only topped but not the same tobacco grown in heavy soils or ferti- soils. Two or three desuckerings are generally carried out as the suckers reach a convenient size for handling. The suckers are removed by hand ploughing. The suckers also can be controlled by applying removal of suckers. The oil will inhibit the development of axillary buds. If there is rank growth of crop, high and late topping are advocated. For FCV the topping is to be done at 18-20th leaf, for Natu tobacco 14- 16th leaf, for cheroot (Lanka) tobacco at 12th leaf. For burley tobacco, topping was done at 21-24 leaf level, 14-16 leaf level and 23-26 leaf level in East Godavari, Guntur and Telangana respectively.

23.13. WEED CONTROL

The weed problem is not severe in tobacco compared with other commercial crops like chillies, turmeric sugarcane, as this crop is generally grown as rainfed crop during monsoon in red soils and depending on residual moisture on black cotton soils without irrigation.. Physical and mechanical methods of weed control are very popular compared to chemical methods. Weeds occur in tobacco both in nursery and main field. The important weeds are *Vernonia* sup, *Physalis* spp, *Euphorbia* spp, and *orabanche* spp. The critical period for weed competition is the first 9 weeks after planting.

The safest and economical method of weed control is the mechanical method of weed control. In the nursery hand weeding is effective. In the transplanted crop, inter row cultivaiton is possible because of wider row spacing. Hence one or two cultivations followed by hand weeding to remove weeds growin close to tobacco plants can give adequate weed control. Further intercultivation with tyned gorru followed by blade harrow is a regular practice to conserve the moisture.

Orabanche is a complete root parasite and causes reduction in quality and yield of tobacco. Deep ploughing, occasional sub- soiling, adequate irrigation and fertilization to the crop reduces the incidence of Orabanche. Trap cropping with pepper is another useful measure. Chemicals like GR-7, GR-24, GR-21 can be used to stimulate the germination of the weed and its ultimate death. Glyphosate (0.2 kg a.i/ha) terbutol (2.5 kg a.i/ha), allylalchohol (0.2% spray) are some of the herbicides recommended. Weeds not only reduce yield of crop but also the quality.

24.14. IRRIGATION

It can tolerate drought more than excess moisture. The total water requirements of crop is about 500 mm. The seedling, preflowering and flowering stages are the critical for moisture.

Tobacco grown in sandy loam soils of Godavari district receives 6 to 7 irrigations and tobacco in river side lankas receives 3 irrigations between 30 to 60th day after planting. One irrigation at 7 weeks after planting was found to keep the soil moisture above critical level, as compared to irrigation in the 4th or 9th week. Under Rajahmundry conditons, it is found beneficial to irrigate cigarette tobacco in black soils to field capacity when 40% of available soil moisture is depleted. If the chloride content in irrigatin water is more than 50 ppm in light soils, and more than 30 ppm in black cotton soils is harmful to the crop.

Proper scheduling irrigations to tobacco not only to increase the yield but also the quality of leaf. Excess irrigation can lead to deterioration in quality.

Generally a major part of water needed by the crop is supplied by the stored soil moisture and the remaining quantity is to be met partly by rain and irrigation.

23.15. MATURITY OR RIPENING

It takes about 70 to 75 days from planting for the crop to be ready for the first priming. Some of the early maturing varieties are ready by 60th day for priming. The leaves which have completed their growth and are turning from green to yellowish green or slightly yellow in colour are detached from the plant. Process of detaching of matured leaves is known as priming. In bidi tobacco development of mottling or sprangling as prominent character that has to be observed before the tobacco is harvested. In cigar or cheroot tobacco yellowing of top and margin, and brittleness of the leaf are indications of maturity.

23.16. HARVESTING

Essesntially there are two methods of harvest namely priming and stalkout method. In stock out method the entire plant is cut at once. At each priming 2 or 3 or more matured leaves are harvested (detached from the plant). After the commencement of the 1st priming, subsequent primings are taken in about 6 to 7 days interval unless affected by rains. The entire harvest is completed in 6 to 8 or 10 primings depending on the leaf number and climatic conditions. Leaves harvested on the immature side cure green while those harvested on the over mature side lose weight and produce more scrap on curing.The most desirable physical and chemical quality characteristics were found in leaves harvested at the correct stage of maturity. Cigar, cheroot, chewing and hookah tobaccos are harvested by the stalkout method. In this method plants are cut close to the ground with a sickle and generally left in the field overnight for wilting.

Bidi tobacco is harvested by one of the following methods.

1. Leaf wise method: Only mature leaves are picked and placed on the ground face down.
2. Whole plant harvest: After harvesting the wholeplant, they are kept inverted at some place for drying.
3. Gugro method: Green lamina of the mature leaves is stripped off leaving the midribs attached to the stem. Midribs and bark of the stem are removed from the stem later.
4. 'Lilvo' method: Fully matured leaves are strung in business of 4 to 5 with a coir string.

23.17. CURING

Curing usually refers to regulated drying of harvestged fresh tobacco leaves under controlled conditions of temperature and humidity, such that the end products possess desirable colour as well as physical and chemical qualities. The purpose of curing is to produce dried leaf of the required physical and chemical properties. The success of curing depends on the condition of the harvestged leaf (brushed leaf does not cure properly) and its degree of maturity. Curing temperature, humidity and ventilation are the principal factors which control the essential biochemical processes.

The different types of curing are: (1) Flue curing, (2) Air curing, (3) sun curing, (4) Pit curifng and, (5) Fire curing.

23.17.1. Flue Curing

Cigarette tobacco is flue cured. The harvested leaves are taken to the shade and strung in bunches of 2 or 3 leaves according to their size on to bamboo sticks about 1.5 m long and 2 to 2.5 cm in diameter with the petioles of the leaves on the upper side, the leaves hanging back to back. Each stick holds 90 to 105 leaves and about 700 sticks are loaded in 16'x 16' x 16' barn or 810 sticks in 24' x 16' x 10-1/2' barn. Before stringing, it is desirable to grade the leaves into yellowish (over mature), light green (mature) and green (immature) grades. The leaves are loaded into the barn before the evening of the same day in such a way that immature leaves are placed on the top tiers and over mature leaves in bottom tiers, the remaining occupying the central portion.

The fuels used for heating the barns are either coal, wood or paddy husk etc. The temperature is raised by not more than 1-2°F per hour reaching 105°F by the time leaf becomes yellow and is raised in such a way that yellowing is nearly completed by the time it reaches 105°F. Top ventilator of barn is left very slight gaps. After yellowing, other curing processes include, colour fixing and leaf and stem drying. The progressive total time required for completion of all these curing processes are 88 to 101 hours. The temperature required for yellowing is 85-105°F, and the time required for completion of this process is 30-40 hours. For fixing colour 110-125°F temperature is maintained and is completed in 5 to 10 hours. At the time of colour fixation bottom ventilators of barn are opened at the base partially. Next for leaf drying 125-130°F temperature, for a period of 20-27 hours are essential. At the later part of leaf drying, for a period of 20-27 hours are essential. At the later part of leaf drying, the ventilators will have to be closed completely. Finally, for stem drying 160°F is maintained for 16 to 17 hrs.

After the curing is over the fire is put off. Allow the barn to cool down keeping the ventilators closed. During flue curing, most of the moisture content of the leaf which is about 77-80% of the green leaf is lost and 12-16% of the original dry matter is also lost. Bring the leaf to proper condition for handling, by opening the ventilators. Then the sticks are removed from the barn and after bulking they are heaped with the sticks. The bulked leaf is redried and aged with fermentation process.

After that, it is graded according to the colour and other quality characteristics prescribed.

23.17.2. Sun Curing

Cigar and chewing tobacco plants are strung on bamboo poles and suncured for about 15 to 20 days. Natu tobacco leaves are strung with jute thread with a needle and sun cured on scaffolds for 1- 1/2 to 2 months. Bidi tobacco plants are cut and left upside down to dry on the spot.

23.17.3. Air Curing

Hookah tobacco is air cured. In Andhra Pradesh, lanka tobacco leaf is cut with some portion of the stem, strung on ropes in a shed and air cured for about 2 to 2-1/2 months. Afterwards they are pit cured.

Burley tobacco leaves are primed, strung on a jute string and secured on a bamboo stick. The sticks are transferred to barns. High relative humidity is maintained (70 to 80%) during curing for wrapper.

23.17.4. Pit Curing

Pit curing is done for Lanka tobacco, Hookah and chewing tobacco. This is done after subjecting the leaf to air curing or sun curing. For lanka tobacco, pit curing is done in cylindrical pits of 1 to 1.5 m deep and 1.5 to 2.5 m in diameter. Two such pits are needed to cure the leaf harvested from 2 hectare area. Sides and bottoms of the pit is smoothened and tobacco strings are arranged in circular layers one above another. The pit is half filled and covered with palmyrah leaf and soil over it to make it air tight. After 24 hrs. the pit is opened and the leaf transferred to the second pit and covered. This pit is opened after 48 hrs. and the leaf is transferred to 1st pit and kept for 24 hrs. By this time the desired colour will develop.

Check Your Progress - 1

What are the different methods of curing of Tobacco?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

23.18. QUALITY

In the production of tobacco emphasis is always laid on quality rather than quantity of the leaf. The quality requirements in different types of tobacco are as follows.

1. Colour
2. Size
3. Texture (the fineness and elasticity of the leaf)
4. Nicotine content
5. Burning property
6. Aroma
7. Sugar content and
8. Filling quality (the number of Cigarettes made from a kilogram of tobacco).

23.19. YIELD

(i) Flue cured virginia tobacco: 1000-1500 kg/ha

(ii) Other types of tobacco: 2000-3000 kg/ha

23.20. IMPORTANT PESTS AND DISEASES OF TOBACCO

A. Pests

1. Tobacco cater pillar *(Spodoptera litura)*

Symptoms: The larvae feeds on the lower surface of epidermal layers of tender leaves and tender shoots by scraping. In the later stages of infestation irregular holes are formed on leaf blades. In severe cases they eat the whole of the leaf blade leaving aside only petioles and veins.

Control: (a) Collection and destruction of egg masses, (b) Clipping and destroying of leaves containing swarms of young larvae, (c) Spray Chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litre) or Fenvalerate (0.5 ml/litre).

2. Green peach aphid *(Myzus persicae)*

Symptoms: The aphids harbour in large numbers on the lower surfaces of leaves and suck the sap. The sucking results in curling and yellowing of leaves. The aphids also transmits tobacco ring spot virus and Rosette disease.

Control: Spray Monocrotophos (1.5 ml/litre). or Dimethoate (1 ml/litre) of Phosphomidon (1 ml/lit).

3. Tobacco stem borer *(Phthorimaea helipa)*

Symptoms: The larvae bores into the stem and causes gall formation. The gall, when split open, contain larvae. The plant growth is stunted and unusual branching at the top is observed.

Control: Spray Monocrotophos (1.5 ml/lit) or Thiodan (1.75 mg/lit) or Fenvalerate (0.5 ml/lit).

4. White fly *(Bemisia tabaci)*

Symptoms: Nymphs and adults suck the sap from leaves and secretes sugary substances. Sooty moulds develop on the sugary secretion and leaves black growth. The flies also transmit tobacco mosaic virus.

Control: Spray Monocrotophos (1.5 ml/litre) or Dimethoate (1 ml/lit).

5. Shoot bug *(Nesidiocoris tenuis)*

Symptoms: The bugs suck the sap from the tender portions and as a result leaves turn yellow.

Control: Spray Chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/lit).

6. Root knot Nematode *(Meloidogyne sp.)*

Symptoms: The nematode attack the roots and causes galls or knots on roots. The infestation results in stunted growth and chlorosis of the leaves.

Control: (a) Application of nemagon at 2 gallons/acre. (b) Application of *Pongamia* leaf, castor cake and FYM.

B. Diseases

1. Damping off *(Pythium aphanidermatum)*

Symptoms: The plants are generally affected from young seedlings stage to transplanting. Small water-soaked lesions appear on the stems and girdles the stem. The rotting from the stem may spread to roots and leaves. In severe cases entire nursery beds may be affected.

Control: (a) Spraying or drenching with 1% Bordeaux mixture or Fytolan, Miltox, Shell opper in 0.2% concentration two days before sowing at the rate of 10 to 15 liters per sq. meter with rose can. (b) Spray Dithane M-45 and Blitox at the rate of 2.5 g/litre at fortnightly intervals. (c) Provision of adequate drainage to the nursery beds. (d) Partial sterilization of nursery beds by burning trash.

2. Black shank disease *(Phytophthora parasitica)*

Symptoms: Small black spots appear and spread on the stem causing irregular patches and often girdling the stem. The infected tissue shrink and leave depression and stems shrivel and finally plants get wilted.

Control: (a) Spray Dithane M-45 (2.5 g/litre) or Bavistin (1 g/lit), (b) Burn the plant residues and debris, (c) Provision of adequate drainage to the field.

3. Frog-eye leaf spot *(Cercospora nicotianae)*

Symptoms: Brown lesions with ash grey centres appear on lower leaves. The typical lesion of the disease resembles the eyes of frog. It has white centre, surrounded in succession by grey and brown portions, surrounded by a dark brown to black margin. In severe cases many spots may coalesce and results in drying starting from the margins.

Control: Spray the nursery with Dithane M-45 (2.5 g/litre) or Bavistin (1 g/litre).

4. Powdery mildew *(Erisyphae cichoracearum var. nicotianae)*

Symptoms: The disease initiates first on the lower surface and spreads upwards. With the advancement of the disease the affected portion show scorched appearance and turn brown. The fungus causes severe yield losses.

Control: (a) Dust sulphur dust at the rate of 10-12 kg/acre, (b) Removal and destruction of affected old leaves.

5. Angular leaf spot *(Psuedōmonas angulata)*

Symptoms: The crop is susceptible at all the stages of growth, including nursery. The lessions are black with yellow halo and are bound by veinlets. Several such lesions may coalesce and results in blighting.

Control: Field sanitation.

6. Tobacco Mosaic virus *(TMV)*

Symptoms: Starts on young leaves as light discolouration along with veins. Afterwards the leaves develop typical light and dark green patterns and the dark green areas usually associated with the veins. In severe infections the leaves become narrow and thin and malformed.

Control: (a) Rogue the diseased plants and destroy, (b) Growing resistant varieties, (c) Workers should wash their hands after weeding.

Check Your Progress - 2, 3 and 4

2. The Scientific name of root knot nematode of tobacco is ____________________.
3. Frog eye leaf spot of tobacco is caused by ____________________.
4. Powdery mildew of tobacco can be controlled by dusting ____________________.

Note: (a) Write your answers in the spaces given above.

(b) Compare your answers with those given at the and.

23.21. SUMMARY

Tobacco leaves after curing are used for smoking, snuffing and chewing. The area under cultivation of this crop is largest in Andhra Pradesh than any other state in the country. The crop grows best on well drained loose and friable sandy loam surface with loamy to clayey sub-soil having high moisture retentive capacity. In Andhra Pradesh, this crop is grown in winter (September-February) season. Excess moisture, the day time variations in relative humidity and diurnal fluctuations influence the crop growth and quality. In Andhra Pradesh mainly the Cigarette, Natu, Burly and Bidi tobacco types are cultivated. In the districts of Prakasam, Guntur and Nellore, the Flue cured virginia tobacco is extensively grown. Seedlings are grown on raised seed beds and transplanted in the mainfield after 6-8 weeks. Watering is not usually done for 3-4 days before pulling to harden the seedlings. In the main field the seedlings are planted at intersecting points marked by a marker, which was worked in cross-wise direction. The seedlings are planted carefully, at the intersecting points, after pot watering if there is no sufficient moisture in the soil. The spacing varies with the type of tobacco. The gaps, if any, have to be filled within 10 days of planting. Interculture is carried out for 5-6 times to control the weeds, and to prevent hardening or cracking of soils. The aim of topping and desuckering is to divert the nutrients of the plant to the leaves instead of flowers and seeds, resulting in gain of size and body of the leaf, thus increasing the yield and quality of the tobacco. The competition between crop and weeds are severe in the first nine weeks after transplanting. Weeds not only reduce crop yield but also the quality. The crop can tolerate the drought better than to excess moisture. The total water requirement of crop is about 500 mm. The seedling, preflowering and flowering stages are sensitive for moisture stress conditions. The crop is harvested when the leaves turned from green to yellowish green or slightly yellow in colour either by detaching (Priming) leaves from plant or by cutting the plant (stem cutting). The most desirable physical and chemical quality characteristics can be obtained when the leaves harvested at correct stage of maturity. Proper curing is always given for quality of tobacco rather than quantity. Seed bed sterilization by buring with waste materials, drenching with fungicides will control the soil borne diseases. Crop rotation is recommended for control of diseases and parasitic weeds like *Orabanche* spp. Protecting the leaf from disease and pest incidence is essential for obtaining quality leaf.

23.22. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The different methods of curing of tobacco are: (a) Flue Curing, (b) Air Curing, (c) Pit Curing, (d) Fire Curing.
2. *Meloidogyne sp.*
3. *Cercospora nicotianae.*
4. Sulphur.

23.23. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give the detailed account of suitable soils for cultivation of different types of tobacco?
2. Write in detail the influence of climatic factors on growth and quality of tobacco?
3. Narrate in detail how the tobacco nursery is raised?
4. Describe in detail flue curing process of cigarette tobacco?

5. Give a detailed account of weed control measures including chemical weed control in tobacco?

6. Write the nature of damage (symptoms) and suggest control measures for the major insect pests of tobacco?

II. **Answer the following questions in about 10 lines each.**

1. Write about the suitability of cigarette and burly types for various regions of Andhra Pradesh.

2. Write about the suitability of Natu, chewing and cheroot tobacco types for various regions of Andhra Pradesh.

3. Write about the harvesting method for tobacco types.

4. Describe the Sun curing, Air curing and Pit curing methods in tobacco.

5. Give an account of weed control with special reference to *Orabanche spp.* (Broom rape) weed?

6. Write on irrigation requirements of tobacco crop?

7. Describe the symptoms of Damping-off and Blackshank diseases in tobacco.

UNIT - 24: MANGO

Contents

24.1. OBJECTIVES

After going through this unit you will be able to:

1. describe the climatic and soil requirements for mango,
2. list out and describe different varieties of mango,
3. describe the method of propagation planting and after care of mangoes,
4. list out the manures and fertilisers for mangoes and the method of their application,
5. suggest the method for the control of mango fruit drop,
6. list out the important pests and diseases, the causal organisms and describe the symptoms caused by them and suggest the control measures for each one of them, and
7. describe the method of harvesting of fruits, artificial ripening, and storage of fruits.

24.2. INTRODUCTION

Mango is the most popular and delicious fruit of the tropics. In India it is being considered as one of the excellent and choicest fruits occupying 65% of total area under fruit crops. It is also cultivated in South East Asia, Egypt, South Africa, South East Africa, Israrel, tropical Australia, USA (Hawaii and Florida), Mexico, Brazil, Cuba and Islands of West Indies. The area under mango in India is about 7,48,000 hectares with a production of 69,88,000 tonnes of fruits. Uttar Pradesh, Andhra Pradesh, Bihar and West Bengal are the leading states that are growing mango.

Andhra Pradesh ranks second in the country both in area (1.5 lakh hectares) and production (19 lakh tones). It is known for its contribution to the national pool a large number of commercial varieties like Banganpalli, Alampur, Suvarnarekha, Neelam, Mulgoa and several juicy varieties like Peddarasam, Chinnarasam, Navaneetham etc. In Andhra Pradesh, Krishna, East and West Godavari, Vishakapatnam, Vizianagaram, Srikakulam, Chittoor and Cuddapah are the important districts that are growing mango.

24.3. CLIMATIC REQUIREMENT

It comes up well both under tropical and sub-tropical conditions. Eventhough they are found growing upto an altitude of 1400 meters, fruiting is less above 500 metres. The optimum temperature for mango is 24°C to 27°C. If the temperature is below 1°C, the mango plants are adversely affected or may get killed by frost. So it is not advisable to go for commercial mango orchards in regions of frost occurrence. There is a close relationship between high temperature and increased percentage of perfect flowers and low temperature with decreased number of perfect flowers. Because of this reason some of the South Indian varieties had less perfect flowers under North Indian conditions. Early onset of high temperature results in early flowering and fruit ripening.

Timing of rainfall is more important than the total amount of rainfall. It grows well in regions receiving annual rainfall of 250 mm as well as 2500 mm. In regions receiving more than 750 mm rainfall it can be grown with little or no irrigation. One of prerequisites for successful mango cultivation is the absence of rain during flowering time. Rainfall at flowering not only washed away the pollen which adversely affects the fruit set but also encourages greater incidence of mango hoppers, mealy bugs and diseases like powdery mildew and anthracnose which sometimes damage the crop completely. Cloudy weather and high humidity encourages greater incidence of such pests and diseases and also interferes with the activity of pollinating insects which inturn affect the fruit set. In regions of high temperature and more rainfall with high humidity persisting throughout the year, there will be no distinct phases of vegetative growth and flowering and hence bearing will be poor. Areas exposed to high velocity of wind during the fruiting period are not suitable for mango cultivation.

24.4. SOILS

It requires well drained soil. In ill drained soils, the trees will become chlorotic and vegetative so that flowering and fruiting are adversely affected. Thus areas frequently subjected to floods are not suitable for mango cultivation. It requires deep soils of 2 metre depth. Loamy soils are best. Red soils, medium black soils and laterite soils are also suitable for mango cultivation. The water table in the soil should be below 180 cm to the surface soil and pH of soil should range between 5.5 to 7.5. The soils having pH more than 8.5 are not suitable for mango cultivation.

24.5. VARIETIES

There are hundreds of varieties in mango out of which only a few have commercial importance. Different regions of the country have their own commercial varieties because there is no single variety which performs equally well in all the regions having different sets of climatic factors. The varieties which are commercially grown in north India are Bombay green, Langra, Dashehari and Samar-behisht Chausa. The following varieties are popular in Andhra Pradesh.

1. **Banganapally** *(Beneshan, Safeda)*: It is a leading commercial variety in Andhra Pradesh. It is best suited to dry condition. Tree medium, fruit large, skin thin, golden yellow, flesh firm to meaty, fibre-less, fruit quality very good, bearing heavy (in terms of fruit weight), regular, late,

crop starts from 5th year and good yields from 10th year, moderately tolerant to hoppers and winds, keeping quality good.

Totapari *(Bangalore, Collector, Lord, Chittoor mamidi):* Most popular in Chittoor area, slowly replacing Banganapally in Nuzuvidu area due to its earlier bearing (crops in 3rd year and good yields from 8th year), more regular and heavier yield. Tree medium, fruit medium to large, skin thick, golden corn colour, flesh firm, fibreless. Fruit quality poor to medium. Tree brittle and more susceptible to cyclone damage as compared to banganapally, less tolerant to hoppers than Banganapally, Fruit keeping quality is excellent.

Suvarnarekha *(Lal Sundari):* Popular in Srikakulam and Visakhapatnam districts, tree medium, fruit medium, Skin medium thick, flesh soft, fibreless, fruit quality medium to good, bearing heavy and regular, early in coastal area and midseason at Sangareddy, moderately tolerant to hoppers, slightly susceptible to powdery meldew. Keeping quality is good.

Neelum: Late variety, more popular in Southern districts of the State, tree medium, fruit medium, skin medium thick, yellow, flesh fibreless, fruit quality good, bearing regular and heavy, late, gives a second crop (September-October) in areas like Kodur. Keeping quality is very good.

Dashehari: One of the leading commercial varieties of North India suited for growing in Western districts of Telangana and trading with North. Tree medium, fruit small to medium, skin medium thick yellow, flesh firm, fibreless. Fruit quality is very good to best, irregular bearer, heavy and midseason, susceptible to hoppers and powdery mildews keeping quality is very good.

Peddarasam: Popular in Godavari and Krishna Districts, tree medium, fruit large, greenish yellow when ripe, juice abundant, fibrous, sub-acidic, bearing early, fairly regular. Keeping quality is poor.

Chinnarasam: Popular in Nuzuvidu area. Tree medium, fruit medium, juice abundant, characteristic strong flavour, fruit quality is very good, bearing regular and heavy, midseason to late. Keeping quality is fair.

Navaneetam: Tree medium to large, fruit medium, juice abundant, fibre short and soft, fruit quality is very good, bearing regular and heavy, midseason, susceptible to powdery mildew and moderately tolerant to hoppers. Keeping quality is poor.

Mahmooda *(Vikarabad):* A drawf variety suited for high density planting. Tree small, fruit medium, skin thin, yellowish green, fresh moderately firm, fibreless, fruit quality is very good, bearing regular, heavy and midseason to late, susceptible to hoppers, tolerates wind. Keeping quality is good.

Chirutapudi Goa *(Royal Special):* Gives second crop (September- October) even in places where Neelum fails to give. Tree medium, fruit medium, juice abundant, fruit quality good, bearing regular and midseason to late, moderately tolerant to hoppers, less susceptible to winds.

'AU' Rumani: A hybrid between Rumani and Mulgoa, fruit medium to large, flesh melting, fibreless, juicy, fruit quality and bearing better than parents, late, stands transportation well. This hybrid was released from R.F.R.S., Anantarajupet, Cuddapah district.

Neeleshan: This hybrid was released from R.F.R.S., Anantarajupet, Cuddapah district. A hybrid between Neelum and Benishan; fruits like Benishan, medium, flesh firm fibreless, moderately juicy, early, coming up well where Beneshan is not.

Dashehari and Mahmooda: Hybrid released from F.R.S., Sanga Reddy, fruit excellent in quality. The quality of Dashehari and the other fruit characters of Mahmooda are acquired.

Rumani Neelum: Hybrid released from FRS, Sanga Reddy, fruit is very attractive and large, looks like Rumani but fruit is larger.

Alampur Benishan: It is cut variety. Gives bearing everyyear. Fruits are bigger in size and come to maturity during the months of May and June. Fruit quality good, resistant to disease.

Jalal: It is a pickle variety, gives bearing every year (Regular), fruits are medium in size. It is a late variety.

24.6. PROPAGATION

Being cross pollinated, it is not possible to get true type through raising seedlings by using stones (seed). In order to have true type to its parents and maintain purity, it is common to plant only grafted material obtained either from Government or private nursery. There are several methods of propagation for obtaining grafts, out of which inarching and veneer grafting are most common. in recent years veneer grafting is gaining popularity since it is the most convenient and easy method for obtaining grafts.

Stones are sown in beds immediately after extracting them from ripe fruits. If they are kept for more than 70-80 days after extraction, they lose their viability. The stones are sown in the nursery at a distance of 45 X 20 cm. These seedlings will be ready for grafting after one year. Seedlings with better vegetative growth should only be used for grafting. In case of inarching propagation method the seedlings are first transferred into pots from the nursery bed and then taken nearer to branches of tree from which the scion part is to be taken. The seedling pots are conveniently kept or tied up to faciliate the process of arching. Sometimes the scion parent is headed back to produce a large number of conveniently available branches for grafting at ground level. A strips of bark about 6 to 7.5 cm long along with small layer of wood is removed from a seedling as well as scion material. Care is taken to ensure that the two exposed surfaces fit with banana fibre or using sutli by covering with mango leaves.

In veneer grafting, the shoot of mother plant (Scion) which is to be multiplied can be cut away from mother plant and taken to the place where the seedlings are raised for grafting. The section stick is to be 3-4 months old with active auxiliary or terminal bud. This is secured by defoliating the scion shoot about a week before the scion shoot is cut. A slanting cut about 5 cm long on one side of the seedling stem is given by removing bark with some portion of wood. Similarly a starting cut on one side of the scion is made which will fill with the notch on the seedling stock so that the cambium of both comes in close contact. It is then wrapped tightly with 1.5 cm wide alkethene tape. When the scion begins to grow at the top (after about 3 weeks), the upper part of stock is removed thus forcing the buds to grow more rapidly. The plastic wrap is removed after about two to three months. For judging good grafting seedling the following characteristics should be observed.

1. The seedling stock and scion should possess same thickness and they should be firmly joined without any gap.
2. The scion should grow straight with healthy growing leaves.
3. There should be no branches of seedling stock below the joint (grafting).

24.7. SEASON OF PLANTING

It is generally planted at the beginning of the monsoon i.e., June-July. In areas with heavy rainfall it is done at the end of monsoon season i.e., November-December.

24.8. PREPARATORY CULTIVATION

In windy locations wind breaks are planted well in advance. The land is well prepared by giving two to three ploughings. Pits are dug deep enough to accommodate the root ball. If the soil is rocky and can not be ploughed, pits of 30 X 30 cm are dug and these are filled with good soil mixed with farm yard manure and two kg single superphosphate.

24.9. SPACING, PLANTING & AFTERCARE

The distance between plant to plant should be 8 to 10 metres depending upon soil fertility and vigour of the variety planted.

Grafted seedlings should be removed carefully along with the soil keeping the root system intact from the pots or nursery beds. These are placed in the pits and the soil is pressed all round the root ball. At the time of planting, care should be taken so that graft joint is above the ground level. The grafts should be protected from the wind damage by ground level. The grafts should be protected from the wind damage by giving support with sticks. small basins are made around the plant for regular pot watering for about 15 days. The sprouts developed on root stocks below graft joint should be removed. Gap filling is done wherever grafts fail to establish. When grafts grow about a metre, the top is pinched to encourage branching. White washing the stem with lime may be practiced to protect the stem from sun.

Young grafted plants of mango may start flowering even after a year of planting. If these are allowed to bear fruit, growth of the plant is adversely affected. These should be removed after their emergence so as to encourage the vegetative growth. This practice should be continued till the trees complete four years of age. It is advisable not to allow any branches on the main stem upto one metre height for the proper frame work of the tree.

24.10. MANURES & FERTILISERS

For improving the structure in light soil, tank silt or Pati-mannu or FYM at the rate of 125-200 cart loads per hectare should be applied. Horsegram, a soil enriching inter crop can be taken in winter. Lighter soils which are deficient in phosphorus respond well to the application of 2 kg phosphorus per tree per annum.

Fertilizer schedule

Area of the tree	N	P_2O_5 in grams/tree	K_2O
First Year	200	100	100
Second Year	350	175	175
Third Year	500	250	250
Fourth Year	650	325	325
Fifth Year	1000	1000	400
Sixth year and onwards	1000	2000	500

Manuring is generally done in the beginning of monsoon. Whenever irrigation is possible it will be advantageous to apply a part of the manure after fruit set. In absence of irrigation foliar spray of 2% urea or diammonium phosphate can be given. For an efficient absorption through soil, fertilizers should be placed in a 10-15cm deep ring near the drip of the tree.

24.11. INTERCROPING AND COVER CROPING

Mango trees take 5 to 6 years for giving economic yield. It is therefore advisable to grow some short duration crop as intercrop till they are shaded by the tree. Quick growing crops like cowpea, greengram, cluster bean, horsegram and lentil are sown which cover the surface soil to protect it from erosion. These crops are turned back into the soil to supplement organic matter content of the soil. These are known as cover crops.

24.12. PRINCIPLES OF INTERCROPPING

1. Intercrops should occupy a secondary place in the orchard, primary consideration being given to perennial fruit trees.
2. Tall-growing plants with excessive vegetative growth should be discouraged.
3. At least 120 cm radius must be left from the base of growing fruit trees.
4. Intercrops should not be exhaustive types for nutrients and moisture.
5. Long duration crops like sugarcane, redgram and cereal crops like maize and sorghum should not be taken as intercrops.
6. Intercrops like vegetables, low-growing field crops and fruit crops like phalsa can be profitably grown in young orchards. In old orchards shade tolering crops like ginger, turmeric etc., can be taken.

24.13. INTERCULTIVATION

Two ploughings in the inter spaces, one at the beginning and another at the end of the monsoon season keep the orchard weed free and facilitate rain water percolation.

24.14. WATER MANAGEMENT

For conservation of rain water, rows (in rectangular system of planting) should be along the contours. Mango responds well to irrigation, particularly at fruit set development phases. If farmers can give only two irrigations it is better to give them at fruit-set and early fruit development stages.

24.15. FRUIT DROP

Fruit crop can be controlled by spraying Naphthalene Acetic Acid (NAA) at the rate of 20 ppm twice at an interval of two weeks during early stages of fruit development. Spraying at the time of peak flowering should be avoided.

Check Your Progress - 1

How do you control the fruit drop in Mango?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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24.16. IMPORTANT PESTS AND DISEASES ON MANGO

A. Pests

1. The Mango hoppers *(Idioscopus niveosparus and I. clypealis)*

Symptoms: The adults and nymphs suck the sap from the inflorescence and cause withering and shedding of flower buds and flowers.

Control: Application of carbaryl (2.5 g/lit) or Phasalons (2 ml/lit)

2. The shoot webber *(Orthaga exvinacea)*

Symptoms: The larvare web the leaves and feed and as a result the leaves wither and dry up.

Control: Spray Monocrotophos (1.5 ml/lit) or Chloripyriphos (2.5 ml/litre).

3. Stem borer *(Batocera rufomaculate)*

Symptoms: The grubs tunnell into bark of branches and eat on the internal tissues. This results in wilting of branches,and in severe cases the trees may die.

Control: (a) Pour chloroform or petrol or carbondisulphide into the holes, (b) Attacked portions should be removed and destroyed.

4. The flower webber *(Eublemma versicolor)*

Symptoms: The larvare web the inflorescene together and feed causing considerable damage. It some times bores into inflorescence stalk (Peduncle).

Control: Spray Monocrotophos (1.5 ml/litre) or chloripyriphos (2.5 ml/litre).

5. Gall midge

Symptoms: Gall midge in manga is caused by three insects viz., *Procystiphora mangiferare, Dasineura amaramanjarae and Erorymia indica.* The larvae of *P. mangiferare* feed on the stalks of stamens, ovaries etc., and cause considerable damage. The maggots of *D. amaramanjarae* feed inside the buds and they fail to open and drop off. The maggots of *E. indica* attack inflorescence stalk, flower buds and the developing fruits. As a result the inflorescence becomes stunted and malformed and the buds fail to open.

Control: Spray Monocrotophos (1.5 ml/litre) or Phosphomidon (1 ml/litre).

6. The Mango nut weevil or stone weevil *(Sternochetus mangiterae)*

Symptoms: The larvae tunnel in a zig-zag manner through the pulp, endocarp and the seed coat and reach the cotyledons. With the development of fruit the tunnels get closed up. The manggots feed on the cotyledons and destroy them.

Control: Spray DDT (2 ml/litre) or Fenthion (2 ml/litre) at monthly intervals.

B. Diseases

1. Powdery mildew *(Oidium mangiferae)*

Symptoms: The infection starts from the tip of inflorescence and spreads downwards and covers floral axis, tender leaves and stem. The infected floral parts get severely damaged and drop off and this results in severe yield losses.

Control: Spray wettable sulphur (3 g/lit) two times once before the flowers open and second after fruit set.

2. Anthracnose *(Colletotrichum fleosporoides)*

The lesions develop as small blisters on the leaves and twigs and under favourable conditions spread severely and caused them to turn black and dry up. Premature leaf fall of infected leaves is also common. Infected fruit drops prematurely.

Control: Spray Bavistin (1 g/litre) or Bordeax mixture (2 g/lit).

3. Leaf spot of Mango *(Psuedomonas mangiferae-india)*

Symptoms: The lesions start as water soaked areas towards the tip of the leaf blade and turn to brown to black in colour. Several lesions may combine and large patches are formed. The leaves may fall under severe cases of infection. Severely infected fruits drop off prematurely and cause yield losses.

Control: Not much work has been done on control measures.

4. Pink disease *(Pellicularia salmonicolor)*

Symptoms: The disease is characterised by the appearance of Pinkish powdery coating on the stem. The fungus invades the bark and establishes in the internal tissues and affects the nutrient translocation. This results in the wilting of the shoot, shedding of leaves and finally drying of the branch.

Control: Remove and destroy the affected branches.

5. Malformation *(Fusarium moniliformae and unknown pathogen)*

Symptoms: The malformation occurs in both vegetative and floral parts. The infected seedlings produce excessive vegetative branches which are swollen with short internodes. This may give the appearance of bunchy top. The swollen auxiliary buds form girdles. All these branches develop floral malformations. The affected seedlings generally have shallow root system with less tertiary roots. The roots get curled and twisted. The affected panicles possess more number of flowers, and generally do not produce fruits. The malformed panicles give a leafy appearance because of bigger size bracts.

Control: No remedial measures.

6. Sooty motuld *(Capnodium ramosum and C. brasiliense)*

Symptoms: The fungus grows on the honey dew secreted by scale insects, aphids etc., on leaves and stems. The black powdery spores give the appearance of soot and cover the leaf surface thus reducing photosynthetic area.

Control: Control of insects stops the growth of sooty moulds, (b) Spraying of starch solution on the sooty growth helps in removal.

Check Your Progress - 2 & 3

2. How do you control the flower webber of Mango?
3. Anthracnose disease of Mango is caused by ______________________

Note: (a) Write your answers in the spaces given below and above.

(b) Compare your answers with those given at the end.

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24.17. HARVESTING AND STORAGE

Early harvest of fully developed but not matured fruits starts in April to catch the early Northern markets. Normal harvest commences when few *Putukayalu* fall from the tree. In case of pickle mangoes the time of harvest is relatively more flexible and it will be between stone hardening and physiological maturity. It was found that mango requires 1426 heat units for its full growth and maturity. By calculating heat units available in different areas from fruit set, the maturity time can be precisely determined. The minimum total soluble solid content for harvesting without sacrificing final quality is 9.0 in case of Banganapally and 8.5 for Dashehari. The fruits are harvested with long bamboo stick having a net at the end and they are gently placed in gunny bags or baskets to minimise the injury.

24.18. ARTIFICIAL RIPENING

Fully matured mangoes ripen in 3-5 days at room temperature. Important commercial varieties of mangoes are transported from one area to another which may take about 8 to 10 days to reach the destination. Therefore the fruits are plucked two weeks earlier of their plucking maturity. Such fruits do not ripen well. Hence various artificial methods are adopted to ripen the fruits such as smoking, calcium carbide treatment, hot water treatment etc. The immature green mangoes when dipped for 5 minutes in hot water at 54^{o}C and left at room temperature will uniformly ripen in 25-35% shorter time than the control. The spoilage of fruits during ripening by hot water treatment was 3 to 5% as against 20 to 25% in control. The taste and flavour of fruits thus ripened are very near to naturally ripened fruits. Though Calcium carbide and smoke treatments produce yellow colour they do not possess the natural taste and flavour. Hence hot water treatment has the advantage over other methods.

24.19. STORAGE OF MANGO FRUITS

Mangoes have short storage life of about one week under normal conditions. Storage life of mangoes can be prolonged by (i) Keeping in cold storage (ii) Storing under controlled atmosphere and (iii) skin coating with wax emulsion.

(i) Cold storage: The biological activity of fruits and vegetable is reduced in cold temperature. This helps in prolonging the storage life of commodity. Mangoes can be stored at 8.5 to 10^{o}C for 4-6 weeks.

(ii) Storage under controlled atmosphere: It was found that under the concentration of 5 to 7.5% of CO_2 in a closed room the biological activity of fruits and vegetable is considerably reduced. The Alphonso mangoes under 7.5% CO_2 atmospheric concentration at 8.5 to 10^{o}C temperature can be stored well upto 5-7 weeks.

(iii) Skin coating of mangoes: The wax coating applied on mangoes and other fruits will protect them from excessive moisture loss, higher respiration rate and heat build-up and thereby prolong the storage life. Mangoes are dipped in wax solution of 4-12% concentration and air dried. These can be stored for two weeks. This is the cheapest method and the cost of treating one tonne of mangoes would be Rs. 10/-

24.20. IRREGULAR BEARING

Manuring and irrigation will keep the trees healthy and vigorous and also reduce the irregular bearing habit. Annual prunning of weak and dead shoots to open the canopy of the tree is suggested to regulate the bearing of old trees.

24.21. SUMMARY

Mango is one of the important and delicious fruit crops of India occupying 65% of total area under fruit crops. Andhra Pradesh contributes a large number of commercial varieties like Banganapalli, Alampur, Suvarna rekha, Neelum, Mulgoa and Juicy varieties like Peddarasam, Chinnarasam and Navaneetham. It comes up well under tropical and semi-tropical conditions with optimum temperature requirement of $24^{o}C$ to $27^{o}C$ and rainless period during flowering time. Well drained and deep soils upto 2 metre depth are best for mango cultivation. It is mostly propagated by vegetative propagation with grafts obtained by raising seedlings and grafting scion of desirable plant type either by inarching or veneer grafting method. Mango grafts are generally planted in the month of June-July at a distance of 8 to 10 metres on either side. It is not advisable to allow any branching upto 1 metre height and also inflorescence upto 4 years of planting. Application of 200 g of N, 100 g P_2O_5 and 100 g K_2O per tree in the first year and gradual increase in the dosage with age of crop upto 5 years and thereafter 1kg N, 2 kg P_2O_5 1/2 kg K_2O per tree per year is recommended. Crops like turmeric or ginger or vegetables or phalsa can be taken as an intercrop in mango orchards. In areas having irrigation facility, crop can be irrigated during post monsoon season particularly at fruit-set and development stages. manuring and irrigation will reduce irregular bearing habit. Fruit crop can be controlled by spraying NAA at the rate of 20 ppm twice at two weeks interval during early stages of fruit development. The incidence of mango hopper, mealy bugs and powdery mildew disease is severe when high humidity and cloudy weather conditions prevail. The harvesting of mature fruits starts from April and continue upto June. Fully matured mangoes ripen in 3-5 days at room temperature. However in the transport of mangoes to long distance, they are packed 12-15 days in advance of maturity and after reaching destination they are artificially ripened by smoking or hot water treatment or calcium carbide treatment. Under normal conditions mangoes can be stored for one week. Storage life can be increased by 5 to 7 weeks under cold storage or storing under controlled atmosphere or wax coating.

24.22. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Fruit drop in mango can be controlled by spraying naphthalene acetic acid at the rate of 20 ppm.
2. Flower webber of Mango can be controlled by spraying Monocrotophos or chloripyriphos.
3. *Colletotrichum fleosporoides.*

24.23. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give the climatic and soil requirements for Mango.
2. Discuss in detail the propagation methods adopted for mango propagation.
3. Describe the characteristic features of commercial varieties of Mango grown in Andhra Pradesh.

4. Explain the symptoms caused by various pests of mango and suggest the control measures.
5. Give an account of harvesting and artificial ripening in mango.

II. Answer the following questions in about 10 lines each.

1. Give the manurial and fertilizer schedule for mango.
2. Explain the steps involved in planting and after care in mango garden.
3. Write in brief about intercroping in mango.
4. Explain the different methods of storage of mango.
5. Describe the symptoms of Anthracnose and powdery mildew diseases of mango with their control measures.

UNIT - 25: CITRUS

Contents

25.1. OBJECTIVES

After going through this unit you will be able to:

1. describe the climatic and soil requirements for citrus,
2. list out the different varieties of citrus and describe each one of them,
3. describe the method of propagation of sweet orange and acid limes,
4 establish an archard on your own,
5. describe the method of caring the young plants
6. list out the manures and fertilisers and describe the method of application,
7. describe the method of weed control,
8. list out the important pests and diseases, name the causal organisms, describe the symptoms caused by them and suggest the method of control of each one of them,
9. describe the methods of harvesting, grading and storage of fruits,

25.2. INTRODUCTION

Since ancient times Citrus was under cultivation in South East Asian countries, including India. The other important citrus growing regions of the world are: USA., Mexico, Central America, Brazil, Argentina, Spain, Italy, Japan, China, Israel, South Africa, Algeria, Egypt, Australia, New Zealand and U.S.S.R.

Among the various commercial fruits of India, Citrus fruits (with 10 per cent of the total area under all fruits), rank third in importance, after mango and banana. The most common citrus fruits grown in the country are mandarins, sweet oranges and limes with 50, 20 and 15 per cent of total area respectively under citrus fruits. The rest of the area is occupied by less important citrus fruits like lemons, pummelos, grapefruits, Vadlapudi oranges etc. Citrus fruits are grown in every state of India, but the leading producers are Andhra Pradesh, Maharashtra, Assam, Karnataka and Punjab.

In Andhra Pradesh, Citrus fruits rank second after Mango in area and production. The total area under Citrus fruits during the year 1983-'84 is 48,800 ha in the state. The principal citrus fruits grown in the state are sweet oranges and acid limes. In acid lime cultivation our state ranks second after Maharashtra. Mandarin oranges, Vadlapudi oranges and lemons are grown to some extent, while pummelos, gajanimma, kichili, are grown in back yards or a few plants are grown in the orchards, mixed with other citrus fruits. About 60 per cent of the area under citrus fruits is concentrated in rayalaseema belt (Ananthapur, Cuddapah, Kurnool and Chittoor), 17 per cent in Nellore and Guntur districts, 15 per cent in Godavari districts, the rest being scattered in other districts. Mandarin oranges (Santras) are grown to some extent in Agency tracts and in some parts of North Telangana region.

Himalayan Region and South China are generally considered as the places of origin for most of the citrus fruits. Many citrus fruits have their origin in India. The sweet orange is believed to have originated in South China or Cochin china from where, it has spread to India, thousands of years ago. Mandarins have their origin in China. Lemon and lime are considered to be native of India.

25.3. VARIETIES

Citrus fruits are members of the Rutaceae family and sub-family Aurantoideae. The genus Citrus consists of more than 150 species. Details of the important Citrus varieties grown in the State are as follows:

Varieties of Sweet Orange *(Citrus sinensis)*

1. Sathgudi orange: This is popular variety of Sweet orange grown not only in our state, but in entire South India. It is also called Chinee orange. Fruit almost spherical, medium to large, smooth surface, attractively orange coloured when fully mature, base and apex evenly rounded, rind thin with little rag, segments 10-12, pulp uniformly straw coloured, juicy (50 per cent), flavour excellent, Brix 9^{O}, seeds 12-20, each fruit weights 150-230 g., highly polyembryonic; yields 1000 to 2000 fruits per tree per year. It is seen in the market from October to February in the State.

2. Batavian Orange: This cultivar can hardly be distinguished from Sathgudi, except in rind colour, which is light-yellowish green, with pale yellow patches on the green rind. This is grown mostly in East and West Godavari district. Palakole was once a famous area for Batavian oranges. However, the fruit is inferior to Sathgudi in quality.

3. Mosambi Orange: Fruits small to medium, sub-globose or elongated, surface smooth with longitudinal furrows and the apex marked, with a circular ring (areole), rind is marigold in colour, thin, tight, difficult to peel, pulp apricot yellow, less juicy (43%). Though sweet, sometimes almost insipid, owing to lack of flavour and inadequate blending of acidity with sugars. Cultivated in Telangana area and seen in the market form November to January.

Varieties of Acid Lime *(Citrus aurantifolia)*

No varieties exist in acid lime. The variety under cultivation in the state is Kagzilime. Fruits small, round to oval, smooth, develop attractive yellow colour when fully ripe, peel very thin, adhering tightly with segments, segments 9-11. Pulp light greenish-yellow, juicy (47%), brix $6\text{-}7^{O}$, acidity 6.8 to 7.0%, Seeds 10-12%, each fruit weighes 40 to 50 g. Yields vary from 3,000 to 5,000 fruits per tree per year.

Varieties of Mandarins *(Citrus reticulata)*

The mandarin variety cultivated in the State is Nagpur Santra. Fruits medium in size, subglobose in shape, colour Cadminum, surface smooth, glossy, worty with glandular furrows, rind thin, loosely adhered to the segments, segments 10-11, rag little, pulp marigold in colour, flavour excellent, juice abundant, sweetness and acidity well blended, seeds few 6-7. Seen in the market from January to March.

25.4. CLIMATIC REQUIREMENTS

Commercial citrus cultivation extends right from tropics to temperate regions. The citrus belt of the world covers a wide range of area in lattitude. Any where within this belt at relatively low altitudes citrus can be grown provided such other conditions like soil and water are favourable.

The climate of Andhra Pradesh is essentially tropical and is well suited for growing sweet oranges and acid limes. In general the above citrus fruits require acid-tropical climate with assured irrigation and can be grown upto an elevation of 1000 m above mean sea level with an annual rainfall of 750-800 mm.

Sweet oranges require arid conditions coupled with distinct summre and winter seasons, low rainfall and assured irrigation like those available in Punjab. Under these conditions superior quality oranges can be produced. In an atmosphere of high humidity and heavy rainfall, oranges will have abundant juice with inferior taste.

Mandarin oranges (Santra) prefer slightly higher elevation (upto 1050 m) with relatively higher humidity and higher rainfall (750 to 2500 mm). But they also grow and fruit well along with sweet oranges in the dry tracts of Deccan at altitudes between 450-750 m, with a rainfall range of 500-750 mm. Santras tolerate more humidity in summer and winter than sweet oranges.

Acid lime requires tropical climate. It does not stand lower temperatures. Situations which are warm, moderately humid, free from strong winds, and frost are ideally suited for its cultivation. it can be grown upto elevations of 900 m above mean sea level, provided the humidity in these regions is not high. In more humid areas and heavy rainfall area, the acid lime becomes highly susceptible to citrus canker. Acid limes thrive well in west and South India.

25.5. SOIL

Sweet oranges and acid limes grow well on a wide variety of soils from heavy clay to very light soils. They require uniformly deep soils without any hardpan beneath, with perfect drainage. The citrus trees are more sensitive to higher concentration of salts and cannot stand water logged conditions for any length of time. Water table should be below 2 meters even in the rainy season. Saline soils are not suitable. The ideal soil, thus seems to be a medium or light loam with a slightly heavier sub soil with a depth of 2-3 meters and pH of 5.5 to 6.5.

25.6. PROPAGATION OF SWEET ORANGE

Sweet oranges are propagated by shield budding. Budding comprises several steps like, selection of Scion and wood, budding operation, etc. Scion and wood for budding should be selected from healthy, vigorous, mature, disease-free, high yielding trees. From these trees scion buds from past season's growth and from round or cylindrical twigs dotted with gray streaks should be collected. Bud wood should not be collected from angular twings, water shoots and thorny twings.

Rootstock seedlings of either sweet orange or Rangpur lime should be raised in nursery beds. Seeds are sown in may-June or September-October at a distance of 2-3 cm in rows of 10-25 cm apart. Within 2-3 weeks seed germinate. Seeds beds may be provided with shade to protect the seedlings from sun and rain. Six to nine months after sowing, the seedlings are transplanted into a nursery bed at 20-30 cm apart in the row and 45-60 cm between the rows, so as to facilitate the budding operation. When the seedlings reach a height of about 25-30 cm or a trunk diameter of about 1-2 cm, budding may be commenced. Budding can be done at any time during the year, provided there is free flow of sap and the bark slips readily and unsprouted; dormant scion buds are available. The operation is most successful when the rootstock seedlings are in growth and the weather is fairly cool and dry. Under the prevailing conditions of our state budding can be done from July to September.

After removing all the leaves, sprouts and thorns on the stem of the rootstock, upto a height of 22-30 cm. first a vertical cut of 3 cm long is made in the bark of the stock, then another cut is made horizontally above the vertical cut. Mean while dormant buds are collected from fruit bearing shoots in the form of shields of about 2.5 cm long. This shield bud is carefully inserted into the cut made on the rootstock with the bud facing upwards and wrapped with a suitable wrapping material above and below the bud, exposing the bud.

It takes 2-3 weeks time for the scion bud to make union with the stock tissues. After 3 weeks, when the bud is still green indicating the union, wrappings are removed. Then the buds are forced to grow by lopping or topping. The budlings are allowed to grow in the nursery for at least one year before they are planted in the mainfield.

25.7. PROPAGATION OF ACID LIMES

Seed propagation is most popular with acid limes. This is because seeds are polyembryonate and breed true to type (nucellar), seedlings generally come to bearing earlier than budlings and produce more uniform quality crop. Further seedlings are hardy, disease resistant and withstand vagaries of climate better than budlings.

Seeds are extracted from well matured fruits collected from healthy and disease free, adult trees. The seed should be sown immediately after extraction within a week, otherwise it loses viability. Seeds are sown on raised seedbeds, prepared out of sandy loam soil. Before sowing, the seeds should be treated with any suitable fungicide. Seeds are sown at distance of 2-3 cm in rows, 10-25 cm apart and at the depth of 2-3 cm during May- June or September-October. Germination will be over within a month.

Generally the seedlings after making a satisfactory growth are transplanted to a nursery bed for hardening. Nursery beds are prepared out of well drained, fairly deep, fertile soils, nearer to a water source. The nursery beds may be either flat or raised. All the weak, lanky, and abnormal seedlings, should be pulled out at the time of lifting the seedlings. Only the seedlings of uniform vigour and height are selected for transplanting. The seedbed is irrigated thoroughly to make lifting easy. The seedlings are lifted carefully without damaging the root system and transplanted at 20-30 cm in the row and 45-60 cm between the rows. Regular watering is provided at short intervals till the seedlings establish well. frequent manuring with nitrogenous fertilizers is also beneficial. Seedlings are carefully guarded against possible diseases and pests. Shade and stacking may be provided.

25.8. ESTABLISHING THE ORCHARD

Selection and Preparation of Site: After the selection of a suitable site, based on the climatic requirements, the site should be prepared well in advance to receive the seedlings or budlings. The existing vegetation on the site, should be cleared and their roots removed. Then the land is ploughed thoroughly in all directions till a fine tilth is achieved. Finally the site should be levelled. If the land is slopy soil and water conservation measures should be practiced. the soil may be enriched by raising cover crops, preferably legumes. Wells may be dug prior to planting and permanent water channels may be constructed. Fencing may be provided. After levelling, the orchard is laid out as per the decided layout (preferably by square or rectangular system).

Digging and filling of pits: Pits of 90 X 90 X 90 cm are dug a season in advance at appropriate spacing. For acid limes 6 m spacing and Sathgudi Oranges 8-10 m spacing in square system are recommended.

Pits are filled with a mixture of top soil, tank silt and red earth in equal quantities, to which 2 to 3 kgs of Bonemeal is added. Filling of pits should be completed atleast a fortnight earlier to planting and allowed to settle and consolidate after copious irrigation.

Planting: Planting of seedlings or budlings is done during the period July to January, making use of both South-West and North- East monsoons. The plant is placed in scooped out hole in a straight way and the ball of earth is firmly pressed without injuring the root system. Then the soil around the plant is levelled and a basin of 60 cm diameter is made for watering. The plant must be set at slightly higher level than in the nursery. In case of budlings the graft-union should be 15 cm the ground level. Immediately after planting, the plants should be irrigated well.

25.9. CARE OF YOUNG PLANTS

The newly planted young plants must be protected during the initial 3 to 4 years from excessive heat, rain and cold, by providing shade. Young plants flush 4 or 5 times in a year. During flushing there will be incidence of leaf miner, Canker, Cirus butterfly etc. which should be controlled promptly. Further, just before flushing light manuring with nitrogenous fertilizers is advisable. The young plant may be trained to modified leader system, with a smooth trunk upto 100 cm height from the ground level and 4-5 well spread branches from there. All the sprouts, which appear on rootstock should be removed as and when they appear.

25.10. MANURES AND MANURING

Organic manuring is more beneficial to citrus than inorganic manuring. If organic manures are supplemented with additional mineral fertilizers, optimum conditions may be created for healthy and abundant growth. It is always advantageous to give a liberal dressing of bulky organic manures as they keep the soil in a good physical condition, besides supplying plant nutrients. The following manurial schedules can be adopted for sweet oranges and acid lime under the prevailing conditions of the state.

Manurial schedule for Sathgudi oranges (g/tree/year)

Year	N	P_2O_5	K_2O
I Year	300	70	80
II Year	600	140	160
III Year	900	210	240
IV Year	1200	280	320
V Year and above	1500	350	400

Manurial Schedule for Acid limes (g/tree/year)

Year	N	P_2O_5	K_2O
I Year	375	150	200
II Year	750	300	400
III Year	1125	450	600
IV Year	1500	600	800
V Year and above	1800	600	800

Nitrogen should be supplied in the form of farm yard manure (25%), oil cakes (25%) and chemical fertilizers (50%), while P_2O_5 and K_2O in the form of superphosphate and muriate of potash.

The organic manures which are slow to release the nutrients, should be applied two to three months earlier to initiation of new growth and flowering, so that they are fully decomposed and become available by the time the growth starts. On the contrary, mineral fertilizers which are quick to release the nutrients,may be applied at the start of growth flush. Generally, the total amounts of phosphoric and potassic fertilizers are applied at a time, while nitrogenous fertilizers are applied in 2 or 3 split doses. In Andhra Pradesh fertilizaation is usually done twice in a year, i.e., once in December-January (Prior to main flowering) and next in June-July (during fruit development a stage.)

Manures and fertilizers are applied by soil application in the tree basins by trench method. A trench of 15-25 cm wide, 15 cm depth is dug around and below the drip of the tree. The manures and fetilizers are applied evenly in the trench and finally covered with the dugout soil. In some places, the manures and fertilizers are broadcasted in the basin, 60-75 cm away from the trunk and incorporated by spades or garden rakes. After manuring copious irrigation should be given.

Micronutrient deficiencies, particularly of zinc, manganese and iron are more common in citrus trees in the State. These can be avoided or minimised by giving a composite spray of the micronutrients in January and October or as and when the new flush (2-4 months old foliage) exists on the tree.

Composite Micro-nutrient spray schedule

Chemical	Quantity
1. Zinc Sulphate	2.25 kg
2. Copper Sulphate	1.35 kg
3. Megnesium Sulphate	0.90 kg
4. Ferrous Sulphgate	0.90 kg
5. Borax	0.45 kg
6. Manganese Sulphate	0.90 kg
7. Urea	4.50 kg
8. Lime	4.00 kg
9. Water	454.00 litres.

25.11. IRRIGATION

Irrigation is a major factor in citrus production. Citrus trees cannot grow and fruit well without frequent and timely irrigation. Except under heavy rainfall areas (Coorg, Wynad, and Assam), Citrus trees are invariably irrigated. Water deficiency at critical periods checks the growth of trees, and lowers the fruit size and quality and even cause fruit drop. Therefore, inorder to keep the trees in a healthy condition and produce higher quality fruits, it is necessary to provide adequate irrigation especially during the bearing stage and dry periods of the year.

Basin system of irrigation is followed generally in citrus fields in India. While irrigating, care should be taken not to allow the water to come into contract with the trunk for the prolonged time, as it leads to trunk and root diseases. This can be avoided by adopting double ring method of irrigation, in which a second ring, about half meter away from the trunk is formed with in the bigger ring below the drip line, so that irrigation water remains between the outer and inner rings.

The time and frequency of irrigation assume an important role in maintaining the health and production at higher level. In winter season the interval may be from 10-15 days and in summer it may be much shorter (5-7 days). Trails conducted at Kodur indicated that when the top 25 cm soil becomes dry, the trees should be irrigated. Irrigation during harvest period should be avoided, because it reduces T.S.S. and acidity.

25.12. INTERCROPPING

During the initial five or six years after planting there is an excellent opportunity for utilizing the vacant interspace profitably as their root system will not extentd into the interspace and their branches do not touch each other as in the case of older tress. Hence growing a crop in the alleys is a desirable practice too, in that besides providing income to the grower, it checks the erosion, smoothers the weed growth, conserves soil moisture and organic matter and protects the soil from adverse climatic conditions.

A great care should be excercised while selecting the type of intercrop in citrus orchards. The intercrop should have similar cultural requirements, should not be too tall or spreading so as to shade the fruit trees, should not require too much water and plant food so as to adversely affect the main trees.

Legumes are preferable as inter crops (Berseem, Lucerne, Cowpea, Pillipesara, etc). Exhaustive crops like gingiely, wheat, maize, sugarcane, cotton etc., should not be grown. Tall growing crops like banana, jowar etc., should not be grown as intercrops because of their shading. Crops like, tobacco, bheind, chillies, brinjal, banana etc. should not be raised as intercrops, as they favour severe infestation of root-knot nematode (*Meloidogyne* spp.). Vegetables like, pumpkin, onion,mung, guar in summer and peas, turnip, cauliflower, carrot, raddish, etc. in winter can be grown as intercrops in citrus.

25.13. SOIL MANAGEMENT

Management of orchard soil is important in fruit growing. While a good soil management maintains and even builds up soil fertility and provides ideal conditions for plant growth. A poor soil management may lead to rapid deterioration of the orchard. Soil management includes soil tillage, mulching and weed control which are interrelated.

Land in the alleys should be cultivated to check the weed growth, to conserve soil moisture and fertility, to incorporate the applied manures, and to provide aeration to the root system. Normally it is sufficient to plough the soil once or twice a year at least deep enough to check the weeds and to cover a green manure crop. Cultivation makes the soil fine for better penetration and spread of roots, enhances the decomposition and nitrification, loosens the soil for better penetration of rain water and keeps the soil surface from becoming hard. The best time for cultivating the land is when the trees are not active (December). In early spring, the soil should be cultivated to keep down the weed growth. However, too frequent and too deep cultivation are not desirable. Light hand digging or hoeing should be given to the basins, after every 3 or four irrigations to avoid soil becoming hard.

25.14. MULCHING

Mulching of tree basins is necessary to check the weed growth, to conserve soil moisture, to hinder the soil temperature fluctuations. After weeding, the basins should be mulched with suitable materials like dry leaves, paddy straw paddy husk, sawdust, wood shavings, stubbles of jowar, maize, coconut coir, etc. Mulches to a thickness of 8 cm or 100-120 kg per basin of 16 squre meters should be added particularly from January to June to conserve the moisture as well as to reduce the number of irrigations.

25.15. WEED CONTROL

Control of weeds is essential in the tree basins, below the drip also upto 1-5 to 3.0 meters on either side of the rows. The weeds besides competing with the trees, interfere with the plant protection measures, harvesting, prunning and other cultural operations.

Various methods are adopted to control weeds. Cultivation of the interspaces is the most common method. Raising of cover crops, intercrops and green manure crops also are helpful in checking the weeds. But inter cropping or cover cropping in the orchard is not desirable during flowering and fruiting, during which time, the trees require maximum moisture and nutrients. At such time, mulching can be practised.

Weeds in the tree basins are not easily accessible to mechanical cultivation. Further, cultivation may cause injury to shallow feeding roots and lower fruiting branches. For these reasons chemical weed control becomes important, especially below and around the trees.

In citrus orchards weeds are generally controlled by weedicides like Monuron and Diuron, to which citrus trees are resistant. Diuron at the rate of 2.5 kg in 500 litres of water may be spread on the soil, 30-40 cm away from the trunk.

25.16. IMPORTANT PESTS AND DISEASES OF CITRUS

A Pests

1. Citrus butterfly *(Papilio demoleus)*

Symptoms: The caterpillars voraciously feed on tender leaves and defoliate.

Control: Spray chloripyriphos (2.5 ml/litre) or Monocrotophos (1.5 ml/litres).

2. Orange borer *(Chloridolum aclamene)*

Symptoms: The larvae makes spiral cut in the twigs which results in wilting. Then they move upwards and feed on the dried stems and then move downwards piercing through the branches and reach the main stem.

Control: (a) Periodical removal of dried twigs, (b) Spraying of Monocrotophos (1.5 ml/litre) or phosphomidon (1 ml/litre).

3. Fruit sucking month *(Otheris fullonica and O. materna)*

Symptoms: The adult moths are directly concerned with the damage. They pierce the proboscis into the fruits and suck the fruit juice. As a result rotting takes place and eventually the fruit drops prematurely.

Control: (a) Cover the fruits with paper polythene bags, (b) Create smoke in the orchards after sunset for keeping of the pest away from the plants, (c) Use poison bait for killing the months with 20 g. of Malathion 50% WP and 200 g. of jaggery and 2 litres of water.

4. Citrus leaf miner *(Phyllocnistis citrella)*

Symptoms: The larvae mines in between the epidermal layers of the leaf, causing zig-zag mines. They feed on chlorophyll which results in distortion of leaf lamina.

Control: (a) Spray Monocrotophos (1.5 ml/litre) or Phosphomidon (1 ml/litre), (b) Prune the infested plant parts.

5. Shoot and bark caterpillar *(Inderbela tetraonis)*

Symptoms: The larvae enters into the axils of branches by making small tunnels and moves about concealed inside the silken gallery and feeds on the bark scraping.

Control: Removal of galleries and injucting chloripyriphos or Monocroptophos and closing the holes with mud.

6. Citrus mite *(Schizetetramychus hindustanicus)*

Symptoms: Both adults and nymphs scrape the leaves and fruit surface and suck the sap.

Control: (a) Spray Dicofol (5 ml/litre) or Sulphur WP (3 g/litre).

Check Your Progress - 1 & 2

1. How do you control citrus butterly?
2. The Scientific name of citrus leaf miner is ______________________________

Note: (a) Write your answers in the spaces given above and below.

(b) Compare your answers with those given at the end.

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B. Diseases

1. Citrus decline

Symptoms: With the advancement of the disease and mottling is observed with reduced leaf size and number. The roots of the affected plants may be dead and show dry rot symptoms. The disorder is a combination of many factors.

The decline may be due to tne following reasons.

1. Injury due to accumulation of nitrite under water logged conditions.
2. Incompatibility of root stock and scion.
3. Malnutrition and the effect of pests and diseases.
4. The symptoms start as yellowing of leaves with heavy bearing of small sized fruits.

Control: (a) General maintenance of plant's health by supplying fertilizers, (b) Good drainage facilities, (c) Periodical spraying of an insecticide and fungicide to control pests and disease.

2. Gummosis *(Phytophthora spp)*

Symptoms: The disease initiates as dark staining on the bark. The staining progresses inside with the advancement of the disease and firm bark shrinks, cracks and shreds. If gumming starts just above ground level the main roots also may get infected. Gumming leads to rotting of the bark and the trees die due to girdling effect.

Control: (a) Dis-infection of stems with Bordeaux paste annually upto 2 feet from ground level, (b) Scraping of diseased portions and applying Bordeaux paste, (c) Good drainage to be provided to the trees, (d) Double ring method of irrigation should be followed.

3. Diplodia gummosis *(Diplodia natalensis)*

Symptoms: The fungus induces excessive flowering and complete drying of individual branches, which shows gumming and flaking on blackened bark.

Control: (a) The diseased branches should be cut and apply Bordeaux paste, (b) In the initial stage of gumming the areas should be scraped and apply Bordeaux paste, (c) Wounding of the trees should be avoided.

4. Root rot

Symptoms: The disease is caused by species of *Macrophomina, Fusarium, Diplodia and Ganoderma.*In the early stage of infection the decay of root is the typical symptom of root rot. The infected parts produce bad odour. The leaves turn yellow and the severely affected trees die eventually. The fungus induces heavy flowering and as a result many small sized fruits are formed.

Control: (a) Clean cultivation to be followed, (b) The affected roots should be cut and Bordeaux paste to be applied.

5. Pink disease *(Pellicularia salmonicolor)*

Symptoms: The typical symptom of the disease is drying and wilting of individual branches.

Control: (a) The affected portion should be removed and Bordeaux paste applied, (b) Oil based copper solution may be sprayed.

6. Powdery mildew *(Oidium tingitanium)*

Symptoms: The young leaves show typical whitish powdery growth. In severe cases the defoliation and die back of branches occur.

Control: Sulphur dust or spraying of wettable sulphur (3 g/litre)

7. Citrus canker *(Xanthomonas campestris pv. citri)*

Symptoms: The lesions start as yellowish spots on leaves. The lesions enlarge and gradually turn into raised, rough brownish pustules.

Control: (a) Removal of diseased parts before South west monsoon and spraying of Bordeaux mixture (10 g/litre) and Phaushamycin (1 g/ litre), (b) Timely control of leaf miner, (c) Growing resistant varieties like Rangpur lime, limequat etc.

8. Tristeza *(Quick decline)*

Symptoms: The disease is caused by a virus. The virus blocks food conducting vessels like phloem and results in starvation of root system. This results in root rot, deficiency disorder, defoliation, die back of twigs, loss of vigour and finally decline. The infected trees generally flowers heavily and the fruits are small. The trees get exhausted and die early and die with the gradual development of fruits.

Control: (a) Use of tolerant root stocks like rough lemon, sweet orange, Rangpur lime etc, (b) Regular plant protection measures to control aphid vectors, (c) Planting of healthy seedlings.

9. Greening disease *(Mycoplasma)*

Symptoms: The disease occurs in sweet orange orchards and is mainly responsible for the early decline of sathgudi. The leaves show chlorotic patterns resembling zinc deficiency. Green dots or islands against yellow back ground of leaf are often associated with greening. The leaf size is reduced. The affected twings shows upright habit and turn dull green. They become spindle shaped and show mottling.

Control: (a) Bud wood should not be collected form the diseased trees, (b) Budling showing mottling patterns should be rejected, (c) Only healthy plant material should be planted, (d) Control the psyllid vectors, which carry the disease.

Check Your Progress - 3 & 4

3. What are the organisms that cause citrus root rot?
4. Citrus canker is caused by ________________________

Note: (a) Write your answers in the spaces given above and below.

(b) Compare your answers with those given at the end.

25.17. CROPPING AND HARVESTING

Budlings of sweet orange come to bearing by 5th year while seedlings of acid lime start bearing from third year. In both cases, commercial bearing status is attained after a couple of years.

Sweet oranges in the state have two crops a year regularly with a variable third crop, as follows.

Name of the crop	Flowering time	Harvesting time
1. Angam	December-January	October-December
2. Edagaru	June-July	March-April
3. Gairangam	September-October	May-June

Generally angam crop is preferred. Fruits of sweet oranges take 9 to 10 months. however, sweet oranges in Rayalaseema are harvested, when they are 5 or 6 months old, to avoid the incidence of fruit sucking months. Nevertheless, the fruits have attained internal maturity by that time.

Acid limes are continuous croppers. The main seasons vary from tract to tract. Main harvesting season for limes in the Circars is from March to April, in Guntur and Nellore from April to June and in Rayalaseema from July to September. Acid limes take about 4 to 5 months for maturity.

Fruits are picked according to the prevailing market demand customarily. However, it is better to harvest the fruits at full maturity, when they develop their characteristic flavour to the maximum and their characteristic colour.

Fruits should not be harvested either during the rains, or immediately after rains. Further, harvested fruits should not be piled up in the sun.

25.18. GRADING AND STORAGE

Grading of harvested fruits is not followed in India. At present, most of the citrus crop is marketed without paying any attention to the grading of the fruit. the fruits should be graded for quality and size.

Harvested fruits may be treated with 2% wax emulsion, mixed with 5 ppm 2, 4-D increase the self life of sweet oranges and acid limes. Such treated acid limes can store well for 3 weeks, when packed in alkathene lined gunnies and transported. It is possible to increase the storage life for longer periods by cold storage. Sweet orange can be preserved for longer periods in cold storage at O to 2^{o}C and acid limes at 8 to 9^{o}C at a relative humidity of 85 to 90%.

25.19. SUMMARY

Since ancient times citrus fruits are under cultivation in India. In Andhra Pradesh the principal citrus fruits grown are sweet oranges and acid limes; they rank second after mango in area and production. Himalayan region and south China are considered as the place of origin for most of the citrus fruits. Sathgudi and Botavian sweet oranges are predominantly grown in the state, followed by acid lime and Nagpur santra. Sweet oranges require acid-tropical climate, while acid limes require tropical climate. The ideal soil for sweet oranges and acid limes is a medium or light loam with a depth of 2-3 meters, pH of 6.0 to 8.0 and good drainage. Sweet oranges and acid limes are propagated by shield budding and by seed respectively. Steps in establishing the citrus orchard include selection and preparation of site, digging and filling of pits, planting and care of young plants. Nutrients are to be supplied both in organic (50%) and inorganic form (50%) for achieving best results. The major nutrients viz., N·P and K are to be applied at he rate of 300g N, 70g P_2O_5 and 80g K_2O per tree during the first year and the quantities may be doubled every year till 5th year and above. Similarly in case of acid limes organic manures should be applied two to three months prior to initiation of new growth and flowering, whereas inorganic fertilizers should be applied at the start of new flush. Nitrogenous fertilizers are to be applied in 2 or 3 equal splits. in Andhra pradesh fertilization is usually done twice in a year. Manures and fertilizers are applied by trench method in the soil. Irrigation is a must to citrus in the state. Double ring method of irrigation is advocated to avoid trunk and root diseases due to contact of water with the trunk. In winter season the interval may be 10-15 days, while in summer it may be 5-7 days. During the pre-bearing period intercrops in between the tree rows can be raised. Land in the alleys should be cultivated once or twice in a year, when the trees are not active. The tree basins may be mulched. Weeds may be checked by cultural methods or by using herbicides. Important pests on citrus are citrus butterly, leaf miner, fruit sucking moths, citrus mite, while the important diseases are cirus decline, gummosis, diplodia gummosis, root rot, pink disease, citrus canker, tristeza and greening. Budlings of sweet oranges come to fruiting by 5th year, while seedlings of acid lime by 3rd year. Sweet oranges produced three crops in a year in the state. Acid limes yield throughout the year. Sweet oranges are harvested thrice in the year viz., October-December (Angam crop). While the main harvesting seasons for lime in the Circars is from March to April, in Guntur Sand Nellore districts from April to June and in Rayalaseema from July to September. The fruits should be graded for quality and size. Storage life of citrus fruits can be extended by treating the harvested fruits with 2% wax emulsion mixed with 5 ppm 2, 4-D or by cold storage.

25.20. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Citrus butterly can be controlled by spraying chlorpyriphos or monocrotophos

2. *Phyllocnistis citrella*

3. The organisms which cause root rot in citrus are ***Macrophomina, Fusarium, diplodia*** **and** *Ganoderma*

4. *Xanthomonas campestris pv.citri*

25.21. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the different varieties of sweet oranges grown in the state.
2. What types of climate and soil are required by sweet oranges?
3. Write in detail the climate and soil requirements of acid lime.
4. Describe the method of propagation of sweet oranges.
5. How do you propagate acid limes? Describe the method.
6. Describe the different steps in establishing he citrus orchard.
7. Menstion the importance of manuring in citrus and give the manurial schedules for sweet oranges and acid limes.
8. Describe the method, and time of application of manuries and chemical fertilizers to citrus trees.
9. Why do you apply micronutrients? Give the composite micronutrient spray schedule for citrus fruits.
10. Detail the importance, method, time and frequency of irrigation in the case of citrus fruits.
11. Write in detail about the intercropping in citrus fruits.
12. Describe the orchard soil management practices in citrus.
13. Describe the cropping seasons in acid limes and sweet oranges.

II. Answer the following question in about 10 lines each.

1. Describe mandarin and acid lime varieties.
2. Describe the climatic requirement of sweet oranges.
3. Write in detail the soil requirement of citrus fruits.
4. Describe very briefly the budding operations in sweet orange.
5. Describe the selection and preparation of site for citrus orchard.
6. Describe digging and filling of pits and planting operations in citrus.
7. Write about the care of young plants in citrus.
8. Write in detail the mulching in citrus.
9. Write about weed control in citrus.
10. Write the symptoms and control measures of tristiza and greening diseases in citrus.

UNIT - 26: CASHEW

Contents

26.1. OBJECTIVES

After going through this unit you will be able to:

1. list out the different varieties of citrus,
2. describe the climatic and soil requirements for cashew,
3. describe the different ways of propagation,
4. establish an orchard in any given area,
5. describe the methods of weed control, manuring and harvesting of the crop,
6. describe different steps of the processing of the kernels of Cashew,
7. list out the different parts of Cashew plant which are of food value,
8. list out the important pests and diseases of Cashew, their causal organisms and the symptoms caused by them and suggest the deferent methods of control.

26.2. INTRODUCTION

Cashew *(Anacardium occidentale)* is native of Tropical South America more particularly to Brazil. From there it was introduced into India by Portuguese people between 1560 and 1565 (i.e. 16th century). It was first introduced on the west coast of India, from where it has spread to the east coast. Cashew now grows on both sides of the peninsular India as if it has born on this land-Naturalized.

Cashew is grown throughout the tropics between the tropic of cancer and capricron on either side of the equator (23^0). Though cashew is cultivated in more than 30 countries in the world, the main cashew producing countries are: India, Tanzania, Mozambique, Kenya, Brazil, Madagascar, Thailand, Malaysia, Indonesia, Nigeria and Srilanka. In all these countries cashew is grown as an export oriented crop. In international trade of free nuts cashew occupies third position, coming after hazelnut and almond. Even in India Cashew occupies third or fourth position in the export of agricultural commodities. it earns more than Rs. 120 crores in foreign exchange every year. In 1981-82, it earned about Rs. 190 crores.

Cashew is mainly grown for kernels, which when roasted and salted have a pleasant taste and flavour. The cashew kernel is one of the most delicious and nutritious nuts of the world, liked by one and all. Most of the cashew trade is occupied by kernels (97%) and the remaining by cashewnut shell liquid (CNSL) 3%.

India is the largest producer of raw cashewnuts and exporter of cashew kernels in the world. Right from its inception, the cashew is mainly export-oriented and highly labour intensive. More than 2 lakh people are engaged in cashew industry.

India is the world's leading producer. The major cashew growing states in the country are Kerala, Karnataka, Andhra pradesh, Tamilnadu, Goa, Maharashtra and Orissa, while West Bengal, Tripura, Pondichery are the minor cashew growing states.

Important cashew growing districts in Andhra Pradesh are Guntur, East and West Godavari, Srikakulam, Visakhapatnam, Vijayanagaram, Nellore and Prakasam.

26.3. VARIETIES

Recently, Cashew Research Station, Bapatla has released the following varieties for commercial cultivation.

1. **Bpp-1** *(H 2/11):* A hybrid between tree No.1 and 273 of Cashew Res. Station, Bapatla, produces 15% bisexual flowers. Nuts are medium in size, Weighing about 5 g., with a shelling percentage of 26. It yields on an average of about 12 kg. of raw nuts per year.

2. **Bpp-2** *(H 2/12):* This is another hybrid obtained from the same above parentage, produces about 18% bisexual flowers. However, the nuts are smaller, weighing about 4 g., with a shelling percentage of 26. On average, it yields about 15 kg. of raw-nuts per year.

3. **Bpp-3** *(SCH 3/3):* It is a selection from a survey collection from Simhachalam. It is a moderate sized tree, a late bearer with about 15% bisexual flowers. The nuts are of medium size (5 g) with shelling percentage of 25. It also yields about 15 kg. of raw nuts on an average per year.

4. **Bpp-4** *(EPM 9/8):* This is also a selection from a survey collection from Epurpalem. This is a vigorous growing tree and produces about 8% bisexual flowers. On an average it gives an yield of about 10 kg. per anum.

5. **Bpp-5** *(Tr. No. 1):* This is a selection from the existing tree of the Cashew Research Station, Bapatla, highly intensive in branching, produces about 10% bisexual flowers and is a prolific yeilder. The nuts are medium in size (5 g) with a shelling percentage of 25. It has given an average yield of 42 kg. per year at an age of 40 years.

6. **Bpp-6** *(Tr.No.56):* This is also a selection from the existing trees of Cashew Research Station, Bapatla. It is a vigorous tree and is a high yeilder. It produces about 8% biseseal flowers. Nuts are medium size (6g) with a shelling percentage of 26. At an age of 40 years, it has given an average yield of 57 kg. per year.

   (Seed may be obtained from Cashew Research Station, Bapatla).

26.4. CLIMATIC REQUIREMENT

Cashew is a tropical fruit corp. Though Cashew can be grown upto an elevation of 10000 m above M.S.L., lower elevation upto 600 m are preferable for profitable cultivation. Lower temperature at higher elevation affect the development of the tree. Cashew requires a minimum of 500 mm of rainfall annually, but can stand extremes of 300 to 4000 mm rainfall also. Well distribution of rainfall is more important than the quantum of rainfall. Inadequate rainfall leads to irregular flowering and fruiting. Cashew thrives under a wide range of temperatures from 15^{o} to 40^{o}C. Cashew is sensitive to cold. Cashew can be grown under a wide range of relative humidity. It can withstand, long period of low relative humidity, provided it has sufficient water supply in the soil. At extremely dry conditions (10% or below) flowers and fruits drop and leaves are scorched. On the other hand, excessive humidity is unfavourable as it favours the fungal infections and pest attack. Proximity of sea is favourable for the performance of cashew. A distance of 160 k.m. from the sea coast is considered favourable.

26.5. SOIL

The best soils for cashew are deep, well-drained sandy loam soils, without hard pan and with the water table at least 3 m depth even in the rainy season. Cashew also thrives on pure sandy soils. Cashew cannot withstand bad drainage, water stagnation and flooding. Cashew is drought resistant. It thrives well in soils with pH ranging from 6 to 7.5.

Under East-Coast conditions chashew is mainly grown on sandy soils, which are highly porous and poor in fertility. Under West coast conditions, cashew is mainly grown on laterite soils on the hill slopes of western ghats.

26.6. PROPAGATION

Though vegetative propagation is possible in cashew, it is mainly propagated by seed commercially even today. This is because of lack of an easy vegetative propagation method and also due to lack of nurseries which supply the planting material.

Seed propagation has several disadvantages. Being a highly cross-pollinated crop, cashew when propagated by seed shows great variation in growth and performance. Generally seed is collected from known high yeilder in the viscinity or from Research Stations and Forest Department. Either for sexual or asexual propagation, elite mother trees should be identified first from them only the seed or scion material should be obtained for further multiplication of cashew. Superior mother trees can be identified based on the following criteria.

1. Tree with compact canopies are to be preferred.
2. Trees should be dwarf, and associated with intensive branching, producing more number of productive shoots per unit area (60% and more).

3. Trees should have short flowering phase of 2-3 weeks only.
4. Trees with more than 20% bisexual flowers should be preferred.
5. Trees capable of carrying 5-8 fruits per panicle an average should be preferred.
6. Trees which produce medium sized nuts (5-6 g) weighing 120-130 nuts/kg.
7. Trees should bear regularly and should be tolerant to pests and diseases.

26.6.1. Seed Propagation

Seeds must be collected from the current crop in the months of May and June on East Coast and March on the West coast. Seeds which sink in water are best. Medium sized nuts are preferable. Cashew seed nuts lose viability on storage within a few months. Hence fresh seeds should be sown. However, seeds can be stored in seated tins without loss in viability for two or three months. Germination of cashew seeds is a slow process because of hard seed coat. Germination may be improved by soaking the seed nuts in water for 24 to 48 hours. Seeds are sown with the stalk end upwards in a slanting position at a depth of 5-7 cm in the rooting medium. Germination will be completed within a month. It is a general practice to sow 2 to 3 seeds in each pit in the main field. On germination the most vigorous seedling is retained and the rest are removed from the pit. When the seedlings are raised in containers in a nursery, they may be transplanted in the mainfield when they are 1-2 months in age. Older seedlings do not transplant effectively.

26.6.2. Vegetative Propagation

Cashew is a highly cross pollinated crop. As such the progeny from seed does not breed true to type. Hence, vegetative propagation is inevitable. Vegetative propagation is also very important for the establishment of high yielding plant material, producing an uniform product of high quality. Various methods of vegetative propagation such as air layering, veneer grafting, sidegrafting, patch budding and epicotyl grafting were tried so far. Different methods have given different degrees of success at different places. However, none of them was found to be suitable for all areas or cashew.

Air layering: Twigs for air-layering should be selected from trees older than 10 years. One-year-old, pencil thickness, non- flowering shoots must be selected when the trees are in flush and flowering. Under East Coast conditions layering done during rainy season has given good results, while under West Coast conditions layering must be done during flushing or getting high success. Rooting of air-layers may be improved and enhanced by the application of growth regulators (IBA, IAA, NAA).

The whole process of air layering takes about 2 1/2 months to 3 months. Under East Coast Conditions sawdust is used as rooting medium while sphagnum moss is used under West coast conditions. A polythene film of 200 guage is used for wrapping. Rooting takes place within 40-50 days of injuring. The rooted air-layer is separated in stages. After separation, the layers may be planted directly in the field or hardened in the nursery and then planted in the mainfield.

Though root development in this method, with or without growth substances is good, there is heavy mortality both in the nursery stage and in the field. Large scale propagation by air-layering for planting extensive areas is not feasible, as the method is cumbersome and time consuming. It is labour intensive and costly. Only a small number of layers can be obtained from a single tree (80-120) per year. Besides, the layers have no tap-root system, but a superficial lateral root system. As such it does not give good anchorage in the soil. Hence, it is not suitable for cyclone prone areas (East Coast).

Veneer Grafting: Vigorously growing, 5-6 months old seedlings are selected for grafting. Scion-sticks from current flush with dormant buds are procured about 7-10 days prior to grafting. On the day of grafting operation, the pre-cured scion-sticks are separated from the mother tree and grafted to root stock at a height of 10-15cm from the ground level. Both stock and scion are then wrapped with a polythene ribbon and tied tighty, leaving the apex of the scion stick exposed. Union takes place within 3-4 weeks depending upon the prevailing climatic conditions. When the scion sprouts the root stock is lopped above the graft joint to encourage the growth of the scion sprouts. Later when the scion sprouts have grown to 6-10cm long, the stock is completely removed. All the sprouts on the root stock portion should be nipped off, periodically so that the scion grows rapidly.

The success in veneer grafting depends on certain conditions. Cool and cloudy days with high humidity are required for union. The union also depends on the number of rainy days available after the operation and during the union. The success depends on the availability of moisture in the soil and high humidity during the period of union and thereafter. The method is successful only with 5-7 months old root stocks.

Availability of scion material for large scale grafting operations is a limiting factor. On large scale, watering and proper supervision are also limiting. The method has given poor results with container grown root stocks.

Veneer grafting has given good results at all centres when done *'in situ'*.High success was obtained when done during rainy season from July to November both under West coast and East-coast conditions i.e., the time of operation is limited to 4-5 months in a year.

Side Grafting: Root stock seedlings are raised in the nursery *'in situ'*. From these, 2 to 3 year-old seedlings are utilized for side grafting. On these stocks, scion sticks are grafted by the method of side grafting. Union takes place within a month. When the scion sprouts, the root stock is lopped to speed up the growth of the scion buds and finally severed completely.

The method is expensive (costly) as the rootstock seedlings have to be nourished and maintained for 3-4 years in the nursery before lifting.

Epicotyl grafting (Stone grafting): Tender cashew seedlings of 10-15 days old are used as root stocks. Grafting is done by cutting off the succulent slender stem (epicotyl) 4-5cm above the cotyledons and a cleft is made in the middle of the rootstock with a sharp knife.

The scion off same thickness as that of rootstock is selected from the current flush, whose stem is still green and succulent. The scion is prepared as a wedge at the base and inserted into the cleft. Then they are both wrapped with a polythene film. The scion is covered with a polythene bag and secured with a rubber band near the base to prevent desiccation of scion. The grafted root stocks are kept under shade. The union takes place within a month.

However, the success in epicotyl grafting depends on delicate conditions: (1) high humidity, (2) freedom from fungal infections, (3) number of rainy days, (4) temperature and, (5) the rate of cambial growth. The operation is a highly skilled job.

The advantages: (1) It ensures quick multiplications in a given time, (2) it can be practised indoor during rainy season, (3) Economical.

26.7. ESTABLISHMENT OF ORCHARD

Selection of site: While selecting the land for cashew, soils with water logging, and excessive salinity/alkalinity should be avoided. Other things, like soil depth, slope fertility, availability of water etc., are of minor importance, because cashew is a hardy plant.

Land Preparation: If the selected site is a jungle, all the vegetation has to be removed from the site. In thickly forested area, only circular spots at proper distance are cleared for raising cashew. On slope lands it is better to retain the vegetation, to avoid soil erosion by water and wind. In areas less prone to erosion, all the vegetation may be removed before planting.

Seeds and Sowing: At the break of monsoon,season seeds are sown in pits of $60cm^3$. Two to three seeds are dibbled in each pit. Later only one vigorous seedling is retained in the pit and the rest are removed.

Of late, cashew seedlings are first raised in nursery in containers and then transplanted in the mainfield, at the break of monsoon. Container raising of seedlings and then transplanting them in the field is more expensive, but has considerable advantages. Germination % is higher, mortality is lower and a better selection of plants can be made at the time of transplanting.

Transplanting: One to two month old seedlings are preferred for transplanting. After transplanting, the seedlings are provided with shade, support and water.

Spacing: A spacing of 8-10m is recommended by Andhra Pradesh State Department of Horticulture. Generally, square or rectangular system of planting is followed and on hill slopes of Western ghats, contour planting is followed.

Check Your Progress - 1

What is the ideal age of the seedling of Cashew for transplantation?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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26.8. IRRIGATION

Cashew is a drought resistant plant. It thrives well in low as well as heavy rainfall areas. Nevertheless, cashew requires irrigation during the initial two to three years, particularly in the summer and other dry periods. It is advisible to clean the basins periodically and mulch the basins with dry leaves or paddy husk during summer to conserve soil moisture.

26.9. INTERCROPPING

Cashew gardens are intercropped during the initial (5-6) years only. Low spreading intercrops, which can be harvested very early in the dry season or at the end of the rainy season are suitable for cashew. In Andhra Pradesh, especially in forest plantations legumes like ground nut or horsegram are raised in the allies. In private gardens finger millet, paddy nurseries, vegetables, chilli and tobacco nurseries are raised. More recently, casuarina is raised as an intercrop in cashew in Andhra Pradesh and Orissa. In Goa, Eucalyptus and Teak are raised as intercrops. On the West cost intercropping is not practised on hill slopes, because of terracing and the need for soil conservation. However, on plains in Kerala, Coconuts are intercropped with cashew.

26.10. WEEDING

In young gardens, ring weeding is practised. Weed growth beyond the rings is kept low by slacing or by disc-harrowing. In mature gardens, weeding is seldom practised in India, except at the time of harvest. Weeding should be done before the end of the rainy season.

Cashew trees are not generally pruned.

26.11. MANURING

The following fertilizer schedule is recommended by Central Plantation Crops Research Institute, Kasargod (Kerala).

Year	Ist Dose			II Dose		
	N	P	K	N	P	K
I Year	100	80	-	50	40	-
II Year	50	40	30	50	40	30
III Year	100	60	60	100	60	60
IV Year and onwards	125	60	60	125	60	60

For the existing bearing cashew trees of age 10 years or more, yielding 5kg of nuts per year, 250g N, 125g P_2O_5 and 125g K_2O per tree per year were recommended in two split doses. For trees giving more than 10kg of nuts, a higher level of fertilizer application is advocated.

The first dose may be applied in July-August under East coast conditions. Similarly the second dose may be applied in October- November on the East coast.

Fertilizes are applied in trenches (10-15cm deep) dug about 100- 150cm away from the base of the tree or fertilizers may be broadcasted below the canopy of the tree and incorporated into the soil with spades or garden rakes.

Fertilizers should be applied when there is abundant moisture in the soil.

26.12. CROPPING

Cashew trees normally come to flowering in 3-5 years and by 10th year they attain commercial status. There is only one season of flowering in cashew. Cashew flowers in January-February on the East Coast.

26.13. HARVESTING

Harvesting commences from April on the East Coast and by the end of May the pickings are over. The duration of harvest extends over a period of 45-60 days, as all the fruits do not ripe at one time.

Generally the nuts which have fallen from the tree are gathered in the morning and as frequently as possible during the day time. In Goa, the fruits are plucked from the tree with least damage to the apple, as it is used for manufacturing Feni. After gathering the fruits, the nuts are separated from the apples.

The separated nuts are sun dried for 2 or 3 days and stored in suitable containers. Proper drying is necessary, otherwise the nuts get discoloured in the storage.

26.14. YIELD

The individual tree yields differ widely. The average yield per tree in the country varies from 0.5kg in Orissa to 5.5kg in Kerala. Majority of the trees fall in the range of 2 to 3kg of nuts per tree. Similarly the yields per unit area also differ from state to state, with highest in Kerala (1200 kg/ha) followed by Karnataka and Goa (800 kg/ha), Andhra Pradesh and Tamilnadu (750 kg/ha). All India average is about 400 kg/ha).

26.15. PROCESSING

The edible part of the cashew tree is the 'kernel' which is enclosed in a hard shell. The extraction of this edible kernel from the hard shell is called 'Processing'. Cashew processing is done mainly by human labour in India (i.e., Manual) and by mechanical means in other countries. There are over 400 cashew processing factories spread over several states. Quilon in Kerala has the largest number of processing units. In A.P. the processing units are located at Vetapalem (Prakasam), Palasa (Srikakulam) Mori (East Godavari). There are bout 80 processing units at the above three places. Besides the above, small scale Cottage industries are also operating in Nellore, Guntur and Prakasam districts.

Cashew processing includes a series of steps as follows.

26.15.1. Roasting

Roasting of nut is done to make the shell brittle for easy shelling and to loosen the kernel inside. Roasting of nuts is done by any of the three methods viz., (1) Open pan method, (2) Drum Roasting method (3) Oil-bath method.

Open Pan Method: Earliest method, still followed in cottage processing units. Nuts are roasted in a perforated open pan over a fire. The CNSL, which oozes out during the roasting process drips through the hole into the fire causing heavy fumes. Soon the nuts catch fire and at this stage water is sprinkled on the nuts and thrown to the ground for cooling. So, this method is not followed by big factories.

Drum Roasting Method: In this method, nuts are roasted in a roasting drum. The drum is held in a slanting position and rotated with a handle. The drum is heated from below. The nuts are fed from one end. The red hot condition of the drum permits the nuts to catch fire within 3-5 minutes and by the time the nuts reach the other end of the drum they get roasted. A temperature of 100°-$120^{\circ}C$ is always maintained inside the drum, as the CNSL, oozing from nuts burns. The burning nuts are released at the other end of the drum. The fire on the nuts is put off by sprinkling after and ash.

The rate of shelling and the out turn of whole kernels are very high in this method, however, the main disadvantage in this method is the total loss of CNSL by burning.

Oil-Bath Roasting Method: Here, the nuts are allowed to pass through a bath of heated CNSL, which is maintained at 190°-$200^{\circ}C$. The nuts take 1-3 nuts for passing the CNSL, During this passage, the cells of the shells get ruptured, releasing the shell liquid. The nuts are removed and mixed with ash for cooling. By this process at least 50% of shell liquid is extracted.

In our state at all the processing centres, drum-roasting method is followed. While in Kerala oil-bath roasting method is adopted in several processing units.

26.15.2. Shelling

Breaking of the roasted nuts to extract the kernel is called 'shelling'. The roasted nuts are broken with wooden mallets mostly by women labour in India, Pedal operated machines are also used at some places. Great care is taken in shelling to minimise damage and breakage of kernels, to get whole, and clean kernels as many as possible. After cracking, the kernels are extracted with a wire or needle. The % of the shelling varies greatly (24- 30%) with an average of 25%.

26.15.3. Drying

The extracted kernels are dried in hot chambers at about 80-90^{o}C for 6-7 hours. The extracted kernels are spread on wire-mesh trays and the trays are staked in heat chambers. Drying is done to loosen the red skin (testa) adhering to the kernals to facilitate easy peeling.

26.15.4. Peeling

The kernel has a thin reddish brown or pinkish outer skin or peel (testa). Removal of this peel from the kernel is called 'Peeling'. Peeling is done by hand. Mostly women are engaged for this purpose.

26.15.5. Grading

The process by which the peeled kernels are sorted out into different grades such as wholes, splits, brokens etc. is called 'Grading'. First the peeled kernels are sorted into wholes, splits etc. on the basis of visual observation. Then the wholes are again graded on the basis of number of kernels per pound (Counts). Grading in India is done mainly by manual labour. There are as many as 25 grades, but only 8 grades are generally in use. They are as follows:

1. 210 count - Zamboo wholes (Best quality)
2. 240 count - Zamboo wholes
3. 280 count - American quality
4. 320 count - standard quality
5. Splits
6. Pieces
7. Baby pieces
8. Broken bits.

26.15.6. Sweating

The drying of kernels renders them brittle and liable for easy breakage during packing and transit. To avoid this the kernels are spread in trays and kept in humid chambers for 5 hours, where humidity is maintained at 80% by air-coolers. During this process the kernels absorb moisture and become less brittle.

26.15.7. Packing

The conditioned kernels are finally packed by 'Vita Pack Method'. In this method after filling the kernels, the tins are vaccumised and filled again with CO_2 and sealed. Kernels are packed in four gallon tins each holding 25 pounds (11.34 kg) of kernels.

Check Your Progress - 2

What is the importance of the process of Sweating for Cashew Kernels?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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26.16. FOOD VALUE AND UTILIZATION

The important parts of Cashew that have food and utilisation value are nuts, cashew apple and cashew nut shell liquid.

26.16.1. Nuts

Cashew nut is the most versatile of all tree nuts and is put to a variety of uses. The kernels are mostly roasted and salted. Cashew kernel is a complete food in it self. It is low in carbohydrates, but rich in proteins and fats. The kernel consists of high percent of vitamins.

The thin brown or pink coloured outer skin of the cashew kernel is the testa. It is rich in tannins, hence is mainly used in leather industry. The testa with adhering kernel pieces serves as an excellent poultry feed.

26.16.2. Cashew Nut Shell Liquid

The cashew nut shell liquid (CNSL) is a by product of the cashew industry. The liquid is present in the spongy tissue of the mesocarp of the shell. CNSL is a phenol and is used for various purposes like the preparation of resins, varnishes, paints, insecticides, break-lings and wood preservatives. As an anti-corosive, ship-bottoms are painted with CNSL.

26.16.3. Cashew Apple

The cashew apple is mostly wasted, except in Goa. It is rich in Vitamin 'C' upto 5 times that of citrus fruit. The juice has 10- 12% sugars. However, because of the presence of astringent and acid principles, they are not consumed largely. The most important utilization of cashew apple in Goa is the synthesis of a liquor 'Feni', a sort of brandy, greatly relished and surpasses even scotch whisky.

The juice is extracted from the apple and allowed to remain a few days for fermentation. The fermented juice is distilled twice to produce 'Feni'.

The apple is also used as a medicine for stomach ailments like diarrhoea. The apples can be dried and powdered into a meal and used as animal feed.

Check Your Progress - 3

What is the importance of Cashew nut shell Liquid?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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26.17. IMPORTANT PESTS

1. Stem and root borer *(Plocaederus ferrugineus L.)*

Symptoms: This is the arch enemy of cashew tree, capable of killing the tree out right. The pest is common in old and neglected plantations. The adult beetle lays eggs in crevices and cracks of bark on the trunk. On hatching the grubs bore into the bark and feed on the bark, making irregular tunnels. This results in the damage of vascular tissues and arresting of the ascent of plant sap, leading to defoliation and death of the tree finally. The symptoms of infestation include the presence of gum, extrusion of frass through holes, yellowing and shedding of leaves, and drying of twigs.

Control: The bark should be peeled at the place of damage, the grubs should be removed and destroyed. Then the peeled portion of the bark is treated with Bordeaux paste. As a prophylactic measure, the orchard should be kept clean and the soil around the trunk should be swabbed with 1% B.H.C. solution before the onset of monsoon rains. The holes may be plugged with phorate granules and finally with moist black earth.

2. Leaf and Blossom Webber *(Macalla moncusalis W.)*

Symptoms: This pest feeds on the tender leaves and inflorescences, by webbing them. The adult moth lays eggs at the growing point. The caterpillar on emergence webs the terminal leaves and panicles and feeds inside. The pest can be identified by such webs on the plants. This results in the shedding of flowers. It also feeds on tender, developing nuts and apples, which drop prematurely.

Control: The pest may be controlled by spraying Fenitrothion or Endosulfan (0.05%) on the new flush and panicles, after mechanically disturbing the webs.

3. Leaf miner *(Acrocercops syngramma M.)*

Symptoms: This pest mines into the young and developing leaves, causing blisters on the leaves.

Control: The pest can be controlled by spraying phosphomidon or Fenitrothion or Endosulfan at 0.05% at the time of emergence of new flush.

4. Shoot and Inflorescence tip borer *(Chelaria hallgramma M.)*

Symptoms: The caterpillar feeds on leaves tender shoots, inflorescence stalks, apples and nuts. The caterpillar enters the shoots by making a hole at the tip and feeds inside, causing drying up of twigs and panicles. At fruiting time, the larva enters the fruit at the joint of the apple and nut and feeds inside, leading to pre-mature fruit drop.

Control: The pest may be controlled by spraying Fenitrothion (0.05%) or carbaryl (0.15%) at the time of new flush and again at the time of fruiting.

5. Apple and nut borer *(Nophopteryx spp.)*

Symptoms: The larva bores into either apple or nut at the joint and feed inside. As a result the development of kernel is arrested. The nuts get shrivelled, apples get hallowed and thus drop prematurely.

Control: As the caterpillars reside inside the apple and nuts they are out of reach for the chemicals. So preventive measures are more important. A prophylactic spray at the time of full bloom or fruit set with 0.05% Endosulfan or phosphomidon or carbaryl (Sevin) may reduce the infestation.

There are no serious diseases on cashew.

Check Your Progress - 4 & 5

4. The scientific name of the stem and root borer is ____________________

5. Shoot and inflorescence tip borer can be controlled by spraying ____________________ or ____________________.

Note: (a) Write your answers in the spaces given above.

(b) Compare your answers with those given at the end.

26.18. SUMMARY

Cashew was introduced into India by Portuguese during the 16th century from tropical South America, which is considered as its native home. India is the largest producer of raw cashew nuts and exporter of cashew kernels in the world. The major cashew growing states in the country are Kerala, Karnataka, Andhra Pradesh, Tamilnadu, Goa, Maharashtra and Orissa. Important cashew growing districts in the state are Guntur, Krishna, East and West Godavari, Srikakulam, Visakhapatnam, Vizianagaram, Nellore and Prakasam. Recently Cashew Research Station, Bapatla has released six cashew varieties viz. Bpp.1 (H 2/11), Bpp 2(H 2/12), Bpp 3 (CSH 3/3), Bpp 4(EPM 9/8), Bpp 5 (Tr.No.1) and Bpp 6 (Tr.No.56) for commercial cultivation. Cashew is a tropical tree and likes tropical climate, in particular coastal humid climate. The best soils, for cashew are deep, well-drained sandy loams without hard pan, but with a water table at least 3m depth, from the surface only and pH 6.0 to 7.5. The commercial method of cashew propagation is by seed. Cashew can also be propagated by vegetative method like Veneer grafting, air-layering, side- grafting and epicotyl grafting. Establishment of cashew orchards include steps like selection of site, land preparation, seeds and sowing and transplanting. Cashew is a drought resistant plant and is well adopted for rainfed agriculture. Nevertheless, it requires irrigation during the initial two to three years during summer for better establishment. During the initial 5 to 6 years cashew gardens can be intercropped with paddy, chilly, tobacco nurseries, vegetables and even casuarina. Year wise manurial doses have to be applied regularly for optimum growth. Cashew trees of 10 years or more, yielding 5 kg of nuts per year, should receive 250 g P_2O_5 and 125 g K_2O per tree per year in two equal splits in July-August and October-November by trench method. Cashew trees come to bearing by 3rd to 5th year. They flower only once in the year during January-February on the East-Coast. The nuts are harvested during April-May. The individual tree yield differ widely. The yield per ha. in Andhra Pradesh is about 750kg. Extraction of soft kernel from the hard nut shell of cashew is called 'Processing'. It involves steps like, roasting (open pan, drum roasting, oil-bath methods), shelling of roasted nuts, drying of extracted kernels peeling of testa of kernels, sweating of peeled and graded kernels and finally packing. Cashew kernels are rich in proteins, fats, carbohydrates and vitamins. Kernels are mostly roasted and salted. Testa is rich in tannins hence is mainly used in leather industry, Cashew nut shell liquid (CNSL) is a by-product of cashew industry and is used in the preparation of resins, varnishes, paints, insecticides, break- lining, wood preservation etc. Cashew apple is mostly wasted in India except in Goa. In Goa a kind of liquor 'Feni' is distilled from the cashew apples. Important insect pests of cashew are root and stem borer, leaf and blossom webber, leaf miner, shoot and infloresence tip borer and apple and nut borer. These pests cause damage to the plant if proper attention is not paid.

26.19. CHECK YOUR PROGRESS: MODEL ANSWERS

1. One to two months is the ideal age for the transplantation of the seedlings of cashew.
2. The dry kernels are brittle and liable for easy breakage during packing. To avoid this the sweating of cashew kernels is usually done.
3. The cashew nut shell liquid is used for the preparation of resins, varnishes, paints, insecticides, break-lings, wood preservatives etc.
4. *Plocaederus ferrugines*
5. Fenitrothion or carboxyl

26.20. MODEL EXAMINATION QUESTION

I. Answer the following questions in about 30 lines each.

1. Describe the various varieties of cashew, released by cashew Research Station, Bapatla.
2. a) Give in detail the climatic and soil requirements of cashew.

   b) How do your propagate cashew commercially. Describe the method.
3. a) Mention the criteria for identifying superior mother trees in cashew.

   b) Describe in detail the method of air-layering in cashew. Explain why it is not adopted on large scale.
4. a) Describe in detail the method of veneer grafting in cashew. Explain the conditions under which veneer grafting is successful.

   b) What is epicotyl grafting? Describe the procedure. Give the advantages of the method.

II. Answer the following questions in about 10 lines each.

1. Bring out different steps involved in the establishment of cashew orchard.
2. Write about intercropping in cashew orchard.
3. Give the manurial schedule for cashew. Describe the method and time of application of manures and fertilizers.
4. Write about the flowering and harvesting seasons in cashew.
5. Describe the different methods of roasting cashew nuts.
6. Give in detail the different steps involved in processing of raw cashew nuts.
7. Write about the food value of cashew nuts. How do you utilize the cashew kernels, cashew nut shell liquid and cashew apple?
8. Give the details of damage caused by the insect pests on cashew with control measures.
9. Describe the damage caused by root and stem borer in cashew and suggest the control measures.
10. Write in detail the damage caused by leaf and blossom webber in cashew and how do you control it.
11. Explain how leaf miner and apple and nut borer cause damage to cashew and how do you propose to control?

UNIT-27: COCONUT

Contents

27.1. OBJECTIVES

After going through this unit you will be able to:

1. list out and describe different varieties of coconut,
2. describe the climatic and soil requirement of coconut,
3. describe the method of growing the seedling in a nursery and the establishment of a garden,
4. explain the method of mainfield preparation and the caring of young palms,
5. list out the manures that are used for adult palms and describe the method of application,
6. give a list of green manure crops and cover crops,
7. describe the method of harvesting and estimate the yields,
8. list out the important pests and diseases of coconut, their casual organisms and the symptoms caused by them and suggest the different ways of controlling them.

27.2. INTRODUCTION

The Coconut palm *(Cocos nucifera Linn.)* is the most useful palm in the world. It provides the basic necessities of life of man *viz.*, food, drink, fuel and shelter. The coconut palm is often called 'Kalpavriksha'. Indo-Malayan region is considered to be the probable place of origin of coconut palm.

Coconut growing is confined to the tropics only. More than 80 countries of the tropics are engaged in the cultivation of the palm. The major coconut growing countries are: Philippines, Indonesia, India, Thailand, Malaysia, Sri Lanka, Fiji, East and West African countries, West Indies, Central and South America. India ranks third in the coconut map of the world, with an area of 1.11 million hectares and production of 5677 million nuts. Of this Kerala's share is 6.59 lakh hectares (60%). About ninety two percent of the total area under production of coconut in the country is concentrated in the four Southern States viz., Kerala, Karnataka, Tamilnadu and Andhra Pradesh. The crop is also grown in the states of Orissa, Maharashtra, Assam, West Bengal, Gujarat etc.

27.3. VARIETIES

There are only two district varieties of Coconuts *viz.*, the tall and the dwarf. The tall varieties reach a height of about 30 meters, while the dwarfs are characterised by their short stature.

27.3.1. Tall varieties

The tall varieties are extensively cultivated throughout the world. The life span of the talls range from 80 years or more. The tall variety comes to bearing in about 6 to 8 years after planting. The nuts of the tall variety are generally medium in size, the quality of copra is good, and oil content is fairly high as compared to those of dwarf types. The important tall varieties are West Coast Tall, East Coast Tall, Lakshadweep Ordinary, Laksha Dweep Micro and Andaman Ordinary.

West Coast Tall: It is largely cultivated on the West Coast of India. They start to flower in 6 to 8 years after planting. Because of high percentage of cross-pollination, large variations in size, shape and colour of the nuts are observed. The shape of the nut varies from spheroid to linear and the colour from green, yellow, yellowish orange to brown. Under rainfed conditions, the palm yields an average of 60-80 nuts per year. Each nut on an average gives 165 grams of copra with 72% oil.

East-Coast Tall: This variety is largely grown on the east coast of India. Bearing in this variety commences from 7 to 10 years. It yields on an average 60-70 nuts per tree per year, under rainfed conditions. The nuts have 150g of copra on an average with a mean oil content of 60-70%.

Lakshadweep Ordinary: It is native to Lakshadweep islands. It is almost similar to west coast tall in growth habit and other characteristics. It is comparatively a high yielder with an annual production of 80 to 180 nuts per palm. The nut yields 140 to 180g of copra with an oil content of 70 per cent. However, its performance is better at lower altitudes than at higher altitudes.

27.3.2. Dwarf Varieties

Dwarf are characterised by their short stature. They are generally self-pollinated unlike talls. They start bearing in about 3 to 4 years after planting, but are short lived with a life span of 40-50 years. A fully grown one rarely exceeds a height of 5 meters. Though they yield heavily, they exhibit a tendency of alternate bearing. The nuts are small, the copra is soft and leathery, with low oil content. The dwarfs are mainly grown for tender nuts and as an ornamental palms. The following are the important dwarf varieties grown in India.

(i) Chowghat Dwarf: This is found on the west coast of India and has two distinct forms *viz.*, Chowghat dwarf orange and chowghat dwarf green, based on the colour of the nuts. These are early bearers but short lived. The annual yields are high when compared to talls. Thus nuts are oblong with tapering ends. They are smaller and tender, and yield 170-225g of sweet water and 90-100g of copra.

(ii) Ganga bondam: This is a semi-tall variety from Andhra Pradesh. The palm commences flowering in the fourth year. It is an irregular bearer. The nuts are medium sized. The average yield is about 60 nuts per palm per year. Copra content is high with good quality and 72 per cent oil.

27.3.3. Hybrid Palms

(i) Tall x Dwarf (TxD) hybrids: The female parent west coast tall was crossed with choughat dwarf orange as male parent, to combine the characters like early and profuse bearing of the dwarf parent and economic characters like medium size, high copra out put and oil content of the tall parent. The hybrid palm comes to bearing in about 4-5 years. The mean annual yield is 100 nuts. The average copra content is 185g with about 70% oil content.

(ii) Dwarf x Tall (DxT): Here the dwarf is the female parent, while tall is the pollen parent. The DxT hybrid is more vigorous than either of the parents and starts bearing in four years after planting and out yields the parents. It is a heavy bearer yielding 100-130 nuts per palm per year. The copra content per nut is about 200g with an oil content of about 70 per cent.

Check Your Progress - 1

Give two examples for dwarf varieties

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

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27.4. CLIMATIC REQUIREMENTS

The coconut palm is a tropical tree, and grows best under hot moist climatic conditions. The best plantations are located upto 600 meters above mean sea level. For best growth and maximum production, an optimum annual temperature of $27^{o}C$ is required with a diurnal fluctuations of 6^{o}-$7^{o}C$. It does not stand extremes of temperature. This distribution of rainfall is more important than the quantum of rainfall. A well distributed annual rainfall of 2000mm is optimum. But the palm can come up under a wide range of rainfall conditions varying from 1000 to 3500mm with irrigation and proper moisture conservation as the case may be. A dry and windy atmosphere is always beneficial in the presence of adequate soil moisture. Slight winds are desirable, but not cyclones etc. The palm requires an annual sunshine of 2000 hours.

The coastal climate, which is always more humid and less prone to wide fluctuations of temperaturei is more favourable than the interior localities.

27.5. SOIL

It adopts remarkably well and grows well in almost all types of well-drained tropical soils such as coastal sands, red loams, laterites, alluvial and the reclaimed soils of mostly low-land, with pH ranging from 7.0 to 8.0. Though coconut grows under a wide range of soils types, moisture availability is the most important single factor that determines the suitability of a particular soil type. In areas where long spells of dry periods are likely, it is desirable to have deep and fine soil types possessing good water holding capacity. Inadequate drainage is harmful, but the palm can withstand occasional floods. However, water stagnation for long periods is harmful. So in heavy rainfall areas well drained soils are the most ideal.

Soil conditions most suited for best performance of the palm area are proper drainage, good water holding capacity, presence of water-table within 2 to 3m depth and absence of rock or any hard substratum within 1 or 2m.

27.6. PROPAGATION

The principal means of propagation of coconut is seed. Coconut is a cross-pollinated crop, so seed propagation results in a considerable genetic variation in the progeny. So, greater emphasis must be given to the selection of superior and right type of planting material.

Seed nuts should be collected from selected mother palms, which have reached full bearing status which are between 25 to 60 years of age. The mother palm should be healthy, vigorous, and a regular high yielder. Other factors, such as high proportion of female flowers, ideal distribution of female flowers, high percentage of fruit set, less tendency for fruit drop and high contents of copra and oil, should also be taken into consideration.

Seed nuts with typical shape of the variety, thin husks, and a higher husked nut weight of 11-12 months old, should be collected from March to June. Collected seed nuts may be stored for about a month prior to sowing for speedy and maximum germination. After harvesting, they are spread on a thick layer of sand with the stalk-end up and completely covered with sand to a thickness of about 7cm. Seed nuts stored will remain viable for about 8 months after harvesting. meanwhile nursery beds are prepared as follows.

27.7. NURSERY

A site with loose and friable soils and adequate irrigation and drainage, having a greater portion of sand is selected for coconut nursery. Open sites are preferable. The nursery beds of convenient length and width, to accommodate only 4 to 5 rows of seed nuts are prepared. Seed nuts are sown at the break of monsoon rains. To ward off termite attack the seed nuts are dipped in 0.2% solution of B.H.C. or D.D.T. prior to sowing. Seed nuts are planted at a distance of 30-45cm on either side. They are planted horizontally.

Nursery beds are regularly weeded and watered for achieving early and maximum germination of seed nuts. The beds are not manured generally.

Under favourable conditions, seed nuts complete their germination by 5 months. When the seedlings are about 9 months old a vigorous seedling selection is practiced. Only healthy, vigorous seedlings with good girth (10cm) at collar and having at least 6 leaves, with early indication of splitting should be selected for planting in the main field.

One day earlier to lifting, the beds should be irrigated judiciously for easy lifting of the seedlings. Seedlings are lifted gently after loosening the soil around the nut. Then they are packed individually in gunny pieces or palmyra baskets in groups.

27.8. ESTABLISHMENT OF COCONUT GARDEN

In general a spacing of 7-9m under square or triangular system of planting is recommended for coconut. In monoculture, triangle system is advisable. Square system is preferable when coconut is mixed with other perennial crops. However, for mixed cropping hedge methods are more preferable, because they facilitate penetration of more sunlight, besides offering comparatively little root competition.

Hedge system of planting of coconuts is of recent development in which more seedlings than necessary are planted in a unit area by adopting a wider inter-row spacing and closer intrarow spacing. Single and double hedge planting can be practised. In single hedge planting a single row of plants is laidout, while in double hedge planting two are paired. With this method the land between rows could be utilized for other perennial crops. For single hedge planting 6.5m in rows and 9m between rows and in double hedge planting 6.5m x 6.5m in rows and 9m between pairs of rows are adopted.

27.9. MAINFIELD PREPARATION

The pits ($1m^3$) are usually dug and prepared 2 to 3 months in advance at the appropriate spacing. After digging the pits, they are exposed to weathering and usually organic refuses are burnt in the pit and the sides are chared to prevent termite attack. Before planting, the pits are filled with the top soil, kept aside mixed with river sand, wood ash, bone meal and muriate of potash. To prevent incidence the soil may be mixed with B.H.C. 10% dust at the rate of 50g per pit. In sandy soils and in areas of drought, two layers of coconut husk should be placed at the bottom before filling the pit with top soil. After filling, the pits are well watered for consolidation.

The best time for planting in light soils is just before the commencement of monsoon rains (May to June). In low lying, and heavy rainfall areas, the planting of coconut seedlings must be done either long before the onset of monsoon rains or the cessation of rains.

The seedling, after lifting from the nursery, should be planted without much delay. A small hole in proportion to the size of the seednut is scooped in the centre of the pit and the seedling is planted in such a way that the top of the husk of seednut is just visible outside. The soil around the seedlings is pressed firmly. The seedlings may be held in position by staking. Immediately after planting the seedlings should be watered.

27.10. CARE OF PALMS

The newly transplanted seedlings should be watered regularly at least during the first two or three years. Further, seedlings should be shaded adequately during summer to reduce casualties and frequency of watering. Weeding the basins is also very essential to conserve moisture and nutrients for the exclusive utilization of the seedlings. A circle of about 1 to 2m in radius must always be kept free from weeds and the area is mulched with dried weeds or any other organic mulches.

The adult stage of the coconut palm commences with flowering and continues till the death of the palm. So judicious manuring, irrigation and regular cultural practices during this stage are very essential to maintain yields at a high level.

27.11. MANURING OF ADULT PALMS

The coconut palm is a perennial crop and once it starts bearing, the production phase continues uninterrupted throughtout the year in 80 or more years. It is therefore, very essential that the palms are manured regularly year after year. The fetilizers may be applied as shown in the table.

Fertilizers should be applied at the active rooting zone i.e. at a radius of about 2m around the palms. The time of application of fertilizer varies from tract to tract depending upon the onset of monsoon. Under rainfed conditions fertilizers may be applied in two split doses. After the receipt of monsoon showers, one-third of the recommended dose of fertilizers may be applied during June-July, the fertilizers are spread around the palm in a radius of 2m and mixed in. Circular basins of 2m radius and 20-30cm depth are dug during August-September and green leaves or compost is spread in the basins 30-40kg per palm and covered partially. The remaining 2/3 dose of fertilizers is spread over the green leaf or compost during December-January and the basins are completely covered. In addition to the above fertilizers 1kg of dolomite or 1kg of lime and 500g of magnesium sulphate per palm per year may be applied. Dolomite or lime may be broadcasted in the basins in April-May and incorporated into the soil by forking, however, it should not be applied with other fertilizers, Magnesium sulphate can be applied along with other fertilizers in the basins in September.

Table 27.1. Fertilizer Recommendations for Coconut (Rainfed)

Age after planting	June-July Nutrient g/palm			December-January Nutrient (G/palm)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
I Year	Planting in May-June			35	17	70
II Year	40	30	75	75	40	150
III Year	75	35	150	155	75	100
IV Year and onwards	110	55	225	230	115	455

Table 27.2. Fertilizer Recommendations for coconut (irrigated) g/palm.

Age after Planting	N (g)	P_2O_5 (g)	K_2O (g)	Time of application
I Year	50	40	135	In four equal splits during
II Year	160	120	400	April-May, August-September
III Year	330	240	800	December and February.
IV Year and onwards	500	320	1200	

27.12. IRRIGATION

Coconut responds well to irrigation which increases the yield considerably. Irrigation also increases the size of the nuts. So palms should be irrigated during summer months in basins of 2m radius and 10-20cm depth dug around the palms. The water requirement of a palm varies according to the soil type and climatic conditions. Generally, an adult palm requires 400 to 800 litres of water once in four to eight days.

27.13. MOISTURE CONSERVATION

Burying fresh or dried coconut husks around the palms is a very beneficial practice for moisture retention especially in drought prone areas. Husk burial is practised in India and Sri Lanka for moisture conservation. Coconut husks act as water reservoir in the soil and in addition supply the palms with small amounts of potash.

At the beginning of monsoon coconut husks are buried either in linear trenches of 1.5 to 2m wide and 30-50cm depth, taken 3m away from the trunk between rows of palms or in circular trenches dug around the palm at a distance of 2m from the trunk. The trenches must be dug against the slope of the land. The husks are to be placed in layers with concave surface facing upwards and each layer is covered with soil. The last layer should be 20cm below the ground level. About 500-1000 husks are needed per palm depending on the age. The beneficial effects of husk burial will last for about 5 to 6 years, so the process should be repeated after every six years.

The husks are also useful as a surface mulching material for moisture conservation in the tree basins.

Check Your Progress - 2

What do you do for the moisture retention in coconut fields in drought prone areas?

Note: (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end.

....

....

....

....

27.14. INTERCULTIVATION

Only minimum tillage is required for coconuts. Frequent and excessive intercultivations are not necessary. Inter-cultural operations are mainly intended to control weeds and to provide aeration to the soil. Intercultivation may be done either by digging or ploughing the orchard soil. Intercultivation prevents the formation of surface matting of roots, provides proper aeration and keeps down the weeds. Intercultivation twice in the winter and twice in rainy season is the optimum requirement.

27.15. GREEN MANURE CROPS AND COVER CROPS

The earliest and most economic method of improving the organic matter in the soil is the raising of a green manure crop in situ and its incorporation into the soil. Sunnhemp (*Crotalaria juncea*), wild Indigo *(C. striata)* and cowpea *(Vigna unguiculata)* are the suitable green manure crops for coconut. These should be incorporated into the soil when there is plenty of moisture in the soil and they are about to flower. Green manure crops may be sown with the onset of monsoon showers (June) and may be incorporated during August-September.

Cover cropping is beneficial in coconut gardens to prevent soil erosion, control of weeds, regulation of soil temperature and finally for the supply of organic matter to the soil. In India, *Indigofera hirsuta, Calopogonium mucunoides, Mimosa invisa* and *Pueraria phaseoloides* are commonly grown as cover crops in coconut gardens. The cover crops must be incorporated into the soil, at least once in two years to-gether with phosphatic fertilizers. In areas where soil moisture is a limiting factor, cover crops should be raised, to prevent adverse effect on yields of coconut.

27.16. INTERCROPPING

The coconut palms take more than five years to come to bearing. There will be adequate space between the young seedlings, which can be utilised profitably by intercropping. Catch crops like pine apple, tapioca, banana, dry paddy, millets, pulses, etc. are suitable for this purpose.

However, these intercrops should receive adequate and separate irrigation and fertilization, since, intercropping coconut without the use of fertilizers and irrigation is definitely harmful to the palms. Under irrigated conditions, coco forms a very beneficial crop combination with coconut. Other crops suitable for mixed cropping in coconut include pepper, and tree spices like cinnamon, clove and nut meg.

27.17. HARVESTING & YIELD

Under sound management conditions tall varieties start flowering in about five years after planting, while dwarfs begin to flower in the third or fourth years of planting. In both cases, full bearing status is reached only two years after the commencement of flowering. After stabilization of yields, the palm has a bearing life of over 60 years.

Coconut generally takes 11-13 months for maturation from the time of opening of flowers. Only fully matured nuts should be harvested for getting maximum yield of copra and oil. Tender nuts for drinking purpose are harvested when the nuts are 6-7 months old. Nuts which are 11 months old give better quality fibre and fairly optimum yield of copra. Harvesting can be done at 30 to 60 days interval. In India harvesting of nuts is commonly done by experienced climbers.

An average yield of 60-100 nuts per palm per year can be obtained from the tall variety under rainfed conditions in India. When irrigation is coupled with good management, average yield may go upto 80-120 nuts per palm per year. On an average about 5500 nuts can be obtained from one hectare of coconut garden in India.

27.18. COCONUT PRODUCTS

The coconut palm gives several products. Every part of the palm is useful in one way or the other. It supplies food, drink, shelter oil and also raw materials for a number of industries. As such the coconut palm is rightly called 'Kalpavriksha'.

The kernel (endosperm) of the ripe coconut is an important food article, useful for various culinary purposes. The kernel is rich in fats (41.6%) carbohydrates (13%) and in vitamins A, B, C and E.

One of the chief commercial products of coconut palm is the copra, the dried endosperm of the coconut fruit. Copra made in India is of two types viz., edible and milling copra. Edible copra is a highly valuable commodity in the world market of oil seeds, meant for edible purposes. The milling copra is mainly utilized for oil extraction. Edible copra is of two types- Ball copra is made from fully matured (¿ 12 months old) whole unsplit nuts after storing them for 8-12 months in a shed. While cup copra is made from nuts by splitting into two halves and drying.

The chief commercial product of coconut palm is the coconut oil. The coconut oil is an endosperm oil, which is extracted traditionally by crushing the milling copra. In modern methods oil is extracted by mechanical or solvent extraction techniques. The coconut oil is a rich source of fat and is extensively used for edible and industrial purposes. Because of the easy digestibility of coconut oil, it is used as an essential ingredient of many ghee preparations. The major industrial use of coconut oil is in soap industry. It is also used in toilet articles, creams ano cosmetics.

The residual cake obtained after oil extraction is the coconut cake, which is mainly used as cattle and poultry feed and some times as an organic manure.

Coconut fibre or coir is the chief by product of the coconut industry. It is obtained from the mesocarp (husk) of the coconut fruit. Coir has been used by man since ancient times. Coir based industries have developed in many coconut growing countries, especially in India and Sri Lanka. In India coir manufacturing is a traditional industry, which fetches substantial foreign exchange. Coir is extracted from husks either by natural retting or mechanical or chemical methods of retting. In India, natural retting is followed. Coir is used in many ways. It is used for making mattresses, carpets, wall decorations etc.

Coir dust, a by product of coir industry is used as a manure or soil conditioner. It forms an excellent surface mulch.

The hard endocarp (coconut shell) of the coconut fruit is another by product of coconut industry. The shell is mainly used as fuel. To a lesser extent, it is used in the manufacture of hookah shells, domestic utensils, curious fancy items, ashtrays, flower vases, latex collecting cups etc.

The stem of the coconut palm is generally used in house constructions. The palm leaves are used for footing, fencing and for making baskets. The midribs of the leaves are made into brooms, bird cages and fishing traps. The petioles, bunch stalks, spathes, stipules etc., are used as fuel and the resultant ash being rich in potash is used as manure. The roots are used in certain medicinal preparations for the treatment of dysentery, mouth wash etc.

27.19. IMPORTANT PESTS AND DISEASES OF COCONUT

A. Pests

1. Rhinoceros Beetle *(Oryctes rhinoceros L.)*

Symptoms: This is the most destructive pest of the coconut palm. The adult beetle is dark brown to black in colour, with a characteristic horn on the head. The adult beetle bores into the soft tissue of the apical bud by cutting and chews the tender unopened leaves and inflorescences.

Control: Since the breeding place of these beetle is manure pits and other decaying refuses, these may be sprayed every alternate month with 0.1 per cent B.H.C. solution. The grubs may be picked by hand from the breeding places and destroyed. The adult beetle may be hooked out with an iron rod from the holes and destroyed.

2. The Black-Headed Caterpillar *(Opisina arenosella)*

Symptoms: This is another serious pest of the coconut. Larva is the destructive agent, which feeds on the leaves. The infested leaflets dry up.

Control: In heavy rainfall areas, the pest is controlled by spraying 0.2 per cent BHC once in two months. In dry areas 0.5 per cent Malathion spray is quite effective. Light traps are also useful to attract the adult months. In severe cases, biological control of the pest is better.

The Red Palm Weevil *(Rhychophorus ferrugineus F.)*

Symptoms: The adult weevil is a brown cylindrical insect with long curved snout. The damage is caused by the grubs which spend all their time in side the palm tree, feeding on the soft tissue. The damage is severe, and once the Weevil gets into the palm, the tree is bound to die. A reddish brown liquid generally oozes from the holes.

Control: The pest usually lays eggs in the sounds caused by rhinoceros beetle. So these wounds must be closed to avoid egg laying. The pest may also be controlled by injecting pyrocone Ec at 1 per cent at the rate of 1000-1500cc per tree through the top most hole after closing all other holes on the trunk with cement.

B. Diseases

1. Budrot

Symptoms: This is a fatal disease of coconut palm, caused by *Phytophthora palmivora*. The disease is characterised by the rotting of terminal bud and the surrounding tissues. The incidence is severe during rains.

Control: In the early stages of the incidence the disease can be checked by removing all the affected tissue and spraying with one per cent Bordeax mixture. In the advanced stages, there is no possibility of recovery. The disease can effectively be prevented by spraying Bordeaux mixture regularly at 40 days interval before and after rains.

2. Trunk and Root Rot

Symptoms: The disease is caused by a root infecting fungus *Ganoderma lucidum*. The disease is fatal, but its occurrence is restricted to lighter soils. Though the seat of infection is the base of the trunk, symptoms develop on the crown. The older leaves wither, and drop and remain suspended for long until they are shed. The new leaves wither and decay. These symptoms are accompanied by the exudation of brownish liquid on the trunk. Generally the symptoms appear on palms aged 40 years and above.

Control: Badly infected palms should be cut and destroyed. Powdered sulphur at the rate of 2kg per palm may be applied to the soil around the palm as an effective check against the disease.

3. Stem Bleeding

Symptoms: Unfavourable soil conditions play a major role in the incidence of disease. The fungus *(Thielaviopsis paradoxa)* is a wood parasite. The characteristic symptom is the exudation of rusty brown liquid from cracks and cuts on the trunk. The tissue below the bleeding region gets decayed. In advanced stages, the bark peels off and the trees may be broken by winds.

Control: The diseased portions of the stem may be clipped and completely scooped out and the wound is then dressed with coaltar or Bordeaux paste or Aureofungin.

4. Tatipaka Disease

Symptoms: This disease is of unknown etiology, reported from East Godavari district. The initial symptoms of the disease are a sudden increase in the yield and the development of dark-green leaves. After this the yield begins to decline. Small and pale leaves are produced. Nuts become smaller with sponge-like mesocarp. As the disease progresses the tree becomes barren with a tampering stem. The roots show decay and the palm dies in due course.

Control: Destruction of the badly affected palms may prevent the spread of the disease. However, no effective control measure has been found so far.

Check Your Progress - 3 & 4

3. The scientific name of Rhinoceros beetle is____________________.

4. The bud rod of coconut is caused by ____________________.

Note: (a) Write your answer in the space given above.

(b) Compare your answer with those given at the end.

27.20. SUMMARY

Coconut palm provides food, shelter & raw material for industries. There are tall varieties, dwarf varieties and hybrids. Tall varieties are West Coast Tall, East Coast Tall and Lakshadweep ordinary; Dwarf varieties are Choughat dwarf, and Ganga Bondam; and Hybrids palms are (a) Tall X Dwarf hybrids (b) Dwarf X Tall. It grows best under hot moist climates in proximity of sea-coastal humid climate is ideal for best performance. It grows well in any soil, provided it is well drained. In arid climates, deep and fine soils are best, without hard pan in the soil horizon. The principal means of propagation is seed. Seed nuts are collected from selected mother palms which have reached full bearing status. Coconut nurseries should have a site with loose and friable soils with a greater portion of sand. In the establishment of a garden generally a spacing of 7-9m under square or triangular system of planting is recomended for coconut. Frequent and excessive intercultivations are not necessary and only minimum tillage is required. Generally the coconut palms take a minimum of 5 years to come to bearing and takes 11- 13 months for the maturation of coconut from the time of opening of flowers.

Coconut palm gives several important products. It supplies food, drink, shelter, oil and raw materials for a number of industries. The important pests of Coconut are Rhinoceros beetle, the black headed caterpillar, and red palm weevil and the important diseases are bud rot, trunk and root rot, stem bleeding and tatipaka disease.

27.21. CHECK YOUR PROGRESS: MODEL ANSWERS

1. The examples for dwarf varieties are chowghat dwarf and ganga bondam.
2. In drought prone areas the moisture retention in coconut fields is done by hurrying fresh or dried coconut husks around the palms.
3. *Oryctes rhinoceros*
4. *Phytophthora palmivora*

27.22. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the tall varieties of coconut.
2. Describe the dwarf varieties of coconut.
3. Describe the characters of West Coast Tall, East Coast Tall, and choughat dwarf.
4. Bring out the salient features of hybrid palms and Ganga Bondam.
5. Give the climatic and soil requirements of coconut.
6. How do you propagate coconut. Give details as selection of mother palm, seed nuts, method of sowing and selection of seedlings from a nursery bed.
7. Give the manurial schedules for adult palms both under rainfed as well as irrigated conditions. How and when do you fertilize the palms.
8. Describe in detail intercultivation, inter-croping and raising of cover crops in coconut gardens.
9. what are the commercial products and by-products of coconut palm. Bring out their uses.
10. Enumerate the important insect pests that attack the Coconut palm, with nature of damage and control.
11. What are the important diseases of coconut palm. Describe the symptoms and damage caused by them. How do you check them.

II. Answer the following questions in about 10 lines each.

1. Distinguish between tall and dwarf varieties of coconut.
2. Describe the salient features of (a) East Coast Tall and Ganga Bandam or (b) Hybrid palms.

3. What type of climate is required for coconuts.
4. What type of soil is required for coconuts.
5. What are the criteria prescribed for selecting a mother palm for propagation. How and when do you collect the seednuts in coconut.
6. Describe the planting of coconut seedlings in respect of digging pits, time and method of planting.
7. How do you take care of young coconut seedlings in the main field.
8. How moisture can be conserved in the coconut gardens. Describe the procedure.
9. How do you rise green manure and cover crops in coconut.
10. Write about intercroping in coconut garden.
11. What are the chief commercial products of coconut. How do you make ball and cupp copra. Write briefly about coconut oil and its uses.
12. Give the nature of damage and control measures in case of Rhinoceros beetle or Black headed caterpillar or red oil palm weevil.
13. Give the symptoms and control measures in case of bud rot, or Trunk and root rot.

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COURSE - IV: CROP PRODUCTION

SYLLABUS

Block-I	:	**Soil, Soil Fertility Tillage and Weed Control**
Unit-1	:	Agricultural Meterology
Unit-2	:	Agroclimatic Zones of Andhra Pradesh
Unit-3	:	Soils
Unit-4	:	Manures and Fertilizers
Unit-5	:	Tilth and Tillage
Unit-6	:	Weeds and Weed Control
Unit-7	:	Cropping Systems
Unit-8	:	Dryland Farming and Recommended Practices
Unit-9	:	Plant Nutrients
Block-II	:	**Crop Production**
Unit-10	:	Rice
Unit-11	:	Wheat and Maize
Unit-12	:	Sorghum
Unit-13	:	Bajra, Ragi and Korra
Unit-14	:	Groundnut
Unit-15	:	Castor and Gingelly
Unit-16	:	Safflower and Sunflower
Unit-17	:	Greengram and Blackgram
Unit-18	:	Redgram and Bengalgram
Unit-19	:	Sugarcane
Unit-20	:	Cotton
Unit-21	:	Chillies
Unit-22	:	Turmeric, Ginger and Coriander
Unit-23	:	Tobacco
Unit-24	:	Mango
Unit-25	:	Citrus
Unit-26	:	Cashewnut
Unit-27	:	Coconut

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FACULTY OF SCIENCES

B.Sc. III Year (3 YDC) Examination

MODEL QUESTION PAPER

BOTANY - Paper-IV

Crop Production

Time: 3 hours | **Max. Marks: 75**

Section - A

Note: *Answer any* **Three** *of the following questions in about* **30** *lines each. Each question carries* **15** *marks.*

1. List 5 cotton varieties that are popularly grown in A.P. and give their characteristics.
2. List the advantages and disadvantages in the use of chemical weedicides and list the limitations in use.
3. Give-three examples in each for long, medium and short duration sugar cane varieties grown in A.P. Describe one variety in each category.
4. Discuss the main principles of dry farming and describe briefly the important practices for soil and moisture conservation.
5. Describe different steps that are necessary for establishing the coconut garden.
6. Discuss the advantages and disadvantages of green manuring.

Section - B

5x6 = 30

Note: *Answer any* **Three** *of the following questions in about* **10** *lines each. Each question carries* **6** *marks.*

7. List three important varieties in Castor that are grown in A.P. and briefly describe their characteristics.
8. Give the cultivation details of wheat crop with respect to time of sowing, seed rate, depth of sowing and recommended fertilizers.
9. Briefly give the cultivation details of safflower.
10. List five important mango varieties and hybrids and give an account of artificial ripening in mangoes.
11. Give the reasons for the low yield in groundnut in A.P.
12. Give the particulars of climate, soil, season, varieties and fertilizer schedule for Coriander.
13. Give the control measures for the control of black headed caterpillar on Coconut.
14. List three important redgram varieties grown in A.P. and describe their characteristics.
15. List three major pests on Ragi crop and give control measures.
16. Give an account of vegetative method of propagation in Cashew nut.

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COURSE - IV: CROP PRODUCTION

ASSIGNMENT - 1

N.B.

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source give the correct reference.
4. Use your own fullscape pages for writing the assignment.
5. Leave sufficient margins for the comments of the evaluator.
6. Completion of this assignment should not take more than two hours time.

I. Answer the following questions in about 30 lines.

1. Give an account of the classification of Manures.
2. Write the classification of weeds based on several factors with 2 examples each?
3. Describe the symptoms of deficiency of essential elements.

II. Answer the following question in about 10 lines each.

1. What are the Agroclimatic zones in Andhra Pradesh? What is the basis for their classification?
2. Define tilth. Mention the usefulness of tilth.
3. What are the advantages of inter cropping?

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COURSE - IV: CROP PRODUCTION

ASSIGNMENT - 2

N.B.

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote rrom any source give the correct reference.
4. Use your own fullscape pages for writing the assignment.
5. Leave sufficient margins for the comments of the evaluator.
6. Completion of this assignment should not take more than two hours time.

I. Answer the following questions in about 30 lines.

1. Discuss the merits and demerits of Indica, Japonica and Javanica varieties.
2. Describe the symptoms caused by important pests of sorghum along with their control measures.
3. Write briefly on the cultivation of Groundnut along with the pests & Diseas caused to it.

II. Answer the following questions in about 10 lines each.

1. Write briefly about the classification of wheat varieties.
2. Mention the symptoms caused by important diseases of Ragi.
3. Write a short note on the weeding and interculture operation in safflower.

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COURSE - IV: CROP PRODUCTION

ASSIGNMENT - 3

N.B.

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source give the correct reference.
4. Use your own fullscape pages for writing the assignment.
5. Leave sufficient margins for the comments of the evaluator.
6. Completion of this assignment should not take more than two hours time.

I. Answer the following questions in about 30 lines.

1. Describe in brief the characteristics of fibres for evaluating the quality of cotton.
2. Describe in detail the different curing processes of tobacco.
3. Describe the different steps that are involved in the processing of Cashew Kernels. Add a note on the importance of CNSL.

II. Answer the following questions in about 10 lines each.

1. Describe in brief the process of Jaggery making.
2. Describe the normal and improved methods of drying of chilli.
3. Describe the different methods of storage in Mango.