IVC Course Code : 109

CROP PRODUCTION & MANAGEMENT
(C.P & M)
First Year
Intermediate Vocational Course

Paper I : **Principles Of Crop Production**

Paper II : **Soil And Water Management**

Paper III : **Farm Management And Agricultural Extension**

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ANNUAL SCHEME OF INSTRUCTION AND EXAMINATION FOR VOCATIONAL COURSE - I YEAR

Part-A		Theory		Practicals		Total	
		Periods	**Marks**	**Periods**	**Marks**	**Periods**	**Marks**
1.	General Foundation course	150	50	0	0	150	50
2.	English	150	50	0	0	150	50
Part-B							
3.	**Paper-1** Principles of Crop Production	135	50	135	50	270	100
4.	**Paper-II** Soil & Water Management	135	50	135	50	270	100
5.	**Paper-III** Farm Management & Agricultural Extension	135	50	135	50	270	100
6.	**OJT**	-	-	363	100	363	100
	Total	**705**	**250**	**768**	**250**	**1473**	**500**

II. on the Job Training for First Year from 1st Nov to 31st December

EVALUATION OF ON THE JOB TRAINING:

The "On the Job Training" shall carry 100 marks for each year and pass marks is 50. During on the job training the candidate shall put in a minimum of 90 % of attendance.

The evaluation shall be done in the last week of January.

Marks allotted for evaluation:

S.No	Name of the activity	Max. Marks allotted for each activity
1	Attendance and punctuality	30
2	Familiarity with technical terms	05
3	Familiarity with tools and material	05
4	Manual skills	05
5	Application of knowledge	10
6	Problem solving skills	10
7	Comprehension and observation	10
8	Human relations	05
9	Ability to communicate	10
10	Maintenance of dairy	10
	Total	100

NOTE: The On the Job Training mentioned is tentative. The spirit of On the Job training is to be maintained. The colleges are at liberty to conduct on the job training according to their local feasibility of institutions & industries. They may conduct the entire on the job training periods of I year and (450) II year either by conducting classes in morning session and send the students for OJT in afternoon session or two days in week or weekly or monthly or by any mode which is feasible for both the college and the institution. However, the total assigned periods for on the job training should be completed. The institutions are at liberty to conduct On the Job training during summer also, however there will not be any financial commitment to the department.

CROP PRODUCTION & MANAGEMENT

Paper - I

PRINCIPLES OF CROP PRODUCTION

INDEX

UNIT 1

AGRICULTURE

1.1 Terminology- Agriculture, Agronomy & its relationship with basic sciences

1.2 National& International Institutesof Agricultural Research in India

1.3 Agro Climatic Zones of Andhra Pradesh

Introduction

Agriculture is a very broad term encompassing all aspects of crop production, livestock farming, fisheries etc. Agriculture terminology and its relationship with other basic sciences helps in better understanding and better management of crop production. Similarly, various national and international institutions are involved in the programmeson teaching,research and extension. Andhra Pradesh is divided into sixdifferent agro climatic zones based on soil type, irrigation facilities and crops grown. It is therefore essential to study the characteristics of each zone so that, it enables to enhance the productivity.

1.1 Terminology

The term agriculture is derived from the Latin words “ager” or ‘’agri” meaning ‘’soil” and ‘cultra’ meaning ‘cultivation’.

Agriculture may be defined as the art, the science and the business of producing crops and livestock for man’s use and employment.

Agriculture is the cultivation of lands for production of crops for a regular supply of food and other needs for progress of the nation.

Agriculture is influenced by a large number of factors, some of which can be controlled by man (soil and irrigation) while others are beyond the control (climate).

The term ‘’Agronomy” is derived from Greek words ‘’Agros” meaning ‘’field” and ‘’nomos” meaning “to manage”.

Agronomy is a branch of agricultural science which deals with principles and practices of soil, water and crop management.Itdeals with methods which provide favorable environment for higher productivityof crops.

Relationship with Basic Sciences

- Basic science is the study of basic principles and fundamentals of the respective subject.
- Applied science is the study in which the basic principles and fundamentals of respective subject are applied in a practical field.
- Agricultural sciences are essentially applied sciences and are dependent on basic sciences of Botany, Physiology, Bio-chemistry, Ecology, Zoology, Chemistry, Physics, Mathematics, Economics etc.

For example

1. Knowledge of Botany is helpful in plant breeding and plant genetics for the development of improved varieties of crops suitable to a particular agro-climatic condition.
2. The knowledge of zoology (basic science of entomology) is helpful to the farmer in identifying the harmful insect pests and their damage to agriculture.
3. Soil chemistry helps in understanding the plant nutrient status in the soil and the deficiency symptoms in plants.
4. Physics helps in understanding the weather phenomena and soil conditions.
5. Mathematics is helpful in agricultural research and experimentation through statistics and Agricultural economics.
6. Study of economics is helpful in estimating the cost and returns and economic conditions of farmers in villages for effecting the improvements.

Without basic science there can be no development in applied science, in the field of agriculture basic and applied sciences are interrelated to each other.

Scope of Agronomy

Agronomy is a dynamic discipline. With the advancement of knowledge and better understanding of plant and environment, agricultural practices are modified and new practices are developed for higher productivity. For example: availability of chemical fertilizer has necessitated the generation of knowledge on the method, quantity and time of application of fertilizers. Similarly, availability of herbicides for the control of weeds has led to development of knowledge about selectivity, time and method of application. To overcome the problems different management practices are developed.

Population pressure is increasing but area under cultivation is static. Therefore, more number of crops have to be grown on the same piece of land to increase the yield. As a result, intensive cropping have come into practice.

New technology has to be developed to overcome the effect of moisture stress under dryland conditions. As new varieties of crops with high yield potential become available, package of practices have to be developed to exploit their full potential.

Restoration of soil fertility, preparation of good seed bed, use of proper seed rates, correct dates of sowing for each improved variety, proper conservation and management of soil moisture and proper control of weeds are agronomic practices to make our limited land water resources more productive.

Relation of agronomy to other sciences

Agronomy is a combination of several disciplines like Soil science, Agricultural chemistry. Crop physiology, Plant ecology, Biochemistry and Economics. Soil physical, chemical and biological properties have to be understood thoroughly to effect modification of soil environment. Similarly, it is necessary to understand the physiology of crops to meet their requirements. Advances in economic analysis help in achieving remunerativeprices.

Agronomist aims to obtain maximum production at minimum cost. He exploits knowledge developed by basic and applied science for higher crop production. Whatever may be the research findings, agronomist has to test their suitability in the field accept them finally and also judge the reactions of farming community. He is a key person with working knowledge of all agricultural disciplines and coordinator of different subject matter specialists.

1.2 National and International Agricultural Research Institutes:

National Research Institutes in India

CAZRI : Central Arid Zone Research Institute, Jodhpur, Rajasthan.

CFTRI : Central Food Technological Research Institute, Mysore, Karnataka.

CICR : Central Institute for Cotton Research, Nagpur, Maharashtra.

CPRI : Central Potato Research Institute, Simla, Himachal Pradesh.

CRIJAF : Central Research Institute for Jute and Allied Fibres, Barrackpore, West Bengal.

CIAE : Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh.

CPCRI : Central Plantation crops Research Institute, Kasargod, Kerala.

CRIDA : Central Research Institute for Dry land Agriculture, Hyderabad, Telangana.

CRRI : Central Rice Research Institute, Cuttack, Orissa.

IISWC : Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand.

CTCRI :Central Tuber Crops Research Institute, Thiruvannanthapuram, (Trivendrum), Kerala.

CSSRI : Central Soil Salinity Research Institute, Karnal, Haryana.

CTRI : Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh.

IIOR : Indian Institute of Oil seeds Research, Hyderabad, Telangana.

IIRR : Indian Institute of Rice Research, Hyderabad, Telangana.

IIMR : Indian Institute of Millets Research, Hyderabad, Telangana.

DWR : Directorate of Wheat Research, Karnal, Haryana.

IIWM : Indian Institute of Water Management, Bhubaneswar, Orissa.

FRI : Forest Research Institute, Dehradun, Uttarakhand.

IARI : Indian Agricultural Research Institute, New Delhi.

IGFARI : Indian Grassland Fodder and Agroforestry Research Institute, Jhansi, Uttar Pradesh.

IISR : Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh.

IISS : Indian Institute of Soil Science, Bhopal, Madhya Pradesh.

IIPR : Indian Institute of Pulses Research, Kanpur, Uttar Pradesh.

IIHR : Indian Institute of Horticultural Research, Bangalore, Karnataka.

IINRG : Indian Institute of Natural Resins and Gums, Namkum, Ranchi, Jharkhand.

JTRL : Jute Technological Research Laboratory, Kolkata,West Bengal.

NCMRT : National Centrefor Mushroom Research and Training, Solan, Himachal Pradesh.

NRCG : Natonal Research Centre for Groundnut, Junagadh, Gujarat.

NRC for Soyabeen, Indore, Madhya Pradesh.

NRC for Spices, Calicut, Kerala.

NRC for Cashew, Pattur, Karnataka.

NRC for Citrus, Nagpur, Maharashtra.

NRC for Rapeseed and Mustard, Bharatpur, Rajasthan.

NRC for Oil Palm, Pedavegi, Andhra Pradesh.

DWR : Directorate of Weed Research, Jabalpur, Madhya Pradesh.

NBPGR : National Bureau of Plant Genetic Resources, New Delhi.

NAARM : National Academy of Agricultural Research Management, Hyderabad, Telangana.

NBSSLUP : National Bureau of Soil Survey and Land Use Planning, Nagpur, Mahrashtra.

NIPHM : National Institute of Plant Health Management, Hyderabad, Telangana

IIFSR : Indian Institute of Farming Systems Research, Meerut, Uttar Pradesh

SBI : Sugarcane Breeding Institute, Coimbatore, Tamilnadu.

International Institutions:

CGIAR : Consultative Group on International Agricultural Research, Washington C.,U.S.A

CIFOR : Centre for International Forestry Research, Bogor, Indonesia.

CIAT : Centre International de Agricultural Tropical, Cali, Columbia.

CIMMYT : Centre International de la MejoramientodeMaizy,Trigo, Mexico.

CIP : Centre International de la papa (International Potato Centre), Lima, Peru.

IBPGR : International Board for Plant Genetic Resources, Rome, Italy.

ICARDA : International Centre for Agricultural Research in the Dry Areas, Aleppo, Syria.

ICRAF : International Centre for Research in Agro-Forestry, Nairobi, Kenya.

ICRISAT : International Crops Research Institute for Semi-Arid Tropics, Hyderabad, India.

IFPRI : International Food Policy Research Institute, Washington, U.S.A.

IITA : International Institute for Tropical Agriculture, Ibadan, Nigeria.

IWMI/IIMI : International Irrigation Management Institute, Colombo, Sri Lanka.

ILRI : International Livestock Research Institute, Nairobi, Kenya.

IRRI : International Rice Research Institute, Manila, Phlippiness.

ISNAR : International Service for National Agricultural Research, The Hague, The Netherlands.

WARDA : West Africa Rice Development Association, Ivory Coast, West Africa.

1.3. Agro Climatic Zone of Andhra Pradesh

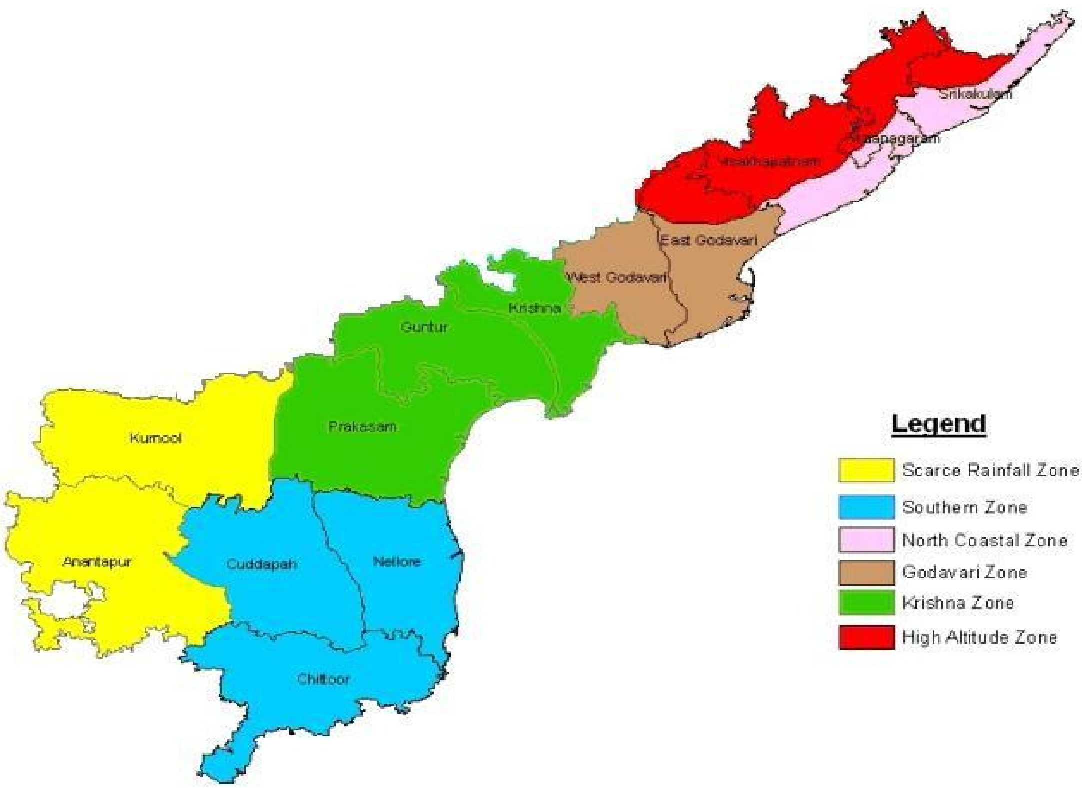
Andhra Pradesh state was formed with 13 districts after bifurcation on 2nd July 2014 with a geographical areaof16.96m.ha., and extends from 12°41' and 19.07°N latitude and 77° and 84°40'E longitude.

The state is divided into two regions namely Coastal Andhra and Rayalaseema. The districts in each region are as follows

Coastal A.P	Rayalaseema
Srikakulam	Kurnool
Vizianagaram	Cuddapah
Sishakhapatnam	Anantapur
East Godavari	Chittor
West Godavari	
Krishna	
Guntur	
Prakasam	
Nellore	

Andhra Pradesh is divided into six agro climatic zones. The details about the geographical area, cropped area, irrigation facility and important crops grown in each zone are furnished here under.

SIX AGRO-CLIMATIC ZONES OF ANDHRA PRADESH



Sl. No.	Name of the Zone	Districts	Geographical area (million ha)	No. of mandals
1	North Coastal Zone	Srikakulam, Vizianagaram, Visakhapatnam	1.85	88
2	Godavari Zone	East Godavari, West Godavari	1.75	96
3	Krishna Zone	Krishna, Guntur, Prakasam	3.77	161
4	Southern Zone	Chittoor, Kadapa, Nellore	4.17	161
5	Scarce Rainfall zone	Kurnool, Anantapur	3.62	117
6	High Altitude & Tribal Areas Zone	High Altitude & Tribal Areas of Srikakulam, Visakhapatnam, East Godavari	1.80	40

I. North Coastal Zone

This zone consists of Srikakulam, Vizianagaram and Visakhapatnam districts with a geographical area of 1.85m.ha., and106 mandals and is primarily agrarian in character, with about 54% of its geographical area under cultivation. The normal rainfall of the zone is about 1060 mm, out which 61% is received during south-west monsoon, 26% during north-east and remaining 13% during winter and summer months. The soils of the zone are predominantly red with clay base accounting for 90 % of the area. Alluvial, coastal sand and lateritic soils also occur in this zone. Tanks and canals are the main source of irrigation and 45 % of cropped area is irrigated

The important crops raised in the north coastal zone are rice, millets, sugarcane, groundnut, gingelly and mesta. Rice is the principal food crop grown in more than 90% of the irrigated area followed by sugarcane. All the other crops are grown under rainfed conditions.

II. Godavari Zone

This zone consists of East and West Godavari districts. The zone comprises of 96 mandals with a geographical area of 1.75m.ha. Paddy is the major crop grownin addition to horticultural cropsbanana and coconut. Deep and alluvial soils are available, most of the area is being irrigated by the Godavari river. Heavy cyclonic rains and poor drainage are important production constraints in this zone.

III. Krishna Zone

This zone includes districts of Krishna, Guntur and parts of Prakasam with a geographical area of 3.77m.ha.The zone has extended coastline with annual rainfall ranging from 800 to 1100 mm. The soils are predominantly deltaic alluvial, deep and medium black soils, red and red loamy soils and coastal sands.

Soil salinity is encountered in areas adjacent to the coast and in soils under ill-drained situations. The zone is agriculturally most important with productive soil resources, ideal tropical humid climate and vast irrigation potential (68 % of cultivated area is irrigated) under Krishna zone.

Rice is the principal crop grown. Other important crops are pulses (blackgram, greengram, redgram), sugarcane, sesamum, tobacco, chillies, cotton. banana and mango are widely cultivated horticultural crops of the zone. Water congestion, impeded drainage, development of salinity, heavy rains and cyclones at the time of harvest are the major constraints of crop production.

IV. Southern zone

The Southern zone consists of the districts of Nellore, ChittoorandKadapa, covering a total geographical area of 3.62 m.ha.withdrytropicalclimate. The average annual rainfall ranges from 700-1050 mm. About 50% of the rainfall is received during SW Monsoon. The soils of the zone are predominantly red loamy, shallow to moderately deep with limited occurrence of heavy textured black soils. Gross cropped area is 1.87 m.ha, tanks and wells are the main source of irrigation with 46% of cropped area under irrigation and cropping intensity is 108%. The principal crops cultivated in the zone are groundnut and rice. Sugarcane, ragi, bajra, redgram and other pulses are confined to localized areas. Gradually sunflower crop is replacing area under bajraandsorghum.Harticulture crops like Citrus, melons and mango are also grown in some parts of the zone.

V. Scarce Rainfall Zone

The zone consists of 117mandals distributed in Kurnool and Anantapur, districts covering an area of 3.62 m.ha. The zone is mostly undulated with mountains and hills. Predominant soils of the zone are black soils. Other soils are red earths with loamy sub-soil, red sandy soil and problem soils. The soils in Anantapur districts are shallow with low fertility. The zone is mainly characterized by frequent droughts with lowest rainfall in the state (500-750mm). The rainfall is also uncertain and erratic and 56% of rainfall is from SW monsoon. Major area in the zone is rainfed and irrigated area is only15.4%. The major crop of this zone is groundnut occupying about 33.4% of total cropped area. Other important crops include sorghum, foxtail millet. rice, cotton, coriander and pearl millet. Cropping intensity is 109%. Very good dryland agriculture technology is available here.

VI. High Altitude and Tribal areas zone

This zone is comprised of 40 mandals distributed in parts of Srikakulam, Visakhapatnam and East Godavari districts covering a geographical area of 1.8 m.ha, The area of this zone lies between 50 to 1680 Mtr., above mean sea level and is characterized by high slopes, mountains, hills and hillocks as part of Eastern Ghats. Red soils are the most Predominant type (94.8%). A small area is covered under alluvial soils and coastal sands. The mean annual rainfall ranges from 1245 to 1288 mm of which about 70% is contributed by south-west monsoon. Large geographical area (58.9%) in the zone is under forests and the net cropped area is only 19.2% with very little irrigation sources. The tribal people of this area practice shifting cultivation locally known as "podu" cultivation.

Rice is the most important crop in the zone occupying 36.2% of the gross cropped area. Tuber crops, tea, coffee and other plantation crops are also grown in addition to aromatic and medicinal plants. Cropping intensity is 120%. Forest produce such as, honey, gum, soap nuts, tamarind fetch income to the tribal people.

Summary

In India 65% of the population depends on Agriculture, which is being practiced by following indigenous technology. Population pressure is increasing but area under cultivation is static. Therefore Agriculture is need to be practiced by utilising best technology available in the world. In this direction one should posses the knowledge of Agriculture with other basic sciences and various institution developments going around.

Andhra Pradesh is divided into six Agro-climatic zones, based on geographical area, cropped area, irrigation facilities and crops grown as

1. Krishna Zone
2. Godavari Zone
3. North Coastal Zone
4. Southern Zone
5. Scarce rainfall Zone
6. High Altitude and Tribal area zone.

Short Answer Type Questions

1. Define Agriculture and Agronomy?

2. Expand

   CRIDA

   CSSRI

   CTRI

   IIOR

   IIRR

   IARI

   IIHR

   NBPGR

   PDFSR

   CIMMYT

   ICRISAT

   IRRI

3. Write a short notes on Krishna zone?
4. Write about North Coastal Zone?
5. Write briefly about High altitude and tribal zone?
6. Describe the relation of Agronomy to other sciences?

Long Answer Type Questions

1. Give an account about Agro-climatic zones of Andhra Pradesh?

References

YellamandaReddy,T.andSankaraReddi, G.H 2016.Principles of Agronomy . KalyaniPublishers, Ludhiana.

Gopal Chandra de.1989.Fundamentals of Agronomy. Oxford & IBH Publishing Co.Pvt.Ltd., New Delhi.

UNIT 2

Agro Meteorology

2.1 Terms and Definitions – Weather & Climate
2.2 Atmosphere – composition & vertical divisions
2.3 Monsoon, types and impact on agriculture operation
2.4 Wind, solar radiation (radiation in solar radiatio is to be deleted). Air temperature, Soil temperature, Atmospheric Pressure, Humidity & Evaporation and their utility in crop production
2.5 Drought and their effects on crop production
2.6 Weather Forecasting – Importance
2.7 Weather hazards and their mitigation – cyclones, depressions, tsunami, frost, hailstorms, hurricanes and tornado
2.8 Remote Sensing and its application in agriculture

Introduction

Agro Meteorology is a branch of meteorology which deals with the study of weather parameters. Agriculture gambles with monsoon. Weather forecasting such as, monsoon arrival and withdrawal, temperature, wind and humidity fluctuations helps in either avoiding or minimizing lossess for improving productivity in Agriculture. Similarly, mid season corrections such as, drought management, fertilizer management and pest management may be followed in accordance with Agro meteorology. Remote sensing is a new subject which is being used in Agriculture widely. This knowledge is used in areas like crop acreage estimation, Land degradation, watershed management, drought detection and management.

2.1 Terms and Definitions

Meteorology

Meteorology is defined as

- "The Science of atmosphere"
- "A branch of physics of the earth dealing with physical processes in the atmosphere that produce weather" .

Weather and climate

Weather

It is defined as "A state or condition of the atmosphere at a given place at a given time". The daily or short term variations of different conditions of lower air in terms of temperature, pressure, wind, rainfall, etc."

The aspects involved in weather include small area and duration, expressed in numerical values. The different weather elements are solar radiation, temperature, pressure, wind, humidity, rainfall, evaporation etc. Weather is highly variable. It changes constantly from hour to hour or day to day.

Table:2.1. Differences between Weather and Climate

S. No.	Weather	Climate
1.	A typical physical condition on the atmosphere	Generalized condition of the atmosphere, representing the characteristics of a region.
2.	Changes from place to place even in a small locality.	Different in large regions.
3.	Changes according to time (every moment)	Change requires longer (years) time.
4.	Similar numerical values of weather of different places usually have same weather.	Similar numerical values of climate of different places usually have different climates.
5.	Crop growth, development and yield are decided by weather in a given season.	Selection of crops suitable for a place is decided based on climate of the region.
6.	Under aberrant weather conditions planners can adopt a short- term planning.	Helps in long-term agricultural planning.

Example: The air temperature of Vijayawada on 10-01-2018 at 2.30 pm is 29^0C.

Climate

It is defined as "The generalized weather or summation of weather conditions over a given region during comparatively longer period".

"The sum of all statistical information of weather in a particular area during a specified interval of time usually a season or year or even a decade". The aspects involved are larger areas like a zone, a state, a country and described by normals .

Example: The climatic elements are latitude, longitude, altitude etc. In Andhra Pradesh the winter temperatures range from 15 to 29^0c.

2.2. Atmosphere

Atmosphere

The earth is elliptical shaped with three spheres. They are:

1 Hydrosphere : The water portion.
2 Lithosphere : The solid portion.
3 Atmosphere : The gaseous portion.

The atmosphere is defined as "The colourless, odorless and tasteless physical mixture of gases which surrounds the earth on all sides". It is mobile, compressible and expansible.

Uses of atmosphere for agriculture

The uses of atmosphere are: It

1. Provides oxygen which is useful for respiration in crops.
2. Provides carbon-dioxide to build biomass in photosynthesis.
3. Provides nitrogen which is essential for plant growth.
4. Acts as a medium for transportation of pollen.
5. Protects crop plants on earth from harmful U.V.rays.
6. Maintains warmth to plant life.
7. Provides rain to field crops as a source of water vapour.

Composition and vertical divisions of atmosphere

There is no definite upper layer to the atmosphere. The decrease of air (density) with altitude (height) is so rapid (figure 1) that half of the atmosphere lies within 3.5 miles (5.5 kms) from the surface and nearly $3/4^{th}$ of the atmosphere lies upto 7 miles (11 km).

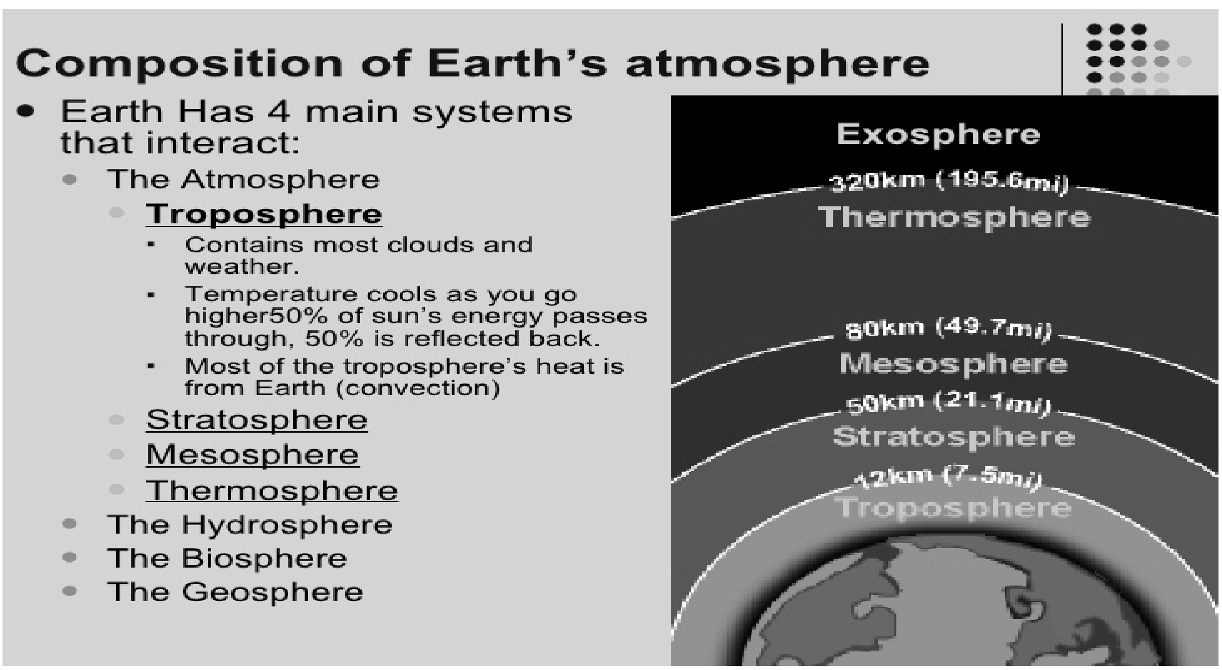
The atmosphere is a mixture of many gases and also contains large quantities of solid and liquid particles collectively called "aerosols". The lower part of the atmosphere contains water vapour from 0.02 to 4 per cent by volume.

S. No.	Constituent	Per cent by volume	Per cent by weight
1	Nitrogen	78.08	75.51
2	Oxygen	20.94	23.15
3	Argon	0.93	1.28
4	Carbon-dioxide	0.03	0.046

Nitrogen and oxygen make up approximately 99 per cent and the remaining 1 per cent by other gases (Table 2.2). Innumerable dust particles present in the lower layers of the atmosphere are microscopic and play an important role in absorption and scattering of insolation. Table: 2.2. Principal gases comprising dry air in the lower atmosphere

Physical structure of the atmosphere

Vertical temperature variation is the basis for atmosphere division into



different spheres or layers and furnished below:

Figure:2.1 Physical Structure of Atmosphere

II Troposphere

1. The word “Tropo” means mixing or turbulence and “Sphere” means region.
2. The average height of this lower most layer of the atmosphere is about 14killometers above the mean sea level; and is 16 kilometers at the equator; and 7-8 kilometers at the poles.
3. Under normal conditions the height of the troposphere changes from place to place and season to season.
4. Troposphere layer is also called as “seat of weather phenomena since various types of clouds, thunderstorms, cyclones and anti cyclones occur in this sphere with high concentration water vapour and aerosols.
5. The wind velocities increase with height reaching maximum at the top
6. Troposphere is characerized by the decrease of temperature with increasing elevation at a mean lapse rate of about 6.5^0c per kilometer or 3.6^0F per 1,000 feet.
7. Most of the radiation received from the sun is absorbed by the earth’s surface and troposphere is heated from below.
8. The troposphere contain about 75 per cent of total gases and most of the moisture and dust particles.
9. Tropopause is a shallow layer at the top of the troposphere and separate it from stratosphere.
10. The tropopause layer is thin and its height changes according to the latitudes and infact, this is a transitional zone and distinctly characterized by no major movement of air.

III Stratosphere

1. This layer exists above the tropopause (around 20 km onwards) and extend, to altitudes of about 50-55 kilometers.
2. This layer is called as “Seat of photochemical reactions”.
3. In any particular locality, the temperature remains practically constant at around 20 kilometers and is characterized as Isothermal because the air is thin, clear, cold and dry.
4. The temperature of this layer increases with height and also depends upon troposphere because troposphere is higher at equator than at poles.
5. In the upper parts of the stratosphere the temperatures are almost as high as those near the earth’s surface, since the ultra violet radiation from the sun is absorbed by ozone in this region.
6. Less convection takes place in the stratosphere because it is warm at the top and cold at the bottom.
7. There is also persistence of circulation patterns and high wind speeds.
8. The upper boundary of the stratosphere is called stratopause and above this level there is a steep rise in temperature.

III Mesosphere / Ozonosphere

1. Ozonosphere lies between 30 to 60 km above the earth's surface with maximum concentration of ozone.
2. Property of ozone is that it absorbs ultra violet rays. Had there been no layer of ozone in the atmosphere, the ultra violet rays would have reached the surface of the earth and no life on it.
3. The temperature of the ozonosphere is high (warm) due to selective absorption of ultra violet radiation.
4. Ozonosphere is also called as "Chemosphere" because of the preponderance of chemical process.
5. Temperature increase with height at the rate of 5˚C per each kilometer.
6. According to some leading scientists the ionosphere is supposed to start at a height of 80 kilometers above the earth's surface. The layer between 50 and 80 kilometers is called mesosphere. In this layer the temperature decreases with height. The upper boundary of this layer is called the mesopause.

IV Ionosphere/Thermosphere

1. Ionosphere layer lies beyond ozonosphere (mesosphere) at a height of about 80 kms above the earths surface and extends upto 400 kilometers.
2. The atmosphere in ionosphere is partly ionized. Enriched ion zones exist in the form of distinct ionized layers. So, this layer is called as ionosphere.
3. Above the ozonosphere the temperature falls again. According to some climatologists, the layer between 80 and 140 kilometers is known as "Thermosphere".
4. The ionosphere reflects radio waves because of one or multiple reflections of short wave radio beams from the ionized shells. So, long distance radio communication is possible due to this layer.

Exosphere

1. The outer most layer of the earth's atmosphere is named as exosphere and this layer lies between 400 and 1,000 kilometres.
2. At such a greater height, the density of atoms in the atmosphere is extremely low.
3. Hydrogen and Helium gases predominate in this outer most region.
4. At an altitude of about 500 to 600 kilometers the density of the atmosphere becomes so low that collisions between neutral particles become extremely rare.

2.3. Monsoon

Importance of rainfall (water) on crop plants

One centimeter of rain over an area of one hectare or 100 m^3(100,000 litters) contains 4,339 grams of oxygen at 20°C. This is equivalent to 3,000 litters of pure oxygen at atmospheric pressure. Consequently, a rain usually has a much more invigorating effect on a crop than does irrigation. Rain water has extraordinary qualities.

1. Water has high solvent power and this plays an important role in crop plants as the plants get their nourishment from soil only in solution form.
2. Water plays an important role in life processes of crop plants (in the exchange of gases).
3. The heat capacity of water is high and its high thermal stability helps in regulation of the temperature of crop plants.
4. Water has highest heat conduction capacity and due to this the heat produced by the activity of a cell is conducted by immediate by water and distributed evenly to all plant parts.
5. The viscosity of water in higher than that of many solvents and this property helps in protecting the crop plants and trees against mechanical disturbances.
6. Water is driest at 4°C. The freezing point of fresh water being 0°C and that of sea water about-2.5°C,the ice can float on the surface and plant life in deeper parts of sea is made possible.
7. The transparency of water facilitates the passage of light to great depths and this helps for the survival of aquatic plants.
8. The high surface tension that water has, helps in movement of water into and through the plant parts.
9. Rainfall influences the distribution of crop plants in particular and vegetation in general. As the nature of vegetation of a particular place depends on the amount of rainfall (the vegetation of a desert where rainfall is less differs a lot from the vegetation of a rainforest).

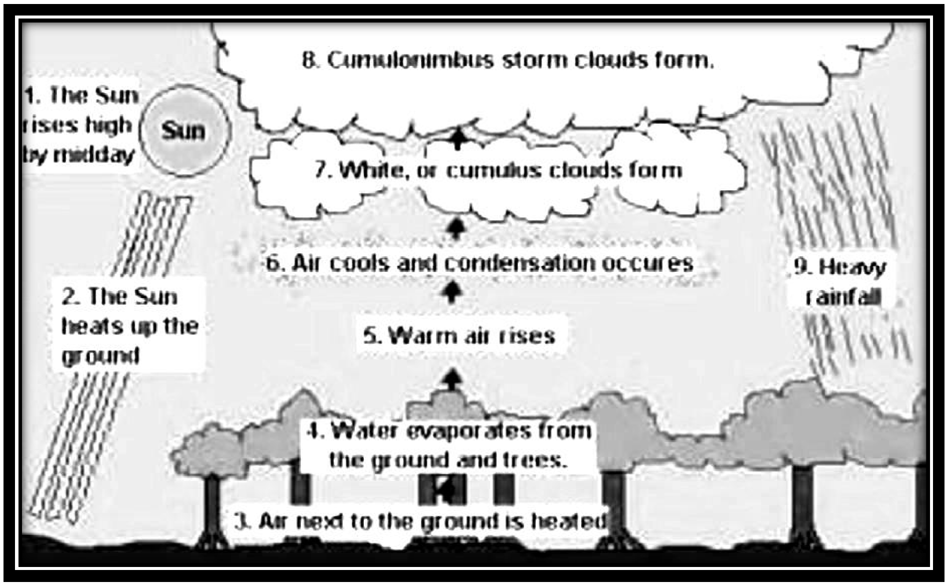


Figure: 2.2 Convectional Rain fall

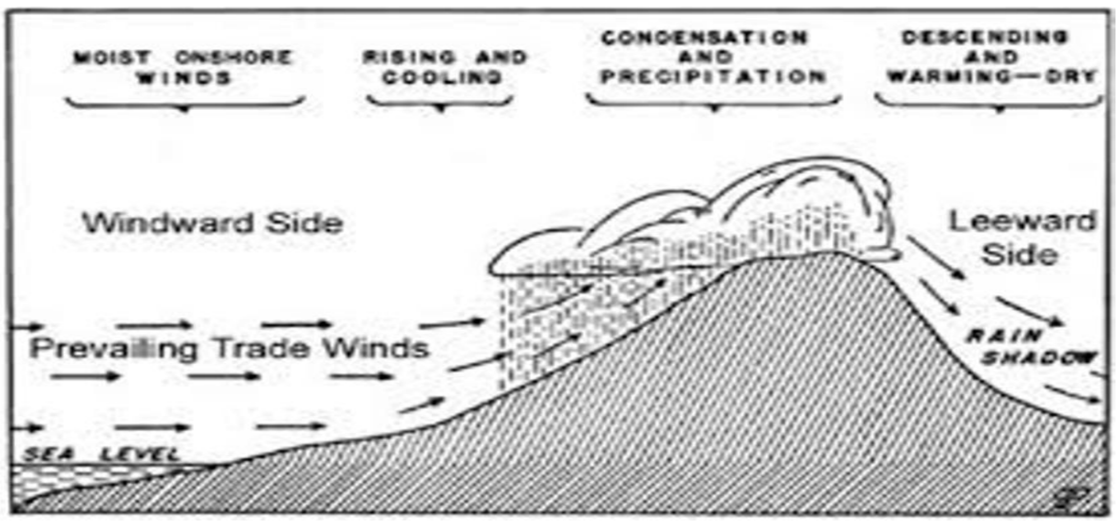


Figure: 2.3 Orographic Rain fall

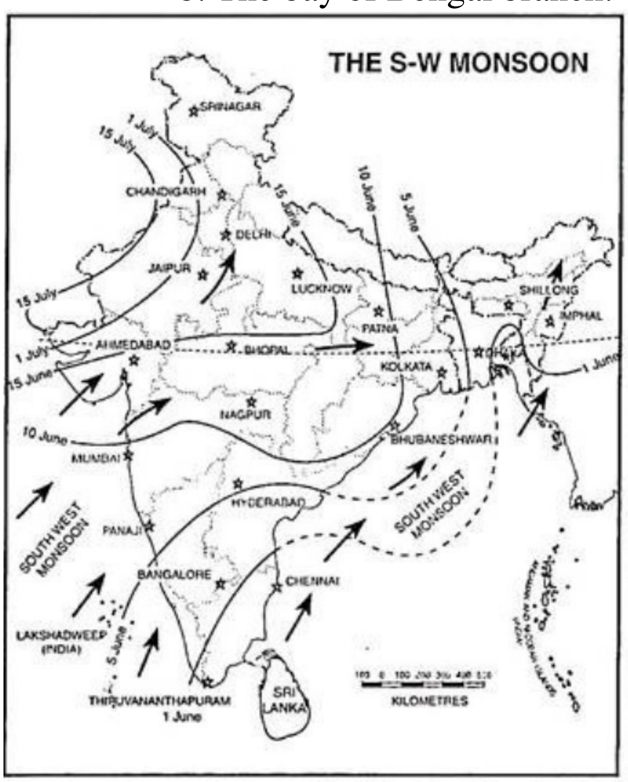
MONSOONS

The term monsoon is derived from an Arabic word "Mausim" means "Season". Of the different concepts that explain Indian monsoons, the "Thermal concept" proposed by Halley in 1636 is of more practical relevance than other concepts like aerological. Flohins etc. The two types of distinguished monsoons over India are

1. South-West monsoon (SW)
2. North-East monsoon (NE)

1. South-West monsoon (SW)

1. In summer the land mass of India heats quickly and develops a strong low pressure centre, particularly over north-west India during April and it exists upto September.
2. As the pressure over the adjacent oceans is high,a sea to land pressure gradient is established.
3. Therefore, the surface air flow is from the high pressure areas over the oceans towards the low pressure areas over the heated land.
4. Eventhough India should have North east monsoon winds throughout the year due to its position in NE trade wind zone the SW winds predominate because of the low pressure through lesing along Ganges and upper India.
5. The air that is attracted into the centres of low pressure from over the oceans is “Warm and moist”.
6. This monsoon is active from June to September.
7. The rainfall received is 80 to 90 per cent of the total annual rainfall of India covering all parts.
8. This monsoon enters Kerala on June and by 15 July reaches the northern most parts of the country.
9. There are two branches of the South West Monsoon.
   a. The Arabian Sea Branch: This branch crosses Western ghats.
   b. The bay of Bengal branch: This branch crosses Gangetic plains.



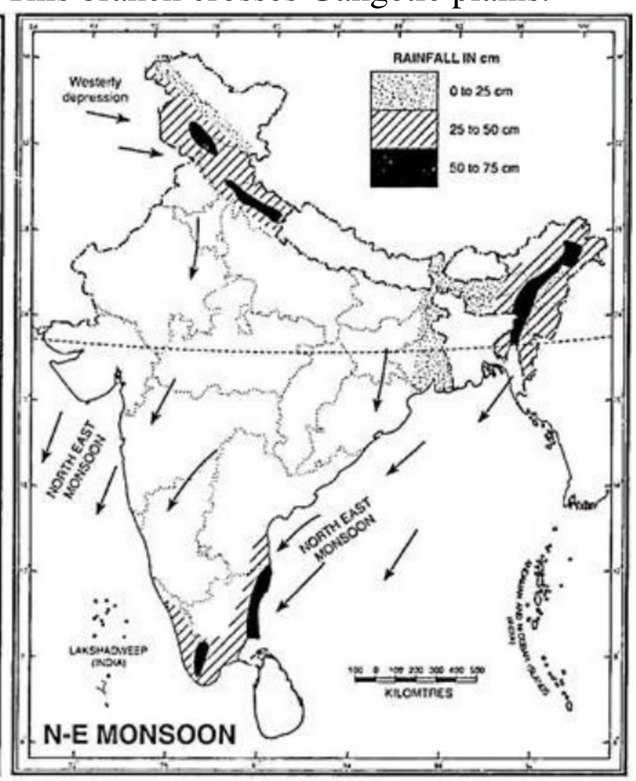


Figure: 2.4 Onset of SW & NE Monsoons.

North-East Monsoon

1. A complete reversal of the South west monsoon winds takes place during winter.
2. In this season the land mass over India cools more rapidly that the surrounding oceans.
3. So, a strong high pressure centre develops over the continent.
4. On the other hand, the pressure over the adjacent oceans is relatively lower.
5. As a consequence, the pressure gradient is directed from land to sea and winds flow in North-East direction.
6. Therefore, there is an outflow of air from the continental land mass to the adjacent oceans.
7. The air flow brings "Cold dry" air towards low latitudes.
8. This monsoon is active from October to mid December.
9. The rainfall received is 10 to 20 per cent of the total annual rainfall of India covering parts of Andhra Pradesh (Nellore, Chittore) and Tamil Nadu.
10. The driving mechanisms of monsoon
    - Differential heating of land and ocean masses causes a pressure gradient and wind is driven accordingly.
    - Twist to wind by rotation of earth.
    - Moist process determines strength, vigour, location etc.
11. The path of monsoon air is distributed by diverse features like
    - Earth's rotation
    - Mountain barriers
    - The retarding effect of friction as wind blow over land.

Withdrawal of monsoon

1. The monsoon withdraws from northern India is around mid September while that of South of India Peninsula by is December.

Break and Activeness of monsoon

1. A period of lean rainfall occurs when "Trough" shifts towards foot hills of Himalayas which is known as break in the monsoon over Indian sub-continent.
2. When the "Trough" shifts south of its normal position, monsoon becomes active over India.

Economic importance and influence of monsoon rains on farm operations

1. Nearly 54 per cent of population of the world depends on monsoon for their income.
2. Monsoon rains are considered as life giving rains. Rice or paddy which is a major food crop depends only on rainfall for its yield. If rainfall is not uniformly distributed, it results in huge loss of rice and other crops. Heavy rain during harvesting causes lodging of crop and seed germination, If rainfall does not occur immediately after sowing , it results in germination failure.
3. Distribution of rainfall influence the crop yield considerably.

Example: Paddy and sugarcane require high amount of water as compared to groundnut and castor.

1. Timely and evenly distributed rainfall during the crop growth is more beneficial than heavy rainfall occurring at once.
2. Rainfall of 20mm is necessary to wet the soil upto a depth of 15cm which rainfall helps in decomposition of organic matter and also influences the fertility status of the soil by way of leaching of nutrients.
3. Many farm operations such as, seed bed preparation, sowing intercultivation etc., depend on rainfall.

2.4. Wind

Air in horizontal motion is known as “Wind”.Windsare named by the direction they come from. Windward refers to the direction a wind comes from and leeward is the direction towards which it flows. The wind which flows more frequently from one direction than any other is called as “Prevailing wind”.

Importance of wind on crop plants

1. Transports heat in either sensible or latent form, from lower to higher latitudes.
2. Provides the moisture (to the land masses) which is necessary for precipitation.
3. Moderate turbulence promotes the consumption of carbon – dioxide by photosynthesis.
4. Wind prevents frost by distrupting a temperature inversion.
5. Wind dispersal of pollen and seeds is natural and necessary for certain agricultural crops, natural vegetation, etc.,

Action of wind on soil:

Wind causes soil erosion in two ways

a. Strong wind flows loose and course soil particles (sand) and dust for long distances. In some areas all the soil is blown by this way, and no cultivation is possible in such areas.
b. In dry countries and sea shores, strong wind is seen to eat up a cliff or a

hard rock. When strong wind armed with millions of small particles of sand flows against a cliff or a hard rock, it gradually eats it up. The action is strongest near the ground so that the rock is undercut and eventually falls over.

Solar Radiation

Solar radiation is the primary source of energy on earth, and life depends on it. Solar radiation is defined as "The flux of radiant energy from the sun". Temperature above the absolute zero, imparts energy to the surrounding space. This energy is transformed by green plants in the process of photosynthesis into the potential energy of organic material. In inorganic bodies the rays absorbed are used in heating.

The variations of the total radiation flux from one site to another on the surface of the earth are enormous and the distribution of plants and animals responds to this variation.

Solar radiation transmitted by the following three processes.

1. Radiation

This is the process of transmission of energy from one body to another without the aid of a material medium (solid, liquid, or gas).
Example: The energy transmission through space from the sun to the earth.

2. Conduction

This is the process of heat transfer through matter without the actual movement of molecules of the substances or matter. Heat flows from the warm to cool part of the body so that the temperature between are equalized.

Example: The energy transmission through an iron rod which is made warmer at one end.

3. Convection

This is the process of transmission of heat through actual movement of molecules of the medium.

Example: Boiling of water in a beaker

Of the above three processes of transmission of energy convection is the predominant form of transmission of energy on the earth.

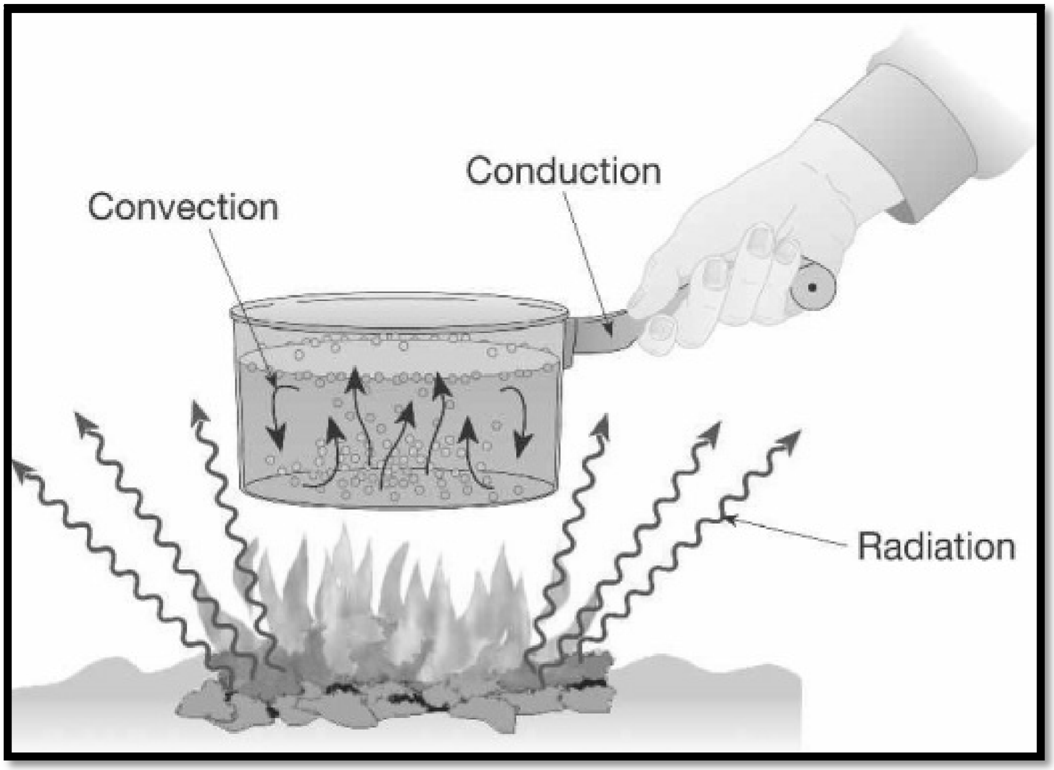


Figure: 2.5 Conduction, Convection and Radiation.

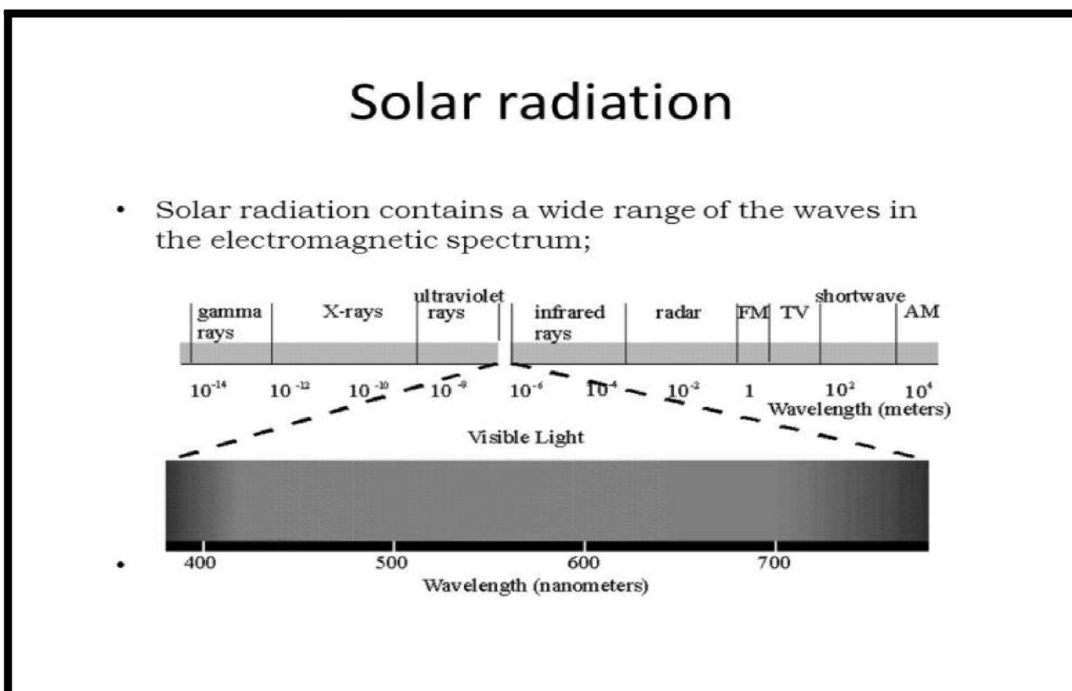


Figure: 2.6 Solar Radiation

Table:2.2Comparison of conduction, convection and radiation.

Conduction	Convection	Radiation
Medium is necessary for transfer of heat by conduction.	Medium is necessary for transfer of heat by convection.	No medium is required for transfer of heat by radiation.
Conduction is not possible in vacuum.	Convection is not possible in vacuum.	Radiation is possible in vacuum.
The molecules of the medium do not leave their mean positions. They transfer heat by vibrating about their mean position.	The molecules of the medium leave their mean positions and move upward direction carrying heat from the source.	The medium remains unaffected.
The transfer of heat can be in any direction.	The transfer of heat is in vertically upward direction.	Transfer of heat is in all direction along a straight path.
The process is slow.	The process is faster than the conduction.	The process is the fastest and transfer of heat takes place with the speed of light, i.e. 3×10^{8} m s^{-1}.

4. Solar Radiation

The radiation transmitted from the sun is known as solar radiation.

Solar spectrum

Radiant energy is transmitted in the form of electromagnetic waves by the sun. The energy from the sun is spread over a very broad band of wave lengths known as solar spectrum. It is also known as electromagnetic spectrum. The spectrum does not constitute only one band, but a combination of different waves which are characterized individually. Example: U.V.rays, light part. near I.R. Radio weaves, Micro waves, radar waves, etc

Table: 2.3 Energy content of different bands in solar spectrum.

Sl No.	Spectrum	Wave length in microns	Percentage of energy
1.	Gamma r-rays frays & x-rays	0.005-0.20	9 %
2.	U.V rays	0.2-0.4	
3.	Violet	0.4-0.43	
4.	Blue	0.43-0.49	
5.	Green	0.49-0.53	
6.	Yellow	0.53-0.58	41 %
7.	Orange	0.58-0.66	
8.	Red	0.63-0.7.	
9.	Infrared rays	>0.70	50 %

Different bands of solar spectrum are:

1. The shorter wave lengths of the spectrum are known as U.V. rays. These are chemically very active. Unless these are filtered in the atmosphere, there is a danger for life on the earth. This band ranges between 0.005 to 0.4 microns.

2. The part of the spectrum which is visible is known as 'light'. It is the part of the spectrum which is essential for all the plant processes and ranges from 0.4 to 0.7 microns.

3. The third part of the solar spectrum (last band) is known as infra red band this is essential for thermal energy of the plant (the source of heat to the plant) This band is less than 0.7 microns.

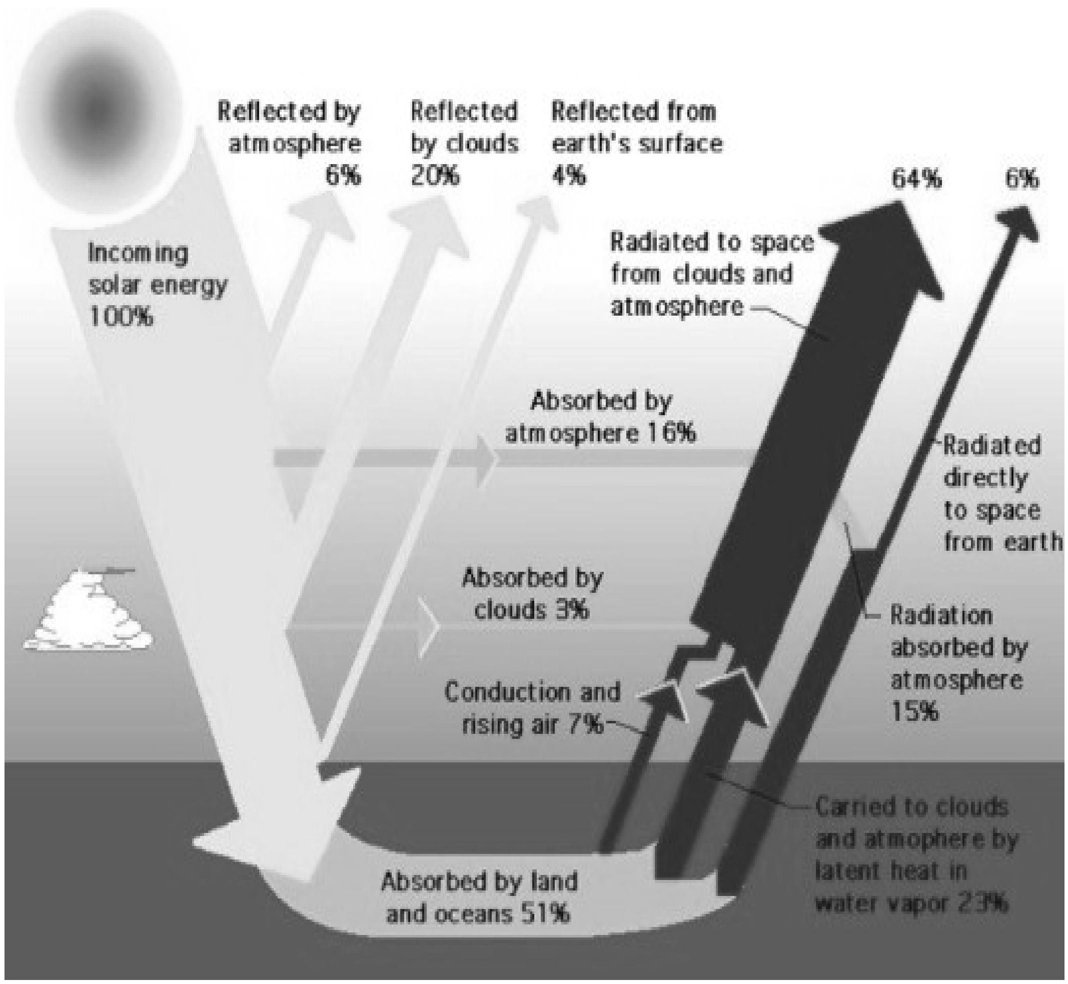


Figure: 2.7 Solar Radiation Distribution.

Functions of light

The functions of light are:

1. All the plant parts are directly or indirectly influenced by light.
2. Light of correct intensity, quality and duration is essential to normal plant development.
3. Poor light availability cause abnormalities and disorders in plants.
4. Light is indispensable to photosynthesis
5. Light governs the distribution of photosynthates among different organs of plants.
6. Effects tiller production.
7. Effects stability, strength and length of culms.
8. Effects dry matter production.
9. Effects the size of the leaves.
10. Effects the root development.
11. Effects the flowering and fruiting.
12. Effects the dormancy of the seed.

Temperature

Temperature is defined as "The measure of speed per molecule of all the "molecules of a body" where as heat is " The energy arising from random motion of all the molecules of a body".

The temperature of a body is the condition which determines its ability to transfer heat to other bodies or to receive heat from them. In a system of two bodies the one which looses heat to the other is said to be at a higher temperature.

Heat measures total molecular energy. Temperature measures average energy of individual molecules. Temperature is that characteristic of a body which determines the direction of heat flow by conduction.

Air Temperature

Temperature Distribution

1. Each day the earth receives energy in the form of incoming solar radiation from the sun.
2. This shortwave solar radiation ranges mostly from ultra-violet (0.2um wavelength) to the near infrared (3.0 microns wavelength), nut reaches its maximum at around 0.5 microns wavelength (Blue-green visible light).
3. This insolation is absorbed by the earth's surface and is converted to heat (long wave radiation)

4. The earth's (terrestrial) longwave radiation reaches its peak intensity at 10 microns wavelength (Thermal infrared) and is responsible for heating the lower atmosphere.

Horizontal Temperature Distribution

Sun rays make different angles at the same place as the different times. Also different angles at the same time at different places as the axis of the earth makes an angle of 23-50 with the vertical. Due to the variation in angle of suns rays distribution of solar heat on earth decrease both ways from equator to polar. This is known as horizontal distribution of the air temperature.

On maps, the horizontal distribution of temperature is shown by isotherms, which are imaginary lines drawn connecting points that have equal temperature.

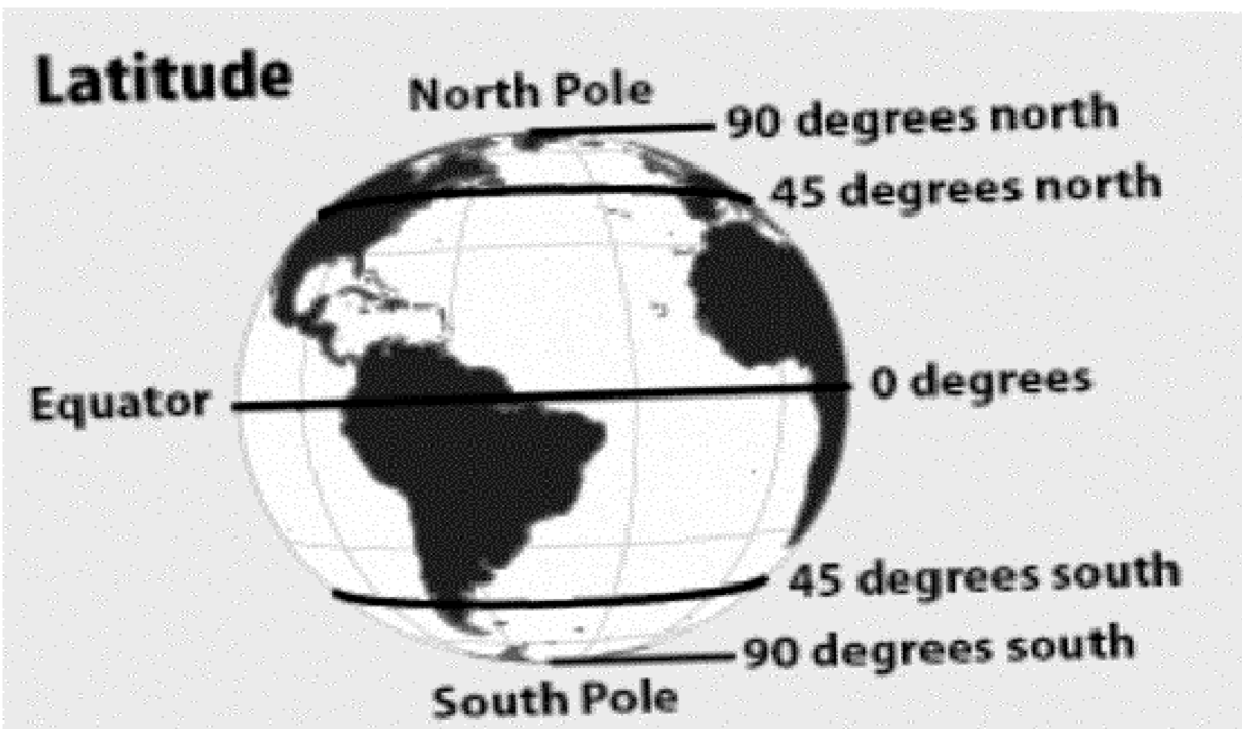


Figure: 2.8 Temperature at different parts of the globe.

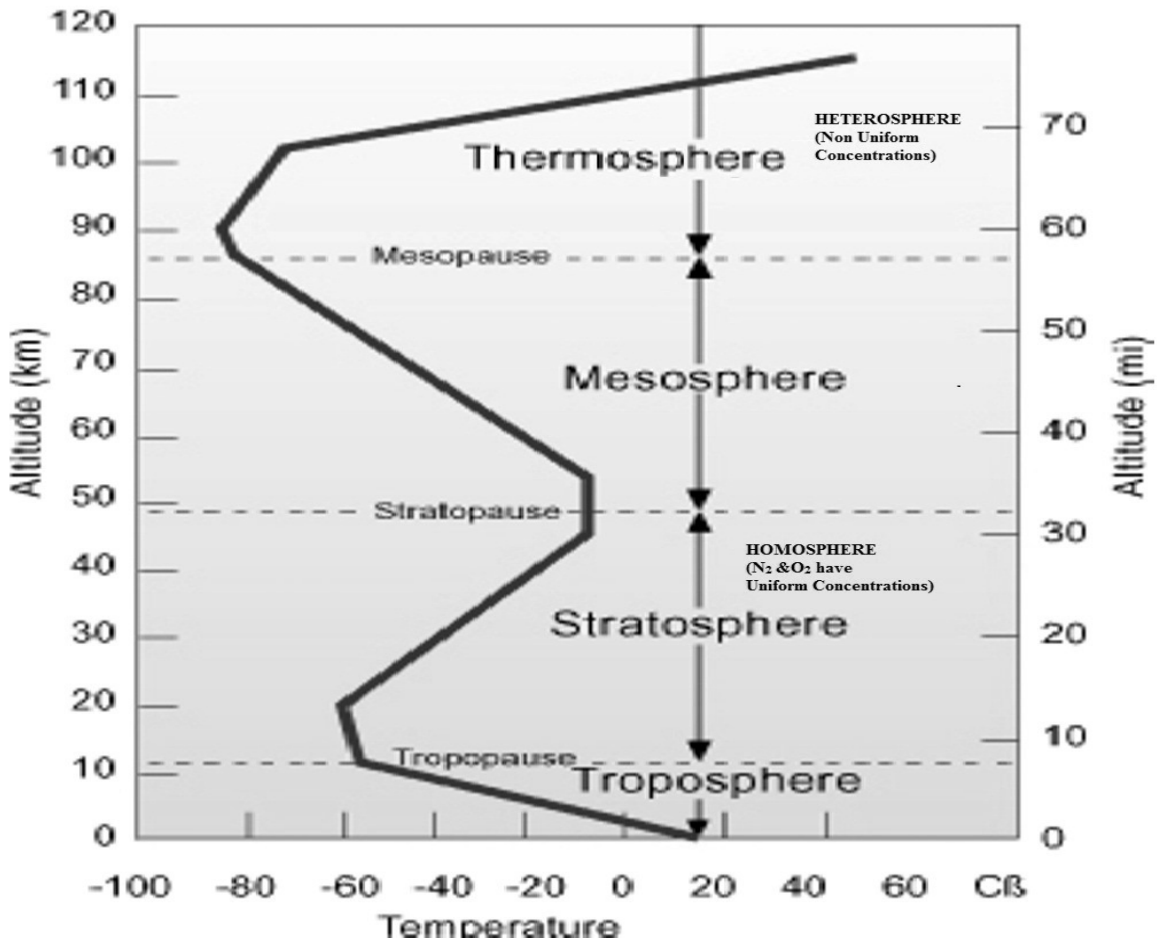


Figure: 2.9 Temperature changes with altitude.

Cardinal temperature for different crops

Sl No	Crop	Min. Cardinal Temp. ºC	Opt. Cardinal Temp. ºC	Max. Cardinal Temp. ºC
1.	Wheat and Barley	0-5	25-31	31-37
2.	Sorghum	15-18	31-36	40-42

Importance of air temperature on crop plants

1. Temperature influences distribution of crop plants and vegetation. In Western Himalayas the temperature falls as altitude increases and this change is responsible for the change of vegetation at different altitudes.
2. The growth and development of crop plants are chiefly influenced by air temperature.

3. Affects leaf production, expansion and flowering.
4. Physical and chemical processes within the plant are governed by air temperature
5. The diffusion rate of gases and liquids change with temperature
6. Solubility of different substances is dependent on temperature
7. Influences biochemical reactions in crops (double or triple with each 10 ºC rise).
8. Equilibrium of various systems and compounds is a function of temperature
9. Temperature effects the stability of enzymatic system in plants.

Soil temperature

- Factors affecting soil temperature
- Heat at ground surface is propagated downward in the form of waves. The amplitude deceases with depth.
- Both meterological and soil factors contribute in bringing about changes of soil temperature.

I Meteorological Factors.

1. Solar radiation:

a. The amout of solar radiation available at any given location and point of time is directly proportional to soil temperature.

b. Even though a part of total net radiation available is utilised to evapotranspiration and heat in the air by re-radiation (latent heat and sensible heat fluxes) a relatively substantial amount of solar radiations utilized in heating up of soil (ground heat flux) depending up on nature of surface.

c. Radiation from the sky contributes a large amount of heat to the surface ares where the sun's rays have to penetrate the earth's atmosphere very obliquely.

2. Wind

Wind is necessary to heat up the soil by conduction from the atmosphere. Example: The moutain and valley winds influence the soil temperature**.**

3. Evaporation and condensation

a. The greater the rate of evaporation the more the soil is cooled. This is the reason for coolness of moist soil inwindy conditions.

b. On the other hand, wheneverwater vapour from the atmosphere or other soil depths condenses in the soil it heats up noticeably. Freezing of water generates heat.

4. Rain fall (Precipitation)

Depending on its temperature precipitation can either cool or warm.

II. Soil Factors

1. Aspect and Slope

(a) In the middle and high latitudes of the nothern hemisphere the southern slopes receive more insolation per unit area than the northern exposes.

(b) The south west slopes are usually warmer than the south east slopes reason is that the direct beam of sunshine on the southeast slope occurs shortly after prolonged cooling at night, but the evaporation dew in the morning also requires energy.

2. Soil Texture

a. Because of lower heat capacity, poor thermal conductivity sandy soils warmup more rapidly than clay soils. The energy received by it, is concerntrated mainly in a thin layer resulting in extraordinary rise in temperature.

b. Radiational cooling at night is greater in light soils than in heavy soils. In the top layer, sand has the greatest temperature range, followed by loam and clay.

c. The decreaseof range with depth is more rapid in light sols than heavy soils when they are dry, but slower whe they are wet.

d. Soils with rough surface absorbs more solar radiation than one with a smooth surface.

3. Tillage and tilth

a. By loosening the top soil and creating a mulch, tillage reduces the heat flow between the surface and subsoil.

b. Since, the soil mulch has a greater exposed surface, than the undistrubed soil and no capillary connection withmoist layers below, the cultivated soil dries up quickly by evaporation.

d. The diurnal temperture wave of the cultivated soil has a much larger amplitude than that of uncultivated.

e. The air 2-3 cm above the tilled soil is often hotter (10^0 C or above) than that over an untilled soil.

f. At night loosened ground is colder and more liable to frost than the uncultivated soil.

4. Organic Matter

a. The addition of organic matter to a soil reduces the heat capacity and thermal conductivity. But the water holding lcapacity increases.
b. The absorptivity of the soil increases because of the dard colour of the organic matter.
c. At night, the rapid flow of heat from sub soil by radiation is reduced with the addition of organic matter because of its low thermal conductivity.
d. The darker the colour, the smaller the fraction of reflected the incoming radiation.
e. Dard soils moist soils reflect lessthan light coloured and dry soils.

5. Soil Moisture

a. Moisture has an effect on heat capacity and heat conductivity.
b. Moisture at thesoil surface cools the soil through evaporation.
c. A moist soil will not heat up as mch as a dry one.
d. Moist soil is more uniform in temperature throughout its depth as it is better conductor of heat than dry soil.

Atmospheric Pressure

Atmospheric pressure is defined as "The pressure exerted by a column of air with a cross sectional area of a given unit i.e., a square inch or a square centimeter extending from the earth surface to the upper most boundary of the atmosphere".

Standard Atmospheric Pressure

The atmospheric pressure varies continuously over a relatively small range and the average of these fluctuationsl is very close to a value adopted for certain standard conditions defined as " Standard atmosphere". At a temperature of 15^{o}C and at 45^{0} latitude the standard normal pressure is * 1013.2 millibars which is equivalent to 29.92 inches (or) 760 mm of mircury at the sea level, which is considered as standard atmospheric pressure.

Humidity

Expression or Measures of humidity

A. Mass and Volume based measures

Specific humidity

It is defined as the ratio of the mass of water vapour in a sample of moist air to the total mass of the sample. It is expressed as kg of water vapour in a kg of moist air.

Absolute humidity

It is the ratio of the mass of water vapour to the volume of moist air which it is contained. Absolute humidity is expressed as kg m^{-1}.

Mixing ratio

It is the ratio of the mass of water vapour contained in a sample of moist air in the mass of dry air. It is expressed as kg water vapour per kg dry air.

B. Saturation based measure

Relative humidity

It is expressed as the ration of actual vapour pressure to the saturated pressure expressed in terms of percentage. It is most common measure of atmospheric humidity.

Vapour pressure deficit

It is another measure of moisture in the atmosphere. It is the difference between the saturated vapour pressure and actual vapour pressure.

Dew point

It is defined as the temperature to which a given parcel of air must be cooled at constant pressure and constant water vapour content in order to become saturated.

Effects of Humidity on crops

Humidity is an important factor in crop production and it is not an independent factor but closely related to rainfall and temperature. It plays significant role in weather and climate. The dampness of air is called humidity.

a. Humidity is the invisible vapour content of the air and is of great importance in determining the vegetation of a region.
b. It affects the internal water potential of plants.
c. Humidity is a major determinant of potential evapotranspiration so, it determines the water requirement of crops.
d. It influences certain physiological phenomena including transpiration.
e. Change in relative humidity can produce various morphological and anatomical changes in the plants. For example, orchids grow abundantly in humid forests as epiphytes depend for their moisture supply on the atmosphere by developing certain morphological and anatomical characteristics that are not found in other plants (Hydroscopic aerial roots).

f. Xerophytes in desert region where relative humidity is low show certain adaptations to conserve water.

g. High relative humidity can prolong the survival of crops under moisture stress.

h. Relative humidity plays a significant role in the outbreak of disease and pest epidermics. High humidity promotes the growth of some saprophytic and parasitic fungi and bacteria which cause various plant diseases.

i. Very high or very low relative humidity is not conductive of higher yields.

Evaporation

The sum is the source of energy that activates the hydrologic cycle i.e., the heat required for ecaporation is supplied by the sun. The moisture in the atmosphere is supplied by evaporation.

Evaporation is defined as "A physical process in which liquid water is converted into its vapour"

In this process molecules of water having sufficient kinetic energy to overcome the attractive forces tending to hold them within the body of liquid water are projected through the water surfaces.

Factors affecting the Evaporation

Several factors determine the evaporation losses from a fully exposed water surface.

I Environmental factors

1. Water temperature

With an increase of temperature the kinetic energy, of water molecules increases and surface tension decreases. So,the rate of evaporation increases with a rise in temperature. The maximum amount of water vapour that can exist in any given space is a function of temperature.

2. Wind

The velocity of wind is directly proportional to evaporation from a fully exposed surface and vice versa. The reason is that the dry wind replaces the moist air near the water. The process of evaporation takes place continuously when there is a supply of energy to provide latent heat of evaporation (approximately 540 calories per gram of water evaporated at 100°C).

3. Relative humidity

A mechanism to remove the vapour so that the vapour pressure of the water vapour in the moist layer adjacent the liquid surface is less than the saturated vapour pressure of the liquid i.e., a vertical gradient of vapour pressure exist above the surface.

When the air above water is dry or has low relative humidity, the evaporation will be greater than air has relative humidity over the water.

4. Pressure

The evaporation is more at low pressure and vice versa.

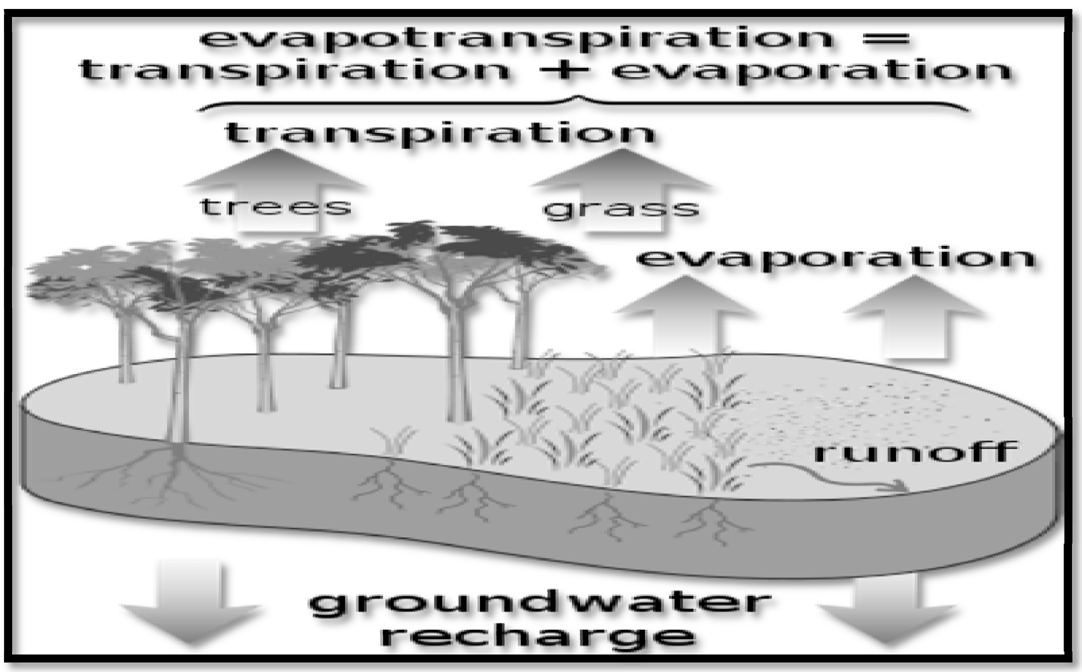


Figure: 2.10 Various Water Losses.

II. Water factors

1. Composition of water

The dissolved salts and other impurities decrease the rate of evaporation. Evaporation in inversely proportional to the salinity of water. The rate of evaporation from the surface of the sea is less than that of fresh water in rivers. under equivalent conditions ocean water evaporates 5 per cent less than fresh water in rivers.

2. Area of evaporation

If two volumes of water are equal in two containers, evaporation will be greater for the one having the larger exposed surface.

Transpiration

Transpiration is defined as "The loss of water from living parts of the plant" there are 3 kinds of transpiration.

Factors affecting the transpiration

I Environmental Factors

1. **Light:** Light plays predominant role in transpiration both directly and indirectly. The direct effect of light in on the opening and closing of stomata. The indirect effect of light is that the increasing light intensity raises the temperature of leaf cells. This increases the rate at which liquid water is transformed into vapour.
2. **Atmosphere humidity:** The rate of transpiration is almost inversely proportional to atmospheric humidity. The rate of transpiration is greatly reduced when the atmosphere is very humid. However, as the air becomes dry, the rate of transpiration also increases proportionately.
3. **Air temperature:** Increase in the temperature results in opening of stomata. Temperature has significant effect on the permeability of the wall of the guard cells and therefore greatly effects the osmatic phenomenon. This phenomenon is responsible for the movement of guard cells.
4. **Wind velocity:** The velocity of wind affects the rate of transpiration to a greater extent. Fast moving wind and air currents bring fresh and dry masses of air in contact with leaf surfaces. So, higher the wind speed higher the transpiration.

II Plant Factors

Some plants adopt physiological modifications to check the excess transpiration. Some other plants modify their structure for this purpose, thereby withstand drought. Such characters greatly effect the transpiration.

1. Plant height: The water need of a crop varies with its height. In general, the rate of transpiration of a tall crop will be more (around 50%) than when the crop is cut or clipped to half.
2. Leaf characteristics: In some plants like cacti and other desert plants leaves are altogether absent and their function taken up by the stem itself. In case of pines, Firs etc., the leaf size is very much reduced. In such cases reduction in leaf area brings about reduction in transpiration. Some graminaceae family plants (Maize), Flower plants etc., roll up or turn the edges of their leaves when exposed to bright sun and fast breeze. This causes reduction in the transpiration.
3. Availability of water in the plant: If there is little in the soil, the tendency for dehydration of leaf causes stomatal closure and a consequent fall in transpiration. This situation occurs during a) periods of drought b) when the soil is frozen and c) at a temperature so low that water is not absorbed by roots.

2.5 Drought

1. Drought is explained by the following ways.

a) The condition under which crops fail to mature because of insufficient supply of water through rains.

b) The situation is which the amount of water required for transpiration and evaporation by crop plants in a defined area exceeds the amount of available moisture in the soil.

c) A Situation of no precipitation in a rainy season for more than 15 days continuously.

2 The other causes contributing to the drought condition are:

a) Defective tillage of soil.

b) Failure to store rain water.

c) Lack of technology to retain the soil moisture.

d) High seed rate and thick plant population.

3 The effects of drought are:

a) Depletion of soil moisture and reduction in ground water table.

b) Reduction of output and turnover in industry, agriculture and thereby total economy of the nation.

4. Classification of drought

Droughts are broadly divided into 3 categories.

Meteorological drought: If annual rainfall is significantly short of certain level (75 per cent) of the climatologically expected normal rainfall over a wide area, then the situation is called by this term. In every state each region receives certain amount of normal rainfall. This is the basis for planning the cropping pattern of that region or area.

Hydrological drought : This is a situation is which the hydrological resources like streams, rivers, reservoirs, lakes, wells etc., dry up because of marked depletion of surface water. The ground water table also depletes. The industry, power generation and other income generating major sources are affected. If meteorological drought is significantly prolonged, the hydrological drought sets in.

Agricultural drought: This is a situation which is a result of inadequate rainfall. Because of this,the soil moisture falls short to meet the demands of the crop during its growth. Since the soil moisture vailable to a crop is insufficient, it affects growth and finally results in the reduction of yield.

Some scientists consider the above classification only as a part of the total classification. The classificationl based on ‘medium’ and also ‘temporal’ are in vogue, in addition lto the information mentioned above.

Droughts and Their Influence on Crop Plants

The influence of drought can be observed not only on phenologybut also on phenophases of crop plants.

1. From seedling to ripening stage the water influence the crops particularly in case of cereals after the leaves are emerged from coleoptile. The influence of drought is more pronounced at the time of maturity.
2. During flowering stage, any little stress of moisture by virtue of droghtsubstantially reduces the size of inflorescence thereby affecting the final yield.
3. In the same way fertilization and grain filling are also markedly influenced and the final yield is substantially reduced.

4. When soil moisture stress increases, it limitsl water supply to all the plant parts, which result inl wilting.
5. If drought occurs at the time of grain filling, it reslts in the decrease of yield considerably.
6. Cell division and enlargment are very sensitive to drought stress. During moisture stress cell enlargement is affected and is the primary cause of stunted growth plants under field conditions.
7. Drought also affects nutrients absorption, carbohydrate and protein metabolism and translocation of ions and metabolities.
8. Protein breakdown infures the drought stressed plant due to the accumulation of toxic products of protein breakdown such as ammonia, rather than due to a protein deficiency.
9. Abscission of leaves, fruits andseeds can be induced by plant water deficit during droughts.
10. Plant respiration is drastically reduced.

Management Practices at the Time of Drought.

1. Modification of microclimate by use of schelter-belts and artificial barriers to reduce evapotransiration and wind movement.
2. Maintaining optimum plant population.
3. Best possible seed-bed preparation to hold and absorb maximum moisture and better weed management.
4. Tillage practices to minimise runoff and evapotranspiration.
5. Crops that evade or endure periods of drought shall be sown.
6. Drought tolerant crops for which row spacing can be increased without affecting the final yield can be identified and practiced.
7. The dates of sowing shall be adjusted such that, the reproductive stage of the crop shall not pass through the drought, in addition to other stages for critical crop growth.
8. Effective control of pests and diseases and use of recommended doses of fertilizers.
9. Correcting nutrient deficiencies and use of recommended doses of fertilizers.
10. Application of antitranspirants and use of mulches will reduce evapotranspiration.
11. Application irrigation at appropriate stages of crop growth.
12. Weed control by keeping the land fallow has an added effect in conserving the moisture.

13. Ploughing of range lands with heavy disks or similar equipment to make a more rapid and complete infiltration.
14. Shaping of land so that the water stays where it falls or runoff from a slope to irrigate a level bench below the slope.

2.6 Weather Forecasting

Weather Forecasting

The weather elements which influence the agricultural operations and crop production can be forecast upto different spans of time. Weather forecast is defined as “prediction of weather for the next few days to follow”

Synoptic Reports

For better crop management under adverse weather conditions synoptic climatology play an important role.

The term synoptic climatology is applied to investigations of regional weather and circulation types. It is also used to refer to any climatological analysis which makes some reference to synoptic weather phenomena. This field is concerned with obtaining an insight into local or regional climates by examining the relationship of weather elements individually or collectively to atmospheric circulation processes.

Synoptic climatology is defined as “The description and analysis of the totality of weather at a single place or over a small area, in terms of the properties and motion of the atmosphere over and around the place or area”.

There are essentially two stages to a synoptic climatological study.

1. The termination of categories of atmospheric climatoloical study.
2. The assessment of weather elements in relation to these categories.

Besides agricultural meteorological observatories, synoptic weather stations also record weather data such as rainfall, temperature, radiation, low level wind, evaporation etc., The surface observatories collect information on various weather elements and based on these recordings daily forecasts, warnings and weather reports are prepared by 5 regional forecasting centres at Chennai, Nagpur, Mumbai, Delhi and Kolkata. The weather bulletins are being broadcast in regional languages through All India Radio and Television.

Synoptic reports

Observed weather conditions are marked in brief coded form as a synopsis of the conditions. Such a brief report on weather conditions is known as “Synoptic report”.

Synoptic chart / weather map

The regular observatories record weather elements at scheduled time and send these readings through a telegram to the main observatory at Pune. They reach Pune within an hour of observation and they are charted on outline map of India, using the international code of signals and abbreviations. These are called “Synoptic charts or weather maps”.

In synoptic charts different weather phenomena and atmospheric characters are marked with different symbols as mentioned below:

Table: 2.4. Character of symbols used in synoptic charts

S.No.	Symbols	Weather element / Character / Phenomenon
1.	Narrow black lines	Isobars
2.	Numbers at ends of isobars	Pressure values in millibars.
3.	Shading	Precipitation
4.	Arrows	Wind direction
5.	Feathers in the arrows	Wind velocity
6.	Small circles with shading	Amount of Clouds

In addition to the above, different symbols are used for recording weather phenomena, in relevant columns of the pocket register and the monthly meteorological register by the observer.

The duties of the observer: The routine duties of the observer include:

1. To make regular and careful observations and to note the general character of the weather and record in the pocket register.
2. To prepare and dispatch the weather telegram as per the instructions to the different forecasting centres, immediately after the observations are taken.
3. To send heavy rainfall telegrams to the various offices on warning list.
4. To prepare and post monthly meteorological and pocket registers for each month to the controlling meteorological office.
5. To keep the instruments clean and maintain them properly.

After the observer sends the data as per the standard procedure it should be decoded and the weather observations for each station must be plotted at the appropriate location in a systematic manner following the international station model. Only weather maps in first class forecasting centres approach the completeness of this model. Printed maps and maps used for plotting usually have an appropriately numbered circle corresponding to each reporting land station and observations are plotted about this location in the appropriate position regardless of the number of observations shown. The weather pattern affecting a locality is an integral part of the much larger hemispheric weather pattern and it is necessary plot a map over a large area. Even if observations are not to be plotted, it is necessary to know the plotting scheme in order to read and interpret weather charts already plotted.

Utility of weather forecasts

In India the total annual pre harvest losses of various crops range from 110 to 100 percent. Similarly, the post harvest losses average up 10 percent.

- Short term adjustments in daily and weekly agricultural operations. If heavy rain occurs immediately after sowing of seeds the seeds are washed away. If a hail storm occurs during harvesting it causes shedding of grains land fruits. If warned in time the farmer would hurry up some of the operations or postpone them suitable adjusting the cropping operations to weather conditions.
- Minimizing input losses resulting from adverse weather (seeds, chemicals, fertilizers, diesel or electric power used for irrigation etc.,) The critical periods for normal growth of the crop can be adjusted for healthy growth and development of crop.
- Markedly improve the yields of crops both qualitatively and quantitatively. The yield of the crop is determined by weather conditions to a greater extent, seeds, chemicals fertilizers etc., If weather is predicted in advance the amount spent on irrigation, electricity, labour can be reduced substantially. Nearly, 50 percent of farmers will definitely be benefited if warnings are given well in advance to them.

If farmer knows when the monsoon rains are likely to commence and how the rainfall cold be from time to time in the season he would be able to plan his agricultural operations like preparation of seed bed, manuring, intercultivation including drying and threshing of the produce.

Prime requirements for weather forecasting

1. A good data set.
2. A good method which can be used to forecast.

Weather data used in forecasting

The following weather elements are measured routinely.

1. Pressure, temperature, wind (speed and direction) and humidity.

2. Rainfall, cloud (type and amount), visibility pressure change, present and past weather, maximum and minimum temperatures etc.

Types of observations

The main observations used in different weather forecasting types are as follows:
1. Surface observations
2. Upper air observations
3. Aircraft observations
4. Radar observations

Different types of weather forecast

There are three types of weather forecast

Table: 2.5 Types of weather forecast and their validity

Sl. No.	Type of forecast	Validity period	Main users	Predictions
1	Short range a.Now casting b. Very short range	Upto 72 hours 0-2 hours 0.12 hours	Farmers, marine agencies, General public etc.	Rainfall distribution, heavy rainfall, heat and cold wave conditions, thunder storms etc.
2	Medium range	Beyond 3 days and upto 10 days	Farmers	Occurrence of rainfall, temperature intensity etc.
3	Long range	Beyond 10 days; a few weeks to a month; season	Planners	This forecast is provided for Indian monsoon rainfall. The out looks are usually expressed in the form of expected deviation from normal conditions

Methods used in Weather Prediction

Three methods are used for accurate weather prediction.

1. **Synoptic method**

This is a subjective technique. In this method weather charts are analysed and the analogous situations happened in the past are matched with present situation. This method is useful for present situation. This method is useful also for short range forecast. The success of the forecast depends on the skill and experience of the fore-caster.

2. **Statistical methods**

In this method correlations and regressions are calculated using weather elements. This method is useful for long range weather forecast.

3. **Numerical methods**

This is basically an objective technique, Several equation are solved numerically sing high speed and large memory computers. This method is useful for short and medium range forecasts.

Agromet Advisories

1. The IMD has established agromet advisory service units (AASUs) at the meteorological offices of the state head quarters. These AASUs issue bitweekly agromet advisories to the states. First, the condition of the crops in the state and then advisory on the farming operations, based on the past weather/ likely future weather realized is provided. The rainfall forecasts valid for the next two days and the out look valid for Two subsequent days is also given. Assistance for the agricultural related aspects is taken from the state agricultural universities and agricultural departments.
2. The agromet advisories are sent to the “Farm Radio” division of all India radio stations through land line telegrams and are broadcast in the farm radio programmers of respective states. A separate pictorial presentation of spatial rainfall distribution over the state is sent to doordarshan for telecasting in the respective states.
3. The advisories are also sent through fax to the agromet Directorate of IMD, Pune on the same day, Where all the advisories sent the various AASUs are assembled and then a consolidated report is prepared. This report is faxed from IMD Pune to IMD Delhi on subsequent day and is used for ministerial/ secretarial briefing.

2.7 Weather hazards and their mitigation

The state is prone to droughts, cyclones, floods and heat waves. One or the other extreme event hits the state affecting the economy. The frequent occurrence of such events may be linked to the adverse impacts of climate change.

Droughts

Andhra Pradesh has historically been one of the most severely drought affected states in India. Out of the 13 districts of Andhra Pradesh, 5 are the worst affected by drought. Four

districts of Rayalaseema (Anantapur, Chittoor, Kadapa and Kurnool), and one district of costal Andhra (prakasam) are most drought prone. Four dry land crops (Jowar, maize, groundnut and sunflower) and one water-intensive crop (rice) are mainly affected owing to drought in these districts. The drought conditions normally occur due to failure of south west mansoon, delay in arrival, break mansoon conditions or early cessation of SW Mansoon. The state has experienced 20 times drought in 40 years, 10 times drought in 20 years, 5 times drought in 10 years and 3 times drought in last 5 years. The major drought years in the recent decade are 1997, 2001, 2002 & 2004, 2002-03 2015-16 has been the worst years of drought. Over 300 million people spread over 18 States were affected by drought along with around 150 million cattle. Food grains production registered an unprecedented steep fall of 29 million tones. In 2009, the overall rainfall deficiency for the country as a whole was 22%, which resulted in decrease of food grain production by 16 million tones. During 2014-15 and 2015-16 large parts of the country were affected by drought causing widespread hardships to the affected population since the calamity encompassed major agricultural States in the country.
(Manual for Drought Management 2016, Govt., of India.)

Cyclones

The state of Andhra Pradesh has a vast coast line of 972 km and it is cyclone prone zone as shown in wind and cyclone hazard map. The districts normally affected by the cyclones are East Godavari, West Godavari, Krishna, Guntur, Prakasham, Nellore and Srikakulam (Reddy and Sreenivas, 2001). The state experienced 71 cyclones during 1892-1997, each time with colossal damage. Between 1892 to 1977, 56 cyclones affected the seven coastal districts. A moderate to severe intensity cyclones can be expected to make land fall every two to three years. About 44 per cent of the state is vulnerable to tropical storms and related hazards. The Nellore, Krishna and Srikakulam districts had more number of cyclones. In the past two decades, major cyclones caused immense loss to humanlives, agriculture, livestock and massive damage to property viz., November 1977, May 1979, November 1984. The November 1977 cyclone was deadliest. Since, 1977-2008 about 473.45 lakh peopole were affected directly or indirectly due to cyclones and floods, with 15, 889 human deaths, 10.61 lakh live stock loss, 152.54 lakh hectares crop loss at an estimated value of 38,317 crores. Severe Cyclonic Storm Hudhud a strong tropical cyclone that caused extensive damage and loss of life during October 2014. It was classified as a Very Severe Cyclonic Storm by the IMD. Hudhud caused extensive damage to the city of Visakhapatnam and the neighbouring districts of Vizianagaram and Srikakulam of Andhra Pradesh. Damages were estimated to be □21,908 crore by the Andhra state government. At least 124 deaths have been confirmed. By effective agro-advisory mechanism, these losses can be minimized to a large extent, if not totally. Research support from the government to better understand the climate change impacts and evolve suitable management strategies is imperative to address these issues.

Tsunami

Andhra Pradesh has the second largest coast in the country next only to Gujarat State and the longest on the East coast of India. About 11.63 lakh live in 500 villages within a coastal belt

of 5 KMs. These people are the most vulnerable to the ravages of nature, particularly of cyclonic storms and tidal waves. On the morning of 26.12.2004, Tsunami tidal waves ranging from 2 to 6 metres high lashed the Andhra Pradesh coast. The major brunt of the tidal waves was along the coast of Nellore, Prakasam, Guntur, Krishna, East Godavari and West Godavari Districts. Many people on the beaches as well as close to the coast were washed away and otherwise affected. The tidal waters entered the villages along the coast, inundating large number of villages. In all 180 coastal villages with a population of 2,11,670 were affected by this calamity. Overall damages across the state was estimated to be Rs. 317.16 crores. The largest damages was in fisheries, housing and other infrastructure, Agriculture sector also suffered damages but not severe.

Heat waves

Heat waves resulting in abnormally high temperatures not only take their tool on human lives but also affect agriculture. The historical record of heat waves (fig) show that, districts of Guntur, Krishna and Prakasam in South coastal Andhra Pradesh are more prone to heat waves than other parts of the state.

Records of the past 16 years demonstrate a shift in the spatial patterns of heat waves. The incidence of heat waves in coastal area has increased in frequency. About 115 such events are recorded in the coastal areas.Of these events in the coast areas 37% were severe. Therefore, both the frequency of incidence as well as the intensity of the heat waves have increased in the coastal areas in the last one and half decades.

The heat waves in Andhra Pradesh during the year 2003 (May-June), created climatological records. The temperature recorded in various parts of the state ranged from 42°C to 47°C. this spells continued for a record 27 days and caused large scale causalities. Heat wave claimed more than 3000 lives and several hundreds suffered from heat strokes. Orchards of sweet orange, mango, acid lime etc., in an extent over 23,000 hectares dried up due to moisture stress. About 20 lakh poultry birds (worth 27 crores).

2.8 Remote sensing –Definition- Introduction-Applications in Agriculture

Remote Sensing

The word "Remote sensing" was coined by Fischer in 1960 AD. Remote sensing is defined as "Collection and interpretation of information about a target without being in physical contact with it".

According to Lilesand and kiefer, remote sensing is " The science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigatjion".

Basic concept of remote sensing

There are two basic interactions between electromagnetic energy and earth surface feature. These interactions are considered as basic concepts of remote sensing.

1. The propositions of energy reflected, absorbed and transmitted will vary for different earth features, depending on their material type and condition. These differences permit to distinguish different features on an image.

2. Even within a given feature type, the proportion of reflected, absorbed and transmitted energy will vary at different wavelengths.

Approaches for information

Mainly, there are Three approaches to obtain information.

1. Visual interpretation.
2. Digital image processing.
3. Satellites and sensors.

Platforms used in remote sensing

Taking aerial photographs by camera, tracking any object or phenomenon by radar, seeing the object by our eyes or producing satellite images are the examples of remote sensing. Basically, there are three plat forms, used in remote sensing.

1 Ground based remote sensing

If the flat form having sensors is at the ground it is known as ground based remote sensing.

2 Air borne remote sensing

If the platform is upto 100 kilometers height with smaller coverage capability like the aircrafts, balloons or rockets it is called as air borne remote sensing.

A remote sensor can detect variation in reflectance between objects depending upon four interrelated factors.

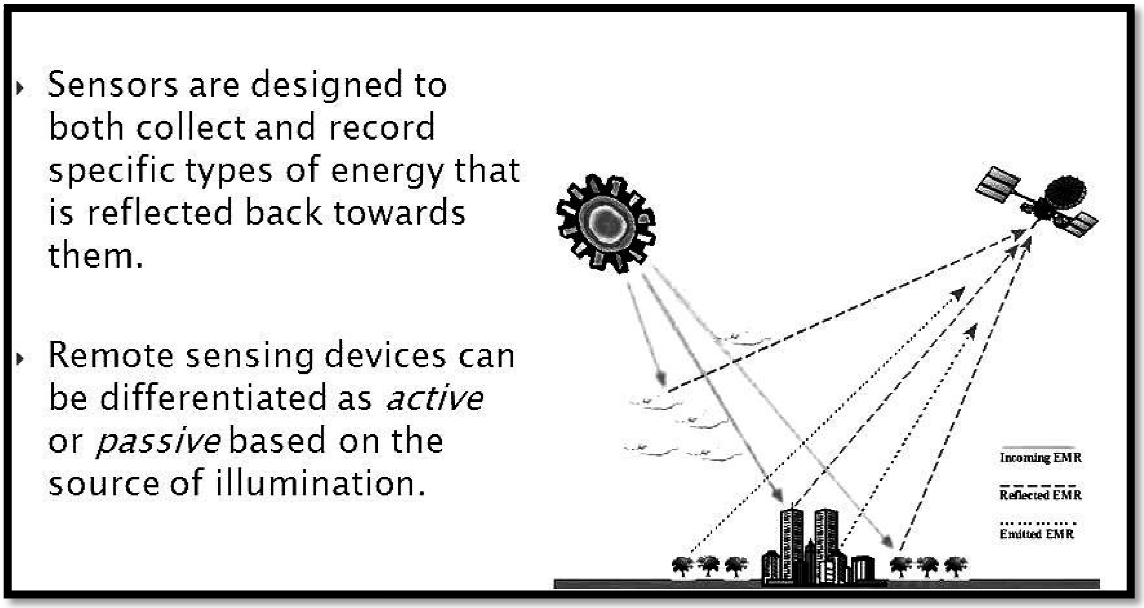


Figure: 2.11 Remote Sensing

a. The radiometric resolution of the sensor
b. The amount of atmospheric scatter
c. The surface roughnes of the objects
d. The spectral variability of reflectance within the scene.

3 Space borne remote sensing

If the platform is in the space having capability of global coverage it is called space borne remote sensing.

Multispectral scanning

The generalized processes and elements involved in electromagnetic remote sensing of earth resources are

a Data acquisition and

b Data analysis.

Sensors are used to record variations in the way earth surface features reflect and emit electromagnetic energy. Multispectral scanners use sensors with very narrow fields of view to scan an area of interest systematically and an image is built up as the scan progress. Each sensor forms an image that represents reflectance of the scan in its particular wavelength of the scene in its particular waveband. The India remote sensing Satellite System provide images with 36.25 m and 72.5 m ground resolution in the bands 0.45-0.52 micron; 0.52-0.59 micron; 0.62-0.68 micron and 0.77-0.86 micron.

Spectral reflectance for vegetation, soil and water

In the field of agriculture the scientists are interested in spectral signatures (characteristics) of vegetation, soil and water. These are useful to describe the nature of energy – matter interaction when the energy is in a) visible b) near infrared and c) middle infrared wavelength bands.

Visible and adjacent infrared spectrum provides useful information for the study of plant communities. Within this range spectral characteristics of soil. Water and vegetation differ significantly for spectral bands.

1. Vegetation

- In visible region chlorophyll absorption bands are approximately central at 0-45 to 0.65 pm.
- Internal structure of leaf is different for vegetations and this difference gets noticed in near infrared to mid-infrared spectral reflectance.
- Crop discrimination gets improved with the measurements in 1.55 to 1.75 and 2.05 to 2.35 pm bands which are sensitive to crop moisture content or leaf air space volume

2. Soil

Soil shows gradual increase in reflectance as the wavelength of optical spectrum increases.

3. Water

- Water bodies show fairly good response to shortwave radiation
- It also shows absorption in infrared bands.

Applications of Remote Sensing in Agriculture

Remote sensing is an effective tool in assessing the damages to crops and their management.

1. Monitoring in season agricultural operations

All the farm operations like sowing intercultivation; harvesting etc. is being monitored effectively by the remote sensing.

2. Crop identification

By using LISS II or III sensors crop identification on regional scale is possible.

3. Crop acerage estimation

By using stratified sampling methodology crop acerage estimation is done to the high level precision.

4. Crop yield estimation

Crop yields are estimated by analysing satellite based vegetation indices which are transformations of reflectance in the near infrared portions of electromagnetic spectrum.

5. Monitoring of crop phenology and stresses.

The crop conditions is affected by several factors like deficiency of nutrients acidic and salinity problems of soil, nutrient deficiencies, adverse weather conditions etc., All these can be detected by remote sensing.

6. Damage assessment and command area management

The damages due to floods, cyclones, water logged areas in command area can be detected and managed effectively by using techniques like multi-temporal Remote sensing etc.,

7. Water availability and soil moisture estimation

The surface and sub surface water availability for irrigation and the amount of moisture stored in the upper few centimeters of soil can be found to a greater accuracy.

8. Land degradation and watershed management

The remote sensing technology is highly useful in indentifying and delineating degraded lands. Also, it facilitates in delineation of watershed areas.

9. Drought detection and management

Assessing the drought realistically and ways to manage the adverse effects is possible through remote sensing.

10. Desertification

Remote sensing provides information to identify the important indicators of desertification. Based on this, action can be taken by the planners at different levels.

Summary

Metereology is defined as “The science of atmosphere. Weather is defined as “A state or condition of the atmosphere at a given place and at a given instant of time”.

Climate is defined as “The generalized weather or summation of weather conditions over a given region during comparatively longer period”.

Atmosphere helps agriculture in many ways such as, providing oxygen, Co_2 Nitrogen and transportation of pollen as a medium and protects earth from harmful U.V. rays.

Atmosphere studies different layers as

1. Trophosphere
2. Stratosphere
3. Mesosphere
4. Ionosphere
5. Exosphere

Monsoons are two types.

1. South west monsoon
2. North west monsoon

Wind plays vital role in Agriculture by way of transporting heat, moisture, Co_2, Nitrogen, etc. and also causes soil erosion. Similarly solar radiation is indispensable to photosynthesis which is essential for life existence.

Humidity is an important factor in crop production and it is not an independent factor but closely related to rainfall and temperature.

Drought can be defined as the condition under which crops fail to mature because of insufficient supply of water through rains.

Drought is broadly divided into meteorological drought, hydrological drought and agricultural drought. The effect of drought can be seen at all the stages of crop plants and we need to adopt various cultural and other methods for mitigation.

Weather forecasting is defined as predication of weather for the next few days to follow. By knowing weather forecasting farmers adjusts agricultural operations, minimize losses and plan for marketing etc.

Remote sensing can be defined as “Collection and interpretation of information about a target without being in physical contact with it. In agriculture this technology is used for monitoring of agricultural operations, crop acreage estimation, crop yield estimation and drought detection and management

Short Answer Type Questions

1. Differentiate between weather and climate?
2. What are the uses of atmosphere?
3. Write short notes on rainfall?
4. Write about wind?
5. What is temperature? Write about temperature briefly
6. Define weather forecasting and write about merits of weather forcast?
7. Define remote sensing and write it's application in agriculture?

Long Answer Type Questions

1. Define monsoon, write about two types of monsoons?
2. Write about the economic importance of mansoons on farm operations? Define Humidity and write about the significance and importance of humidity in crop production?
3. Define transpiration and write about the factors influencing transpiration?

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UNIT 3

Tillage and Tilth

3.1 Definitions, Objectives and Factors influencing tilth

3.2 Characteristics of good seedbed

3.3 Types of Tillage– Primary tillage, secondary tillage & intercultural operations

3.4 Primary and Secondary Tillage implements (mechanized seed drill problems are to be deleted) – Ploughs, Harrows, Cultivators, Ridger, Rotovator, Leveler, Puddler

3.5 Seeding implements–Seed drills, ferti- cum- seed drill, paddy transplanted, paddy seed drum

3.6 Harvesting implements– Paddy combined Harvesters

3.7 Modern Concepts of tillage – Minimum tillage, Zero tillage and Stubble mulch farming

Introduction

Tillage is as old as agriculture. After the harvest of crop the soil becomes hard and compact because of:

1. Beating action of rain drops.
2. Irrigation and subsequent drying
3. Movement of implement and labour

Soil is the source for the supply of air, water and nutrients for plant growth and is composed of 50% soil, 25% air and 25%. Tillage is the basic operation to loosen the soil and make it friable. Tillage operations are required to open the soil, leveling, sowing and intercultural operations. The implements used for each operation are different. The structure and mode of operation need to be understood for better usage. Similarly labour availability for Agriculture has become very less as they were diverted to non-agricultural works. Therefore, machinery / implements are to be used from seeding to harvest of the crop. Conservation technologies such as, minimum tillage and zero tillage are the proven technologies in reducing cost of cultivation.

3.1 Definitions

Tillage

It is the physical manipulation of soil with tools and implements to result in good tilth for better germination and subsequent growth of crops.

Tilth

It is the physical condition of soil resulting from tillage.

3.2 Characteristics of Good Seedbed

- A soil should be mellow, friable, crumbly and adequately aerated.
- A soil in good tilth is porous with equal proportion of Capillary and non capillary pores. This facilitates free movement of air and water.
- Irrigated agriculture require higher percentage of larger aggregates(more than 5 mm in diameter) while dry land agriculture need smaller aggregates (1 to 2 mm diameter).
- Tilth can be coarse or fine while sandy soils require fine tilth, heavy black soils need rough cloddy or coarse tilth.
- With very fine tilth the surface gets caked up when it dries after a rain. Because of this the soil is unable to absorb rain water and it result in runoff loses.

Objectives of Tillage

1. To produce a satisfactory seed bed for good germination andcrop growth.
2. To make the soil loose and porous.
3. To aerate the soil.
4. To control weeds.
5. To remove the stubbles. (that may harbor pests).
6. To expose the soil inhabiting pathogens and insect pests to sun and kill them.
7. To break hard pans in the soil.
8. For deep tillage and inversion of soil.
9. For incorporating bulky organic manures.
10. To warm up the soil.
11. To increase infiltration rate.

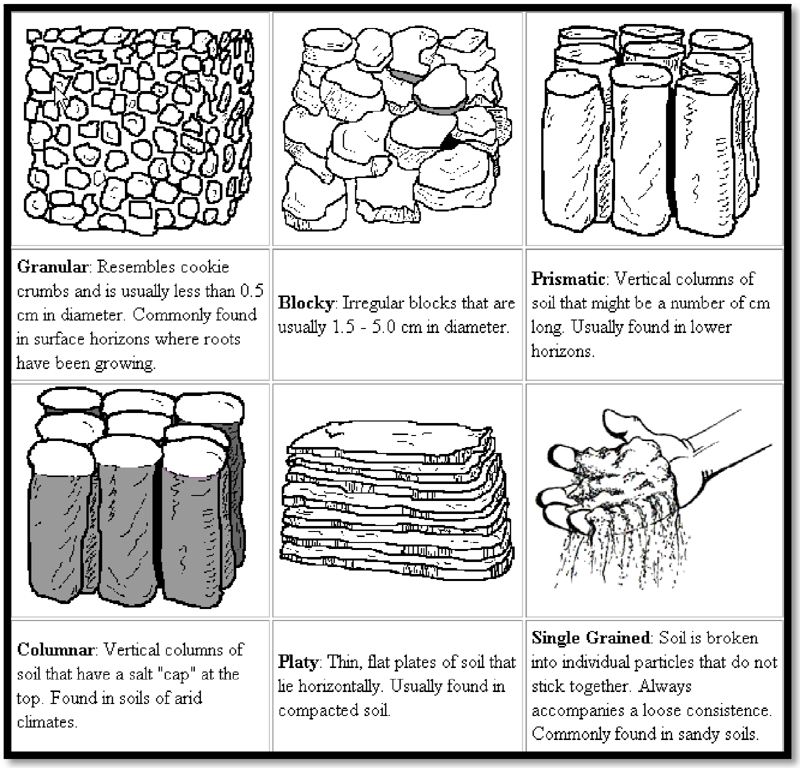


Figure: 3.1 Different soil structures.

Factor influencing Tilth

1. Soil Structure

Arrangement of soil particles with crumbly and granular nature in considered good. Best size of soil aggregate for good crop growth is 1-5mm. smaller aggregates may clog soil pores and larger ones may have large pore space. Tillage at optimum soil moisture level improves soil structure while it spoils if done in too wet condition. Ploughing a dry soil is difficult and will not help in improving structure.

2. Soil texture

Relative proportion of different soil particles namely sand, silt and clay.

Coarse sand - 2.0 – 0.2mm.

Fine sand - 0.2 – 0.02mm.

Silt - 0.02 – 0.002mm.

Clay - <0.002mm.,
Tillage has no effect on soil texture.

3. Pore space

When a field is ploughed, the soil particles are loosely arranged and pore space is increased. When the soil is in good tilth the capillary and non capillary pores would be roughly equal. This facilitates free movement of air and moisture in the soil.

4. Bulk Density (B.D)

When the soil is loosened, the soil volume increases without any affect on weight. BD of clay soils is low (1.05 m^3 and that of sandy soils is high (1.25- 1.30 m^3) and bulk density of tilled soil is less than that if untilled soil. Particle density is always more than BD.

5. Particle density

It is unaltered by tillage.

6. Soil Colour

Organic matter is mainly responsible for the dark brown to dark grey colour of the soil. Tillage increases oxidation and decomposition of organic matter resulting in fading of colour.

3.3. Types of Tillage

Time of operation classify tillage into two groups 1. Preparatory cultivation and

2. Secondary tillage.

1. Preparatory cultivation

Preparatory cultivation is carried out before sowing the crop:

Primary tillage- Ploughing: It is carried out to open the hard soil or to remove the previous crop stubbles. Generally sharp and scissoring implements would be used for this operation. Eg: Bullock drawn plough, Tractor drawn cultivator, Mould bold plough etc.

Secondary tillage-Harrowing: After primary tillage soil furrows wii be opened. Sometimes very big clods are opened, which need to be broken to soil aggregates. The operations that done for breaking the clods and levelling the field are called secondary tillage operations. Implements such as harrow, rotavator and leveler etc are used for these operation.

Factors influencing preparatory tillage

1. The previous crop grown

Stubbles of previous crop influence the tillage (Redgram, cotton stubbles are very deep rooted and require deep tillage to remove)

2. The crop to be grown

Crops like sorghum can be grown with rough tilth. For very small seeded crops like tobacco, chilles etc. fine tilth is required. Deep tillage is required for crops like sugarcane and tuber crops.

3. Types of soil

Clay soil can be ploughed only within a narrow range of soil moisture and the power or draught required is high. Light textured soils can be ploughed under a wide range of soil moisture and require less draught.

4. Climate

Deep tillage in shallow soils in low rainfall areas leads to rapid drying and loss of stored soil moisture. Deep cultivation is possible in high rainfall areas.

5. Type of farming

Intensive cropping requires intensive tillage.

2. After Cultivation–(intercultivation)

It is practiced after sowing the crop.

Tillage operations are performed between the crop rows with the following objectives:

- To destroy the weeds
- To form soil mulch
- To prevent cracking of soil
- To prevent crust formation

Intercultivation starts from very early stage of crop i.e., two to three weeks after sowing. Short duration crops require two-three intercultivations while long duration crop requires 3-4.

After cultivation

It includes intercultivation and various other special operations in a standing crop. They include.

1. Thinning and Gap filling.
2. Rogueing in seed production plots.
3. Earthing up in crops like sugarcane, banana, and groundnut.
4. Propping in banana.

5. Desuckering in banana.
6. Wrapping and propping in sugarcane
7. Nipping in castor.
8. Topping and trimming in tobacco (basal leaves are removed).
9. Defoliation in cotton.
10. Hand pollination in sunflower,

Fertilizer application and irrigation also comes under after cultivation.

3.4 Primary and Secondary Tillage Implements

Indigenous Plough

Indigenous plough is one of the most common implements used by Indian farmers. There are about 40 or more different types of indigenous ploughs in this country which are basically the same, but with minor variations in their shape, size and weight, to suit the soil types and tillage requirements of various crops.

In addition to ploughing, the plough is used for sowing crops like wheat, barley, gram etc., for interculture and for harvesting the underground parts of crops.

The main parts of the plough are i) body ii) shoe iii) share iv) beam and v) handle. The body is the main part of the plough to which the shoe, beam and handle are attached. The share is the working part of the plough, and is attached to the shoe, which penetrates into the soil and breaks it open.

The shoe also helps in stabilizing and balancing the plough while in operation. The beam is generally a long wooden piece which connects the main body of the plough to the yoke. A wooden piece which is attached vertically to the body to enable the operator to control the plough is called the handle.

Ploughing by Indigenous plough

When the plough is pulled forward, the shoe and share enter the soil and separate the furrow slice from the main body of the soil. A portion of the soil rides over the shoe, but the larger portion is pushed aside to both sides. After the plough has moved ahead leaving the furrow behind, some of the cut soil falls back into the furrow. It has been observed that an indigenous plough cuts a trapezoidal furrow cross section and leaves some unploughed land between the two adjacent furrows. To plough almost every bit of soil in the field, an indigenous plough has to be used thrice. This is the main reason for the high energy and time requirements in using an indigenous plough as compared to other types. For complete and through ploughing of a field, the indigenous plough must be operated three times: first ploughing, then cross ploughing and finally ploughing along the corners.

Mould Board Plough

A mould board plough is very common implement used for primer tillage operations.

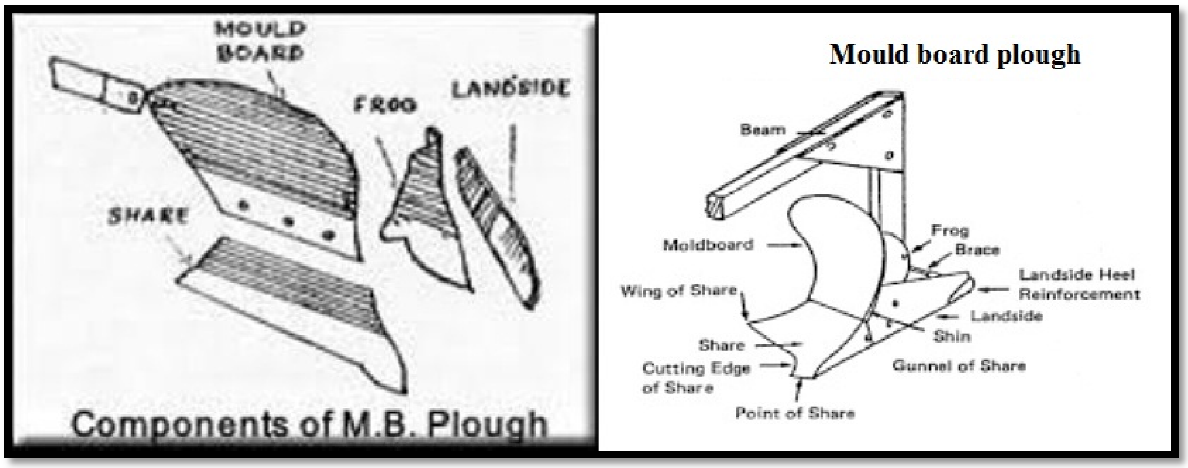


Figure: 3.2 Components of Mould board plough.

This plough performs several functions at a time such as Cutting, Lifting, Turning furrow slice and pulverizing the soil.

Components

M.B Plough consists of (a) Share, (b) Mould Board, (c) Landside and (d) Frog.

Disc Ploughs

Disc plough cuts, turns and in some cases breaks furrow slices with help of separately mounted large steel discs. It is designed to reduce friction by making a rolling plough bottom. A disc plough works well in the conditions where mould board plough does not work satisfactorily.

Advantages of Disc plough

(i) A disc plough can be forced to penetrate into the soil which is too hard and dry.

(ii) It works well in sticky soil in which a mould board plough does not scour. It is more useful for deep ploughing.

(iii) It can be used safely in stony and stumpy soil without much danger of breakage.

(iv) A disc plough works well even after a considerable part of a disc is worn off in abrasive soil.

(v) It works in loose soil also (such as peat) without much clogging.

Disadvantages of Disc plough

(i) It is not as good as mould board plough for covering surface trash and weeds.

(ii) Comparatively, it leaves the soil in rough and cloddy condition compared to mould board plough.

(iii) Disc plough is much heavier than mould board plough for equal capacities because penetration of this plough is affected largely by its weight rather than suction. The significant difference between mould board plough and disc plough is that mould board plough forced into the ground by the suction of the plough, while the disc plough is forced by its own weight.

Harrowing

It is secondary tillage operation which pulverizes, smoothens and packs the soil in seed bed preparation and/or to control weeds.

Harrow

A harrow is an implement that cuts the soil to a shallow depth for smoothening and pulverizing the soil as well as to cut the weeds and to mix materials with soil. It is an implement used to break the clods after ploughing to collect trash from the ploughed land and to level the seed bed. Several types of harrows used in India are mentioned below:

Disc Harrow

It is harrow which performs the harrowing operations by means of a set (or a number of sets) of rotating steel discs, each set being mounted on a common shaft. Disc harrows are of two types depending upon the sources of power:

1. Tractor Drawn
2. Animal drawn.

Tractor drawn disc harrow: Disc harrow is found very suitable for hard ground, full of stalks and grasses. It cuts the lumps of soil, clods and roots. Discs are mounted on one, two or more axles which may be set at a variable angle to the line of motion. As the harrow is pulled ahead, the discs rotate on the ground. Depending upon the disc arrangements, disc harrows are divided into two classes (i) single action, and (ii) double action.

Single action Disc Harrow: It is a harrow with two gangs placed end to end, which throw the soil in opposite directions. The discs are arranged in such a way that, right side gang throws the soil towards right, and left side gang throws the soil towards left.

Double action Disc Harrow: A disc harrow consisting of two or more gangs, in which a set of one or two gangs follow behind the sets of the other one or two, arranged in such a way that the front and back gangs throw the soil in opposite directions. Thus the entire field is worked twice in each trip. It may be of two types:

(i) Tandem, and

(ii) Off-0set.

Tandem Disc Harrow

It is a disc harrow comprising of four gangs in which each gang can be angled in opposite direction.

Off-set Disc Harrow

It is disc harrow with two gangs in tandem, capable of being off-set to either side of the centre line of pull. Two gangs are fitted one behind the other. The soil is thrown in both directions because discs of both gangs face in opposite directions. It is very useful for orchards and gardens. It travels left or right of the tractor. The line of pull is not in the middle, that's why it is called off-set disc harrow.

Penetration of Disc Harrow

There are several factors which affect the penetration of disc harrow in the field. If the disc gangs are set perpendicular to the line of draft, the penetration is not adequate. Penetration can be increased by adding some additional weight on the frame of the harrow. For obtaining maximum penetration, the gangs should be set with the forward edges of the disc parallel to the direction of motion. For better penetration the hitch point should be lowered,

A sharp edged disc has more effective penetration compared to blunt edged disc. It is observed that penetration is better in low speed than in high speed. In short, the following are a few adjustments for obtaining higher penetration.

1. By increasing the disc angle.
2. By adding additional weight on the harrow.
3. By lowering the hitch point.
4. By using sharp edged discs of small diameter and lesser concavity and
5. By regulating the optimum speed.

Care and Maintenance of Disc Harrow

Bearing must be thoroughly greased at regular intervals. All the nuts and bolts must be checked daily before taking the implement to the field. Blunt edges of the discs should be sharpened regularly. During slack season, the worn parts including bearing should be fully replaced. It is better to coat the outer and inner surfaces of the discs when the harrow is lying without use in slack season.

Animal drawn disc harrow

It consists of: (i) disc, (ii) gang frame, (iii) beam, (iv) gang angle mechanism, (v) scraper, (vi) spacer (spool), (vii) clevis, (viii) axle, (ix) middle tyne, and (x) bearings.

1. **Disc:** Disc is the main part of the harrow which cuts and pulverizes the soil. Discs are arranged in two gangs. The thickness of the material used for disc in at least 3.15mm. The cutting edge is beveled for easy penetration. The disc has a square opening in the centre to allow the passage of the axle. The disc is usually made of steel with carbon content ranging from 0.80 to 0.90%.

2. Gang frame: All the gangs are mounted on a frame, called Gang frame. It is usually made of study mild steel structure. The gang frame is bolted to the beam of the implement.

3. Beam: It is that part of the harrow which connects the implement with the yoke. The rear end of the beam has a clevis to fix its height of hitching to suit the size of animals. It is made of wood which is locally available in the area.

4. Gang angle mechanism: It is a mechanism by means of which the gang angles are adjusted. The width and depth of cuts of the implement is done by gang mechanism. The lever of the gang angle is usually made of mild steel flat with a wooden handle. The gang angle can be adjusted approximately in the range from 0° to 27° only.

5. Scraper: It is that part of the harrow which scrapes the soil from the concave side of the disc and keeps it clean for effective working of the harrow in the field.

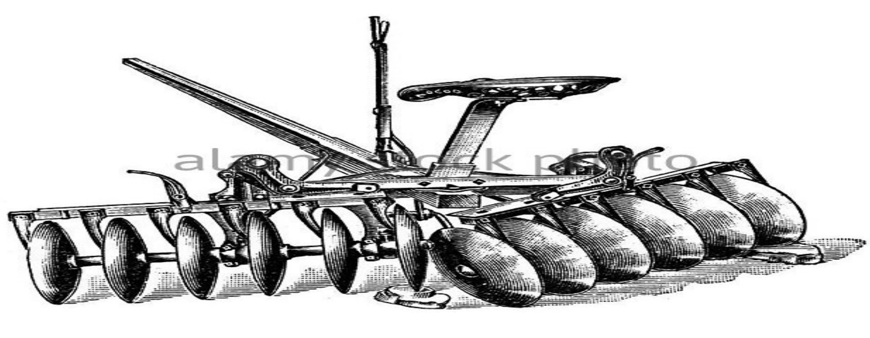


Figure: 3.3 Animal Drawn Disc harrow

6. Spacer (spool): Spacer is used to separate the two adjacent discs and to keep them in position. It is usually made of cast iron. The spacer has a suitable square opening in the middle to allow the passage of the axle.

7. **Clevis:** Clevis is the part fitted to the beam and the frame which permit vertical hitching of the harrow.

8. Axle: The axle is usually 20x20mm square section. The length of axis depends upon the size of the harrow.

9.Middletyne: The tyne which breaks the unbroken strip of soil left in between two gangs of the harrow during operation is called middle tyne. This tyne is suitably fixed to the rear end of the gang frame in such a way that it is replaced easily.

10. Bearing: One or Two bearings, made of cast iron or wood fitted at each end of the gang.

Blade harrows: The blade harrows popularly known as bakhar, is the most common type of harrow used by Indian farmers. It is generally used in clay soils for preparing seedbeds of both kharif (rainy season) and (winter) crops. It is also used for the seed in kharif sowings. The action of blade harrow is like that of sweep, moving into the top surface of the soil without inverting it. Sometimes, it is used to chisel out the uncut portion left after ploughing by an Indigenous plough. Thus the primary function of the implement is to pulverize the soil and creat soil mulch. The blade made of steel. Shisham or Babool wood is used for making body and the beam. The width cut by the harrow varies from 38 to 105 cm. Guntaka also is an improved type of this implement.

Frequent clogging with the roots and weeds which wrap along the edge of blade possess a serious problem and stoppage of work. However, the improved V-shaped blade if fitted on the implement can provide relief from clogging. Besides, it offers the advantage of reduction in draft, easy penetration and sooth working in the field.

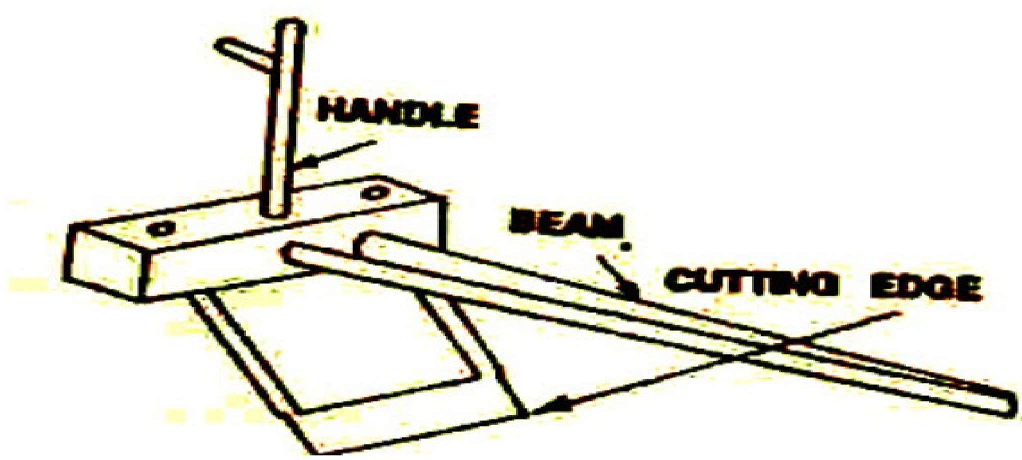


Figure: 3.4 blade harrow

Cultivator

Cultivator with spring loaded tynes. A tine hinged to the frame and loaded with a spring so that it swings back when an obstacle is encountered, is called spring loaded tyne. Each tyne of this cultivator is provided with two heavy coil springs, tensioned to ensure minimum movement except when an obstacle is encountered. The springs operate, when the points strike roots or large stones by allowing the tynes to ride over the obstruction, thus preventing damage. On passing over the obstruction, the tynes are automatically reset and work continues without interruption, the tynes are made of high carbon steel and are held in proper alignment on the main frame members. This type of cultivator is particularly recommended for soils which are embedded with stones or stumps. A pair of gauge wheel is provided on the cultivator for controlling the dept of operation. The cultivator may be fitted with 7, 9, 11, 13 tynes or more depending upon the requirement.

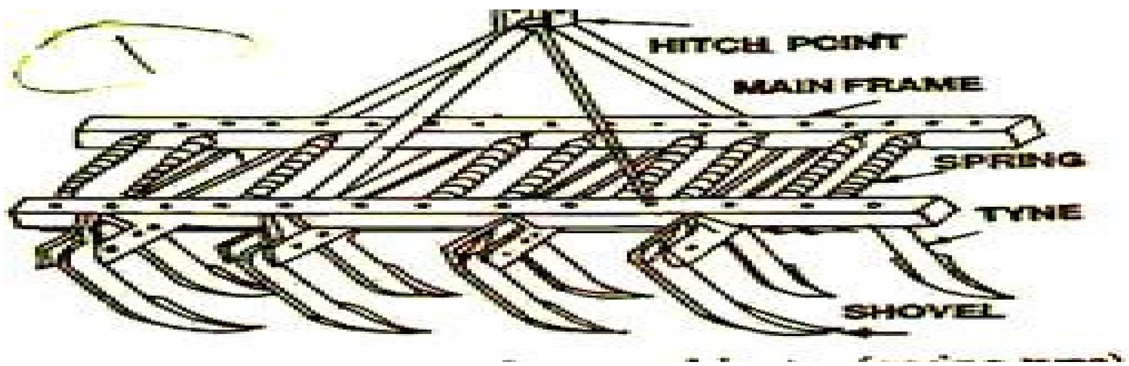


Figure: 3.5 Cultivator with spring loaded tynes

Cultivator with rigid tynes

Rigid tynes of the cultivator are those tynes which do not deflect during the work in the field. The tynes are bolted between angle braces, fastened to the main bars by sturdy clamps and bolts. Spacing of the tynesis changed simply by slackening the bolts and sliding the braces to the desired position. Since rigid tynes are mounted on the front and rear tool bars, the spacing between the tynes can be easily adjusted without getting the tynes chocked with stubbles of the previous crop or weed growth. A pair of guage wheel is used for controlling the depth of operation.

Figure: 3.6 Cultivator with rigid tynes

Puddlers

Puddling of soil is one of the most common farm operations in paddy growing areas. The most desirable soil conditions at the time of transplanting appears to be one having semi-pervious hard pan covered with approximately 10 to 15cm dense mud and very little free water on the surface. It usually refers to the churning of soil in the presence of excess water by means of a puddler or any other implement for that purpose. Purpose of puddlin'g is to reduce leaching of water, to kill weeds by decomposing and to facilitate the transplanting of paddy seedlings by making the soil softer. It is done in a standing water of 5 to 10cm depth in the field, which has already received on ploughing by the mould board plough. In some areas, an indigeneous plough is used as a puddler by some framers.

Puddlers are classified as: (i) hand operated puddlers, (ii) animal drawn puddlers, and (iii) tractor drawn puddlers. Among the various types, animal drawn puddlers are mostly used in the country. The indigenous plough and peg tooth harrow are used for puddling in paddy growing areas. None of these implements are as effective as the rotating blade type puddlers.

The open blade type implement is commonly used for puddling in south India. It consists of series of steel or cast iron blade fastened to a cast iron hub at an angle. The number of cast iron hubs may be two or more. These hub revolve on a steel shaft to which the wooden beam and the operator's seat are attached. Sometimes, these hubs form an integral part of the shaft which revolves either in wooden or metallic bearings at the ends in the frame. This type of implement is generally a walking type. The effective width of the puddler varies between 0.9 and 1.2m

Figure: 3.7 Open blade puddler

There are four classes of tractor drawn puddlers: (i) tyne tiller, (ii) rotating blade puddler, (iii) disk harrow and (iv) power rotary tiller. Among these tractor drawn implements, disk harrow and power rotary tiller are in great use.

Cage wheel

It is a wheel or an attachment to a wheel with spaced cross bars for improving the traction of the tractor in a wet field. It is generally used in paddy fields.

Rotavator

It is an implement that cuts and pulverizes the soil by impact forces through a number of rotary tynes or knives mounted as a horizontal shaft. It is also called “rotary tiller”. It is suitable for shallow cultivation and weed control. It consists of a power driven shaft on which knives or tynes are mounted to cut the soil and trash. Rotor has got several types of tynes fitted on the shaft having a speed of 200-300 rpm. Generally, sharp edged L-shaped blades are used in the rotor. According to power used, rotavators are classified as animal-drawn, engine operated and tractor-drawn rotavators. One or two operations of this implement are sufficient for good pulverization of soil depending upon soil and crop conditions. It is not meant for sandy soil. The power from the engine to rotor shaft is transmitted through chain. A clutch is provided in transmission system for engaging and disengaging power. The speed of rotor is kept at about 350-1500 rpm. The depth of penetration can be adjusted up to 12.5 cm. The suitable protective cover is provided at the rear to prevent under scattering of soil. It can cover about 1.5-2.0 ha/day. Bullock-drawn engine operated rotary tiller is quite useful for timely preparation of seedbed particularly in rice-wheat rotation. Power tiller operated to rotary tillers are also quite useful for hilly areas and small hand holdings.

ANGRAU Puddler

It is used for preparation of paddy fields with standing water (5-10 cm depth) after initial ploughing. It breaks up the clods and churns the soil. The main purpose of puddling is to reduce leaching of water and ato kill weeds. Puddling facilitates transplanting of paddy seedling. Puddler consists of puddling unit each having four paddles (or blades) mounted on an axle, frame, beam,metal-cross and handle. Paddles are made of mild steel sheet having thickness of 3.15 mm. The baldes are welded of metal cross, made of mild steel rounds. The blades with the metal cross are welded to the axle, at an angle of 10˚ for 30” (750 mm) puddler and 7 ½˚ for 40” (1000 mm) puddler. While moving, blades (paddles) churn the soil and mix it properly.

The weeds are also chopped and mixed with soil for decomposition. Two to three operations are good enough to get desired puddle soil. The animal-drawn puddler can cover 0.4-0.5 ha/day. According to the power used, puddlers are classified as hand operated animal- drawn and tractor-drawn puddlers. Animal-drawn puddlers are commonly used in India.

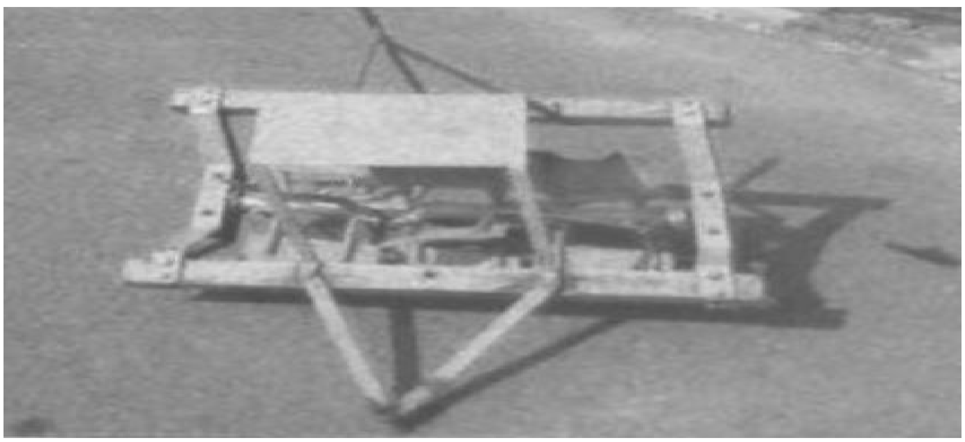


Fig 3.8 ANGRAU Puddler

3.5 Seeding Implements

Seeding or sowing is an art of placing seeds in the soil to have good germination in the field.

Seed drill is a machine for placing the seeds in a continuous flow in furrows at uniform rate and at controlled depth with or without the arrangement of covering the seed with soil. Drills are used for sowing seeds in rows at 15-35 cm apart. The seed drill performs the following functions: (i) to carry the seeds, (ii) to open furrow to an uniform depth, (iii) to meter the seeds, (iv) to place the seed in furrows in an acceptable pattern, and (v) to cover the seeds and compact the soil around the seed.

Seed drills fitted with fertilizer dropping attachment, distribute the fertilizer uniformly on the ground, is called seed cum fertilizer drills. It has a large seed box which is divided length wise into two compartments, one for seeds and another for fertilizers.

Components of seed Drill

A seed drill with mechanical seed metering device mainly consists of : (i) frame, (ii) seed box, (iii) seed metering mechanism, (iv) furrow openers, (v) covering device, and (vi) transport wheels.

Frame

The frame is usually made with angle iron suitable braces and brackets the frame is strong enough to withstand all types of loads in working condition.

Seed Box

It may be made of mild steet or galvanized iron with a suitable cover A small agitator is sometimes provided to prevent clogging of seeds.

Covering device:

It is a device to refill a furrow after the seed has been placed in it. Covering the seeds are usually done by patta, chains, drags. Packers,rollers and press wheels, designed in various sizes and shapes.

Transport wheel.

There are two wheels fitted on the main axle. Some seed drills have got pneumatic wheels also. The wheels have suitable attachments to transmit power to operate seed dropping mechanism.

Seed Metering Mechanism

The mechanism of a seed drill or fertilizer distributor which deliver seeds or fertilizers from the hopper at selected rates is called seed metering mechanism. Seed metering mechanism may be of several types: (i) fluted feed type, (ii) internal double run type, (iii) cup feed type, (iv) cell feed mechanism, (v) brush feed mechanism, (vi) auger feed mechanism, (vii) picker wheel mechanism, and (viii) star wheel mechanism.

Most common type of metering devices that delivers a more or less continuous flow of seeds is fluted roller type or internal double run type. These metering devices are driven by ground wheel. Some of above metering devices have not been commercially accepted and popularized.

Fluted Feed Type Seed Metering Mechanism

The fluted wheel (also known as fluted roller) is driven by a square shaft. Fluted rollers are provided with longitudinal grooves along the outer periphery and can be shifted on the shaft sideways. The size of groove is different for different crops. The fluted rollers are mounted at the bottom of the seed box; receive the seeds into longitudinal grooves and pass on to the seed tube through the seed hole. By shifting the rollers sideways, the length of the groove exposed to the seed, can be increased or decreased and hence the amount of seed sown is changed. The number of rollers on a drill is the same as the number of furrow openers. There is also an adjustable gate on the discharge side of the fluted wheel. The gate opening can be changed to fit the size of the speed of the shaft can also be changed, resulting in a change in the seed rate. The number of flutes on the roller ranges from 8 to 12. This method is favoured for sowing small or medium size seeds. For bold size seeds, this mechanism is not preferred as the seed are likely to get crushed during metering operation.

Fluted roller is a simple, low cost, trouble free device suitable for bulk emtering even for granulated fertilizers, An improved design of the fluted roller has spiral shaped flutes. This design offers a uniform distribution of seeds as compared to straight shaped flutes. However, most of the low cost animal drawn ferti-drills are fitted with straight shaped rollers. It is mostly used for drilling wheat. The fluted feed mechanism is more positive in its metering action than the Internal double run method.

Internal Double Run Type Seed Metering Mechanism

It has a double faced wheel, one face has a larger opening for the larger opening for the larger seeds and the other face or side has a smaller opening for use with smaller seeds. A gate is provided in the bottom of the box to cover the opening not in use. When one of the sides is being used, the seed is prevented from flowing through the other side by using a special cover. The discs mounted on a spindle and housing in a casing fitted below the seed box. The rate of seeding is varied by adjusting the speed of the spindle which carries the discs. This mechanism is used for metering bold and small seeds.

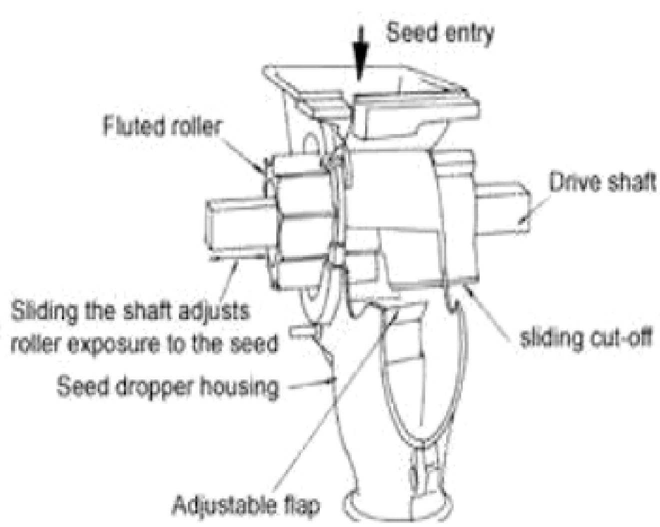
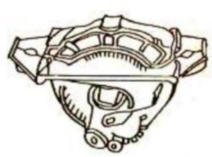


Figure: 3.9 Fluted roller seed metering mechanism

Cup feed seed metering mechanism

It is a mechanism consisting of cups of spoons on the periphery of a vertical rotating disc which picks up the seeds from the hopper and delivers them into the seed tubes. It consists of a seed hopper which has two parts. The upper one is called grain box and the lower one is called feed box. Shuttles are provided to connect these boxes. The seed delivery mechanism consists of a spindle, carrying a number of discs with a ring of cups attached to the periphery of each disc. The spindle with its frame and attachment is called feed barrel. When the spindle rotates, one disc with its set of cups rotates and picks up few seeds and drops them into small hoppers. The cups have two faces, one for larger seeds and other for smaller seeds. The seed rate in controlled by the size of the cups and the rate at which the seed barrel revolves. This type of mechanism is common on British seed drills.

2.Internal double run type



3. Cup feed mechanism

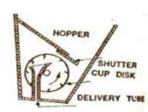


Figure: 3.10 Seed metering mechanisms in seed drill

Cell Feed Seed Metering Mechanism

It is a mechanism in which seeds are collected and delivered by a series of equally spaced cells on the periphery of a circular plate or wheel.

Brush feed Seed Metering Mechanism

It is a mechanism in which rotating brush regulates the flow of seed from the hopper. A number of bullock drawn planters in the country have brush feed mechanism.

Auger feed Seed metering mechanism

It is a distributing mechanism, consisting of an auger which causes a substance to flow evenly in the field, through an aperture at the base or on the side of the hopper. Many of the fertizer drills of the country have got augur feed mechanism.

Picker Feed Seed Metering Mechanism

It is a mechanism in which a vertical plate is provided with radially projected bars, which drop the large seeds like potato in furrows with the help of suitable jaws.

Star Feed Seed Metering Mechanism

It is a feed mechanism which consists of a toothed wheel, rotating in a horizontal plane and conveying the fertilizer through a feed gate below the star wheel.

Calibration of Seed Drill and Seed-Cum-Fertilizer Drill

The procedure of testing the seed drill for correct seed rate is called calibration of seed drill. It is necessary to calibrate the seed drill before operating in the field to get a predetermined seed rate of the machine. The following steps are to be followed for calibration of seed drill or seed-cum-fertilizer drill.

Step 1: Determine the nominal width (w) of drill.

$$W = M \times S$$

Where M is the number of furrow openers and S is the spacing between the openers in metre and W is in metre.

Step 2: Find the length of a strip (L) having nominal width W necessary to cover 1/25th of a hectare.

Step 3: $$L = \frac{10000}{W} \times \frac{1}{2.5} = \frac{400}{W} \text{m}$$

Determine the number of revolutions (N) the ground wheel has to make to cover the length of the strip (L).

$$\pi x D x N = \frac{400}{W}$$

$$\therefore N = \frac{400}{\pi x D x W} \text{rpm}$$

Step 4: Raise the seed drill in such a way that the ground wheels turn freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help in counting the revolutions of the drive wheel.

Step 5: Put selected seed and fertilizer in the respective hoppers. Place a sack or a container under each boot for seed and seed fertilizers.

Step 6: Set the rate control adjustment for the seed and the fertilizer for maximum drilling. Mark this position on the control for reference.

Step 7: Engage the clutch or on-off adjustment for the hoppers and rotate the drive wheel at the speed N.

$$\therefore N = \frac{400}{DW} \text{rpm}$$

Step 8: Weigh the quantity of seed and fertilizer, dropped from each opener and record on the data sheet.

Step 9: Calculate the seed and fertilizer, dropped in kg/ha and record on the data sheet.

Step 10: Repeat the process by suitable adjusting the rate control till desired rate of seed and fertilizer drop is obtained.

Problems:

Problem 1: The following results were obtained while calibrating a seed drill, Calculate the seed rate per hectare.

No. of furrow openers – 8
Spacing between furrows – 15cm.
Diameter of drive wheel – 1.5m
RPM of the drive wheel – 600
Seed Collected – 25 Kgs.

Solution:

Effective width of seed drill = 8 x 15 = 120 cm = 1.2m
Circumference of drive wheel = 15m
Area covered in one revolution = 1512 = 5.66 m^2
Area covered in 600 revolutions = 5.66 x 600= 3396 m^2
Seed dropped for 3396 m^2= 25 kg.
Seed dropped /ha = $\frac{25 \times 10000}{3396}$ = 73.6 kg.
Seed Rate= 73.6 kg.

Problem 2: Calculate the cost of seeding one hectare of land with bullock drawn seed drill of 5x30 cm size. The speed of bullocks is 3 kmph. Hire charges of bullocks is Rs. 100/- per pair, hire charges of seed drill is Rs.200/- per day and wage of operator isRs. 200/- per day of 8 hours.

Solution:

Width of seed drill = 5x30 = 150 cm = 1.5 m

Area covered per hr= width x speed = 1.5x3x1000 = 4500 m² = 0.45 ha To cover 0.45 ha of area, one hour is required

To cover one ha of area, time requirement = $\frac{1}{0.45}$ = 2.22 hr.

Time taken /ha = 2.22 hr

Cost of seeding / hr= $\frac{100+ 200+ 200}{8}$ = 62.50/-

Cost of seeding / ha = 62.5 x 2.22 = 138.75/-

Problem 3: A fluted feed seed drill has eight furrow openers of single disc type. The furrow openers are spaced 30 cm apart and the main drive wheel has a diameter of 110 cm. How many turns of main drive wheel would occur when the seed drill has covered one hectare of area.

Solution :

Circumference of dive wheel = 110 = 345.7 cm

Total width of seed drill = 8x30 = 240cm

Area covered per revolution = 345.7 x 240 = 82968 cm² = 8.29 m²

Number of turns per ha $= \frac{1000}{8.29} = 1206.3$

Problem 4: Maximum yield of maize is obtained with a population of 30,000 plants per hectare. The rows are 140 cm apart and an average emergence of 80% is expected. Find: (a) How many seeds per hill should be planted if hills are 140 cm apart

Solution :

Number of seeds per ha $= \frac{30000}{0\ 80} = 37500$

Area covered per hill = 140x 140 = 19600 cm² = 1.96 m²

No. of hills per ha $= \frac{10000}{1.\ 96} = 5102$

(a) No. of seeds per hill $= \frac{37500}{5102} = 7.35$ rounded to 8

(b) Total length of row $= \frac{10000}{1.\ 4} = 7142.85$ m

Spacing of drilled seed $= \frac{7142.\ 85}{37500} = 0.19$ m = 19 cm.

Paddy Drum Seeder

The seeder consists of a seed drum, mainshaft, groundwheel, floats, and handle. Joining smaller ends of frustum of cones makes the seed drum. Nine numbers of seed metering holes of 10 mm diameter are provided along the circumference of the drum at both the ends for a row – to – row spacing of 200 mm. Flat spikes 12 mm wide and 25 mm long are joined to ground wheel parallel to its axis of rotation. The slopes of the cone facilitate the free flow of seeds towards the metering holes. Two floats are provided on either side to prevent the sinkage and to facilitate easy pulling of the seeder.

Specifications

Length (mm)	: 2000
Width (mm)	: 1500
Height (mm)	: 640
Number of rows sown	: 6 and 8
Row to row spacing (mm)	: 200
Number of seed metering holes	: 9
Diameter of the metering holes (mm)	: 10
Number of floats	: 2
Weight (kg)	: 10
Capacity (ha/day)	: 1.1

Paddy Transplanter

Two methods are used for raising rice crop in India, namely upland cultivation l(direct seeding) and wetland cultivation (direct seeding and seedling transplanting). Rice transplanting by hand is very tedious, expensive and labour consuming operation. Many attempts have been made to develop manual as well as self-propelled rice transplanter for transplanting of rice seedlings in rice growing countries such as Japa, china, Korea and India.

The manual rice transplanter consists of frame, movable tray and seed picking fingers. Mat type seedlings are placed in the inclined trays. Fingers pick up the seedlings when they are pushed downward and place them in the prepared soil. Plant-to-plant spacing can be controlled by the operator.

Transplanters are available in 5-6 rows with comb type fingers. It’s working capacity varied from 0.3-0.4 ha/day and requires two persons, one for operating the transplanter and other for filling the tray with mat seedlings. The self propelled rice transplanter consists of air-cooled gasolines engine, main clutch, running clutch, plantingclutch, seeding table, float, star wheel, accelerator lever, ground wheel and handle and linkage mechanism.

Seedlings are grown in special seedling trays in controlled environment called mat seedlings. When seedlings are 25-30 day-old, they are uprooted and placed in planting seedling trays. Power from the engine is transferred to main clutch from where it is transferred to planting and a running clutch. The fingers on four bar linkage mechanism catch 3-4 seedlings at a time separate them from the mat and place it in the puddle soil.

A float supports the machine on the water while working in the filed. There are two end wheels that facilitate the movement of the transplanter. A marker is provided to demarcate the transplanting width during operation. The machine maintains row to row and plant to plant spacing. The planting capacity of the machine is about 0.05-0.1 ha/hr. These transplanters are now commercially available in India.

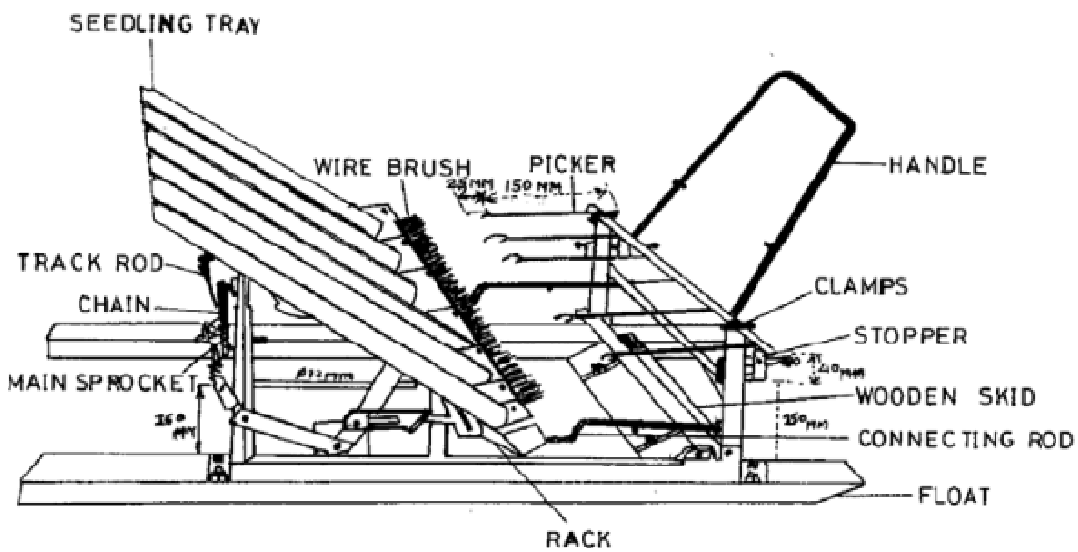


Figure: 3.11 Rice Transplanter

3.6 Harvesting Implements

Combine Harvester

Combine harvester is a machine designed for harvesting, threshing, cleaning and collecting the grain while it moves over the land. All the five operations are carried out in single operation of the harvester. The machine is versatile and with minor adjustments can handle a variety of crops. The size of the combine is indicated by the width of cut, it covers in the field.

Combine harvester in its primitive form was introduced in Germany and U.S.A in late 19^{th}centuy and became popular in next decades. In India, through a few tractor drawn combine harvesters manufactured by Minneapolis Moline U.S.A, and self propelled Russian combine harvesters were available with some Govt., farms and land lords. However, between 1970-73introduction of E512 GDR combine in Punjab, Haryana an M.P. was made in a big way. This was another revolution in the farm mechanization sector.

Gradually indigenous production started with the manufacture of a Swaraj 8100 combine harvester in organized sector by M/s. Punjab Tractors Ltd., which followed manufacturing of the machine in small sector in a small way. Surprisingly in 30 years of its production on commercial scale in India there are 60 more manufacturers with a production capacity of 5 to 150 combines per year. On an average about 800 combines are added every year on Indian farms. All these manufacturing units are located in the state of Punjab.

Functions of Combine Harvester

1. Cutting the standing crops.
2. Feeding the cut crops to threshing unit.
3. Threshing the crops.
4. Cleaning the grains from straw.
5. Collecting the grains in a container.

3.7 Modern concepts of Tillage

In conventional tillage, the soil is opened with mouldboard plough for primary tillage. The soil mass is broken into a loose system of clods of mixed sizes. Subsequently, a fine seedbed is prepared by secondary tillage in which crushing of clods, repacking, incorporation of plant residues, fertilisers, smoothing of soil surface etc., is done. In this process, energy is often wasted and sometimes, soil structure is destroyed. The farmer opens the soil with wooden plough, followed by running a drill or blade harrow for secondary tillage. Finally, planking is done to crush the clods and for, micro – leveling. Recently, considerable changes has taken place in tillage practices and several new concepts have been introduced, namely, minimum tillage, zero tillage, stubble mulch farming etc.

Minimum Tillage

Minimum tillage is aimed at reducing tillage to the minimum necessary for ensuring a good seedbed, rapid germination, a satisfactory stand and favourable growing conditions. Tillage can be reduced in two ways: by omitting operations which do not give much benefit when compared to the cost and by combining agricultural operations like seeding and fertilizer application.

Minimum tillage can be practiced by different methods.

Row Zone Tillage. After primary tillage with mouldboard plough, secondary tillage operations like discing and harrowing are reduced. The secondary tillage is done in the row zone only.

Plough- plant Tillage. After the soil is ploughed, a special planter is used and in one run over the field the row zone is pulverised and seeds are sown.

Wheel Trach Planting. Ploughing is done as usual. Tractor is used for sowing and the wheels of the tractor pulverise the row zone.

Zero Tillage

Zero tillage is an extreme form of minimum tillage. Primary tillage is completely avoided and secondary tillage is restricted to seedbed preparation in the row zone only. It is also known as no-till and is resorted to where soils are subjected to wind and water erosion, when time is too short for tillage operation and also when requirements of energy and labour for tillage too high. Zero tilled soils are homogenous in structure with more number of earthworms. The organic matter content increases due to less mineralisation. Surface runoff is reduced due to the presence of mulch. The favourable effects of zero tillage on soil physical properties are apparent after two years of its practice.

Stubble Mulch Tillage

The traditional methods of tillage developed in temperate moist climates based on mould board plough, often increase soil erosion when adopted indiscriminately in arid land cultivation. The best known example is that of the dust bowl of central United States which was created as a result of ploughing the original prairie lands for growing cereals using clean tillage methods until wind erosion assumed devastating proportions. A new approach was developed for keeping soil protected at all times whether by growing a crop or by crop residues left on the surface during fallow periods. It is known as stubble- mulch tillage or stubble- mulch farming. It is a year round system of managing plant residue with implements that undercut residue, loosen the soil and kill weeds. Soil is tilled as often as necessary to control weeds during the interval between two crops. Good management of stubble mulch farming system begins with the harvest of the crop. Sweeps or blades are generally used to cut the soil up to 12 to 15 cm depth in the first operation after harvest and the depth of cut reduced during subsequent operations. When unusually large amount of residues are present, a disc type implement is used for the first operation to incorporate some of the residues into the soil. This hastens decomposition, but still keeps enough residue on the soil.

Summary

Tillage operation is required to produce a satisfactory seedbed for good germination and good crop growth. A soil should be mellow friable, crumbly and adequately aerated. Factors such as, soil structure, soil texture, pore space, bulk density, particle density and soil colour influence the tilthof the soil. Initially the primary tillage is to be done to open the

furrow and to break the hard soil surface and secondary tillage is done to break the clods and level the field. Similarly inter cultivation is done between the crop rows to remove weds and pulverise the soil, Implements viz., indigenous plough, cultivator, M.B.Plough, disc plough are used for primary tillage and Guntaka, disc harrow, blade harrow and laser guided levellers are used as secondary tillage implements. Similarly seed cum fertilizer drill is used for sowing the seed and application of fertilizers. Conservation agriculture is the recent concept and it is being followed widely for reducing cost of cultivation and inorganic farming system.

Short Answer Type Questions:

1. What is good seed bed?
2. What are the objectives of tillage?
3. Write the differences between primary and secondary tillage?
4. Write about combine harvestor?
5. Write about paddy direct seeding drum?
6. Write about rotavator?
7. Write the advantages of disc plough?

Long Answer Type Question:

1. What is preparatory cultivation? Write about the factor's influencing preparatory tillage?
2. Write about the factors influencing tilth?
3. Write about fertilizer cum see drill?

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UNIT 4

Cropping Systems

Introduction

Cropping system is an order in which the crops are cultivated on piece of land over a fixed period of time. The basic idea followed in cropping system is to meet the dietary requirement of the family, increase the productivity and to escape from severe pests and diseases. Farming system is as old as Agriculture. It is being practiced to maintain the sustainability of soil fertility and crop production. Terminology of cropping systems, farming systems and their principles are discussed in this chapter.

4.1 Concept of Cropping System and Terminology of Multiple Cropping:

Cropping pattern: The proportion of areas under various crops at a point of time in a unit area. It indicates the yearly sequence and spatial arrangement of crops followed in an area.

Cropping System

It is an order in which the crops are cultivated on a piece of land over a fixed period of time.

Monocropping or Monoculture

It refers to growing of only one crop on a piece of land year after year.

Example: Rice-Rice (In Godavari belt)

Groundnut every year in Anantapur district.

Disadvantages in Monocropping

- Improper use of moisture and nutrients from the soil.
- Pests, diseases and weeds become a problem.

Multiple cropping

Growing two or more crops on the same piece of land in one agricultural year is known as 'Multiple Cropping'.

It is the intensification of cropping in time and space dimensions i.e., more number of crops within a year and more number of crops on the same piece of land. It includes intercropping, mixed cropping and sequence cropping.

Mixed Cropping

It is the process of growing two or more crops together in the same pieceof land. This system of cropping is generally practiced in areas where climatic hazards such as flood, drought, frost etc., are frequent and common.

4.2 Intercropping – Principles, Advantages and Disadvantages

The main idea in the cultivation of intercropping is to maximise productivity duly maintaining the soil fertility. The following principles have to be followed in inter cropping system.

1. Legume crops may be intercropped with non legumes. So as to share nutrients each other and enrich the soil.
2. Long duration crops have to be inter cropped with short duration crops. So that the growth period of component crops should not be coincided.
3. Deep rooted crops should be intercropped with shallow rooted crops. So that the nutrients uptake would be from all layers of the soil.
4. The crops which have common pests and diseases should not be intercropped as it aggravates the pests/diseases intensity.
5. Wide row crops may be intercropped with narrow spaced crops in order to control the erosion and improve soil moisture retention.
6. Selected Crops should be able to supply the dietary requirement of the family either in full or partially.

Advantages:

1. Intercropping gives higher income per unit area than sole cropping.
2. It acts as an insurance against failure of crop in abnormal year.
3. Intercropping maintain soil fertility as the nutrient uptake is made from both layers.
4. Reduce soil runoff.

Disadvantages / Limitations

1. Intercropping system is uneconomical and undesirable during rabi or in irrigated system of farming.
2. Farm mechanization is not possible in intercropping system.
3. Requires more labour for inter cultivation and harvesting etc.,

Differences between intercropping and mixed cropping.

S. No.	Intercropping	Mixed Cropping
1.	The main objectiveis to utilize the space left between two rows of main crop especially during early growth period of main crop.	Main objective is to get at least onecrop under any climatic hazard (flood, drought or frost) conditions.
2.	More emphasis is given to the main crop and subsidiary crops are not grown at the cost of main crop thus there is no competition between main and subsidiary crop.	All crops are given equal care and there is no main or subsidiary crop. Almost all the crops compete with one another
3.	Subsidiary crops are of short duration and they are harvested much earlier than main crop	The Crops are almost of same duration
4.	Both the crops are sown in rows. The sowing time may be thes ame or the main crop is sown earlier than subsidiary crop.	Crops may bebroadcasted and sowing time for all the crops is the same.

4.3 Sequence Cropping and Relay Cropping

Sequence Cropping

It can be defined as growing of two or more crops in sequence on same piece of land in a farming year. Depending on number of crops grown in an year, it is called double, triple and quadruple cropping involving two, three and four crops respectively.

Ex: Maize- Early Potato – Wheat – Mung.

Relay Cropping

Relay cropping: It is analogous to a relay race where crop hands over land to next crop in quick succession.

Eg: Broadcasting of blackgram seeds before harvest of kharif paddy. This is followed in view to utilise available soil moisture most efficiently.

Overlapping System of Cropping

In this the succeeding crop is sown in standing proceeding crop thus in this system before harvesting one crop the seeds of next crop are sown. Ex: Maize-Potato-Onion-Bhendi in North India.

Ratoon cropping: It refers to raising a crop with regrowth coming out of roots or stubbles after harvest of the crop. Ex. Sugarcane.

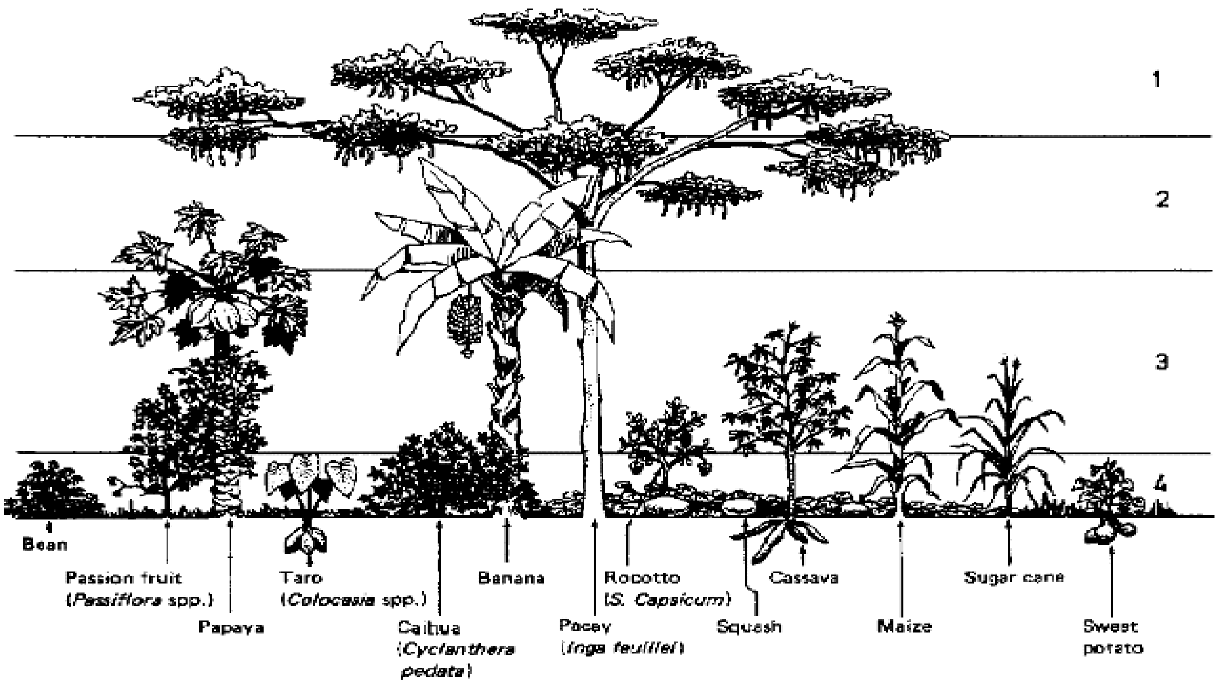

Figure: 4.1 Multi storeyed cropping system.

Multi storeyed system: Growing of plants of different heights in same field at the same time is termed as multistoreyed cropping.
Ex: Coconut – Piper – Banana – Pineapple.

4.4 Crop Rotation:

It is a process of growing different crops in succession on a piece of land in a specific period of time with an object to get maximum profit from least investment without impairing soil fertility.

Principles of Crop Rotation

1. The crops with tap roots should be followed by those which have a fibrous root system.
2. Leguminous crops should be grown after non leguminous crops.
3. More exhaustive crops should be followed by less exhaustive crops.
4. Selection of crops should be demand based.
5. Selection crops should be problem based.
6. The crops of the same family should not be grown in succession because they act like alternate host for insects, pests and disease pathogens.
7. An ideal crop rotation is one which provides maximum employment to the family and farm labour, the machines and equipments are efficiently used.

4.5 Farming Systems – Mixed farming – Advantages

What is a System?

A system is a group interacting components, operating together for a common purpose, capable of reacting as a whole, to external stimuli: It is unaffected directly by its own outputs and has a specified boundary based on the inclusion of all significant feedbacks.

For example, the human body is a system- it has a boundary (e.g. the skin) enclosing a number of components (heart, lungs) that interact (the heart pumps blood to the lungs) for a common purpose (to maintain and operate the living body). Collection of unrelated items does not constitute a system. A bag of marbles is not a system. If a marble is added a subtracted, a bag of marbles remains and may be almost completely unaffected by the change.

The marbles only behave as a whole, if the whole bag is influenced. For example, by droppingit. Butif it bursts the constituent parts go their own way. It is the propoerties of the system that chiefly matter and they may be summarized in the phrase 'behavior as a whole in response to stimuli to any part'.

Systems Approach

In system approach all the components and activities are linked and affect each other. It is not sensible to look at one component by itself without recognizing that what it does and what happens to it will affect other parts of the system. For example, consider what happens when you stub your toe, the whole body may react and different parts may respond differently. Eyes may water, the voice may make appropriate sounds the pulse rate may increase and hands may try to rub the damaged toe. It would be very rash to alter any component of a system without regard to the consequences and reactions elsewhere.

You cannot, for example, improve a car (system) by doing research on one wheel and then making it rather bigger than the rest, or increase the power and size of the engine without regard to the ability of the chassis to support it.

These things are common sense in such familiar contexts- they also apply to biological and agricultural systems.

In agriculture, management practices are usually formulated for individual crop. However, farmers are cultivating different crops in different seasons, based on their adaptability to a particular season, domestic needs and profitability. Therefore, production technology or management practices should be developed in view all the crops grown in a year or more than one year. If any sequence or rotation extends beyond one year, such a package of management practices for all crops leads to efficient use of costly inputs, besides reduction in production cost. For instance, residual effect of manures and fertilizers applied and nitrogen fixed can considerably bring down the production cost, if all the crops are considered than individual crop.

Farming system:

Farming system is a complex inter-related matrix of soil, plants, animals implements, power, labour, capital and other inputs controlled in part by farm families and influenced by varying degrees of political, economic, institutional and social forces that operate at many levels. In other words it is defined as unique and reasonable stable arrangement of farm enterprises that the household manages according to its physical, biological, economic and socio-cultural environment in accordance with the household's goals, preferences and resources. Conceptually it refers to a set of elements or components that are interrelated which interact among themselves. At the center of the interaction is the farmer exercising control and choice regarding the type and result of interaction.

It is a resource management strategy to achieve economic and sustained production to meet diverse requirement of farm household, duly preserving resource base and maintaining a high level of environmental quality.

For example, it represents integration of farm enterprises such as, cropping systems, animal husbandry, fisheries, forestry, sericulture, poultry etc for optimal utilization of resources bringing prosperity to the farmer, The farm products other than the economic products, for which the crops are grown, can be better utilized for productive purpose in the farming systems approach.

Farming Systems Concept

In farming system, the farm is viewed in a holistic manner. Farming enterprises include crops, dairying, poultry, fishery, sericulture, piggery, apiary, tree crops etc., a combination of one or more enterprises with cropping when carefully chosen, planned and executed, gives greater dividends than a single enterprise, especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of the enterprises to be combined with crop production activity, such that the end- products and wastes of one enterprise are utilized effectively as inputs in other enterprise. For example, the wastes of dairying viz., dung, urine, refuse etc are used in preparation of FYM or compost which serves as an input in cropping system. Likewise the straw obtained from crops (maize, rice, sorghum etc) is used as a fodder for dairy cattle. Further, in sericulture the leaves of mulberry crop as feeding material for silk worms, grain from maize crop are used as a feed in poultry etc.

Sustainability is the objective of the farming system where, production process is optimized through efficient utilization of inputs without infringing the quality of environment with which it interacts on one hand and attempt to meet the national goals on the other. The concept has an undefined time dimension. The magnitude of time dimension depends upon ones objectives, being shorter for economic gains and longer for concerns pertaining to environment, soil productivity and land degradation.

Principles of farming system:

- Minimization of risk
- Recycling of wastes and residues
- Integration of two or more enterprises
- Optimum utilization of all resources
- Maximum productivity and profitability
- Ecological balance
- Generation of employment potential
- Increased input use efficiency
- Use of end products from one enterprise as input in other enterprise

Objectives and Advantages of Farming System

1. Productivity: Farming system provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises. Time concept by crop intensification and space concept by building up of vertical dimension through crops and allied enterprises.

2. Profitability: The system as a whole provides an opportunity to make use of produce/waste material of one enterprise as an input in another enterprise at low/no cost. Thus by reducing the cost of production the profitability and benefit cost ratio works out to be high.

3. Potentiality: Soil health, a key factor for sustainability is getting deteriorated and polluted due to faulty agricultural management practices viz., excessive use of inorganic fertilizers, pesticides, herbicides, high intensity irrigation etc. In farming system, organic supplementation through effective use of manures and waste recycling is done, thus providing an opportunity to sustain potentiality of production base for much longer time.

4. Balanced food: In farming system, diverse enterprises are involved and they produce different sources of nutrition namely proteins, carbohydrates, fats & minerals etc. from the same unit land, which helps in solving the malnutrition problem prevalent among the marginal and sub- marginal farming households.

5. Environmental safety: The very nature of farming system is to make use or conserve the byproduct/waste product of one component as input in another component and use of bio-control measures for pest and disease control. These eco-friendly practices bring down the application of huge quantities of fertilizers, pesticides and herbicides, which pollute the soil water and environment to an alarming level. Whereas IFS will greatly reduces environmental pollution.

6. Income/cash flow round the year: Unlike conventional single enterprise crop activity where the income is expected only at the time of disposal of economic produce after months depending upon the duration of the crop, the IFS enables cash flow round the year by way of sale of products from different enterprises viz., eggs from poultry, milk from dairy, fish from fisheries, silkworm cocoons from sericulture, honey from apiculture etc. This not only enhances the purchasing power of the farmer but also provides an opportunity to invest in improved technologies for enhanced production.

7. Saving energy: Availability of fossil fuel has been declining at a rapid rate leading to a situation wherein, whole world may suffer for want of fossil fuel by 2030 AD. In farming system, effective recycling of organic wastes to generate energy from biogas plants can mitigate to certain extent this energy crisis.

8. Meeting fodder crises: In IFS every inch of land area is effectively utilized. Alley cropping or growing fodder legume along the border or water sources, intensification of cropping including fodder legumes in cropping system helps to produce the required fodder and greatly relieve the problem of non- availability of fodder to livestock component of the farming system.

9. Solving timber and fuel crises: The current production level of 20 million m^3 of fuel wood and 11 million m^3 of timber wood is no match for the demand estimated or 360 m^3 of fuel and 64.4 million m^3 of timber wood in 2000 AD. Hence, the current p0roduction needs to be stepped up several-fold. Afforestation programmes besides introduction of agro- forestry component in farming system without detrimental effect on crop yield will greatly reduce deforestation, preserving our natural ecosystem.

10. Employment generation: Various farm enterprises viz., crop +livestock or any other allied enterprise in the farming system would increase labour requirement significantly and would help solve the problem of under employment. An IFS provides enough scope to employ scope to employ family labour round the year.

11. Scope for establishment of agro industries: When once the produce from different components in IFS is increased to a commercial level there will be surplus of value addition in the region leading to the establishment of agro- industries.

12. **Enhancement in input use efficiency:** An IFS provides good scope for resource utilization in different components leading to greater input use efficiency and benefit- cost ratio.

Summary

Cropping system is a age old practice of growing crops in different combinations in a given soil and during fixed period of time.

Intercropping, mixed cropping, relay cropping, crop rotation etc., are the same important cropping systems followed for improving soil fertility and system productivity. While following different root growth and duration, so that, they never compete each other for soil and atmospheric resources.

Mixed farming not only helps to improve the overall income of the farmers but maintains the sustainable income during the period of unfavourable season. The best farming system would be chosen based on the expertise available with farmer and the resource and marketing facilities available at that area.

Short Answer Type Questions

1. Write briefly about the principles of crop rotation?
2. What are the differences between intercropping and mixed cropping?
3. Define farming system?
4. What are the advantages of crop rotation?

Long Answer Type Questions

1. Describe the principles and advantages of intercropping system?
2. Write about objectives and advantages of farming system?

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UNIT 5

Weed

Introduction

Weeds are no strangers to man. Existence of weeds experienced by the farmer since he started to cultivate crops about 10,000 BC and are the major problem from the beginning. A weed may be any other plant in the field than his crop. Again the characters of certain weed species are very similar to that of wild plants in the region. Some of the crops for example including the wheat of today are the derivatives of wild grass, further improved to suit after transfer of desirable traits such as, drought, cold, disease and pest resistance/ tolerance. So the weeds are to begin with essential components of native and naturalized flora but in course of time these plants are well placed in new environment by the conscious and unconscious efforts of man. Hence, it is considered that many weeds principally originated from two important and major arbitrarily defined groups.

1. By man's conscious effort
2. By invasion of plants into man created habits

In the world there are 30,000 weed species, out of these 18,000 sps cause damage to the crops. Jethro Tull first coined the term weed in 1931 in the book "Horse Hoeing Husbandry"

Definition

Weeds are the Plants, which grow where they are not wanted (Jethro Tull, 1731). Weeds can also be referred to as plants out of place.

Weeds are unwanted or undesirable plants compete with crops for water, soil nutrients, light and space (i.e. CO_2) and thus reduce crop yields.

Weeds are competitive and adaptable to all the adverse environments. Weed losses are estimated to be 5%, 10% and 25% respectively in the most developed, less developed and least developed countries respectively.

Harmful effects of weeds

Of the total annual loss of agricultural production from various pests in India, weeds account for 45%, insects 30%, diseases 20% & others 5%.

The losses due to weeds depends on

1. Type of weed
2. Severity of Infestation
3. Duration of infestation
4. Competitive ability of the crop plants with weeds
5. Climatic conditions which effect the growth of the crop and the weed.

Common Weeds and Classification

Weeds can be grouped based on planning, interpretation and control measures against them. Weeds belonging to any group of these classes have specific mode of propagation, dispersal and persistence.

Out of 2,50,000 plant species, weeds constitute about 250 species, which are prominent in agricultural system. Under world conditions about 30000 species are grouped as weeds. Out of these 18,000 sps can cause damage to the crops.

Classification of Weeds

1. Based on morphology
2. Based on life cycle
3. Based on habitat
4. Based on origin
5. Based on association

6. Based on nature of stem
7. Based on soil types
8. Special classification

Classification based on morphology / cotyledon characters

During 1940 2,4-D was discovered and it was a selective translocated herbicide. After the discovery of the herbicide, classification based on morphology has got strong recognition as it controlled broad leaved weeds. The herbicidal absorption, retention, & translocation depend on morphological characters of plant. The weeds belonging to the same group are likely to have same kind of response to specific herbicides.Based on cotyledon characters they are classified into

Monocots	Dicots
1. Narrow and upright leaves 2. Parallel venation 3. Retention of herbicide is less 4. Adventitious root system 5. Growing point is open 6. Cambium (conductive tissue) is scattered Eg: Grasses or narrow leaved weeds	1. Broad & horizontal leaves 2. Reticulate venation 3. Retention of herbicide is more 4. Tap root system 5. Growing point is open 6. Conductive tissue intact Eg: Dicots Amaranthus spp. Chenopodium album Convolvulus arvensis Phyllanthus niruri Pathenium hysterophorus Xanthium strumarium

This is the most widely used classification by the weed scientists. So, weeds are generally divided into three groups

1) Grasses
2) Sedges
3) Broad leaved weeds

Grasses	Sedges
1. Stem is hollow except at nodes	1. Stem Angular & solid
2. Ligulate	2. Does not posses ligules
3. Alternate or opposite leaves	3. Leaves in whorls around the stem
Eg: *Digitaria, Cynodon*	Eg: *Cyperus, Scirpus*

Classification based on Habitat / Situation

Depending upon the place of their occurrence they are classified into terrestrial and aquatic weeds. Terrestrial weeds are again classified into

1. Crop land weeds: weeds in field.
   Eg. *Echinochloa* in rice.
2. Non-crop land weeds: weeds in waste land
   Eg. *Tribulus terrestris,Croton bonplandianum.*
3. Grass land weeds: Eg. *Vernonia* and *Rumex spp.*
4. Weeds of lawns & public parks Eg *Chloris barbata and Eleusine indica*.
5. Orchard or garden weeds Eg. *Euphorbia geniculata. Imperata Cylindrica, Acalipha indica.*
6. Weeds of plantation crops Eg. *Euphatorium spp. Makania micrantha*
7. Parasitic weeds Eg. *Loranthus,Cuscuta,Striga*
8. Road side weeds Eg. *Euphorbia, Lantana camera, Hyptis* and *Prosopis juliflora*.

Aquatic weeds: They are classified into

1) Sub merged weeds Eg. *Hydrilla verticillata, Utricularia stellaris.*

2) Emerged weeds Eg. *Typha latifolia,Nelambium speciosum*

3) Floating weeds: *Eichhornia crassipes, Pistia stratiotes*

Classification based on origin

Indigenous weeds: All the native weeds of the country come under this group most of the weeds are indigenous. Eg. *Cynodon dactylon* and *Echinochloa colonum.*

Introduced or Exotic weeds: These are the weeds introduced from other countries. These weeds are normally troublesome and control becomes difficult.

Eg. *Parthenium hysterophorus, , Eichhornia crassipes, Argemone Mexicana,Lantana camera* . when man aids in its introduction such weeds are called as anthrophytes.

Classification based on association

Alien / Introduced weeds	Native weeds
1. They are not native of India, they were introduced into India	1. Seed within the geographical boundaries of origin.
2. They disseminate from their origin,	2. Dissemination does not have geographical boundaries
3. Introduced weeds can be effectively controlled by biological methods	3. In case of native weeds, natural enemies are already existing.

When two plants are living together i.e. called association. Based on association they are season bound weeds, crop bound weeds and crop associated weeds.

Season bound weeds: They are seen in that particular season irrespective of crop.

Crop bound weeds: Weeds which usually parasite the host crop partially of fully for their nourishment i.e. parasitism also called as parasitic weeds. Those parasites which attach roots are termed as root parasites and those which attack shoot of other plants are called as stem parasites

1 Root parasites

a. complete root parasite eg. *Orobanche* (broom rape) in tobacco

b. partial root parasite eg. *Striga spp* (witch weed) on millets

2. Stem parasites

a. Complete stem parasite. Eg: *Cuscuta* (dodder) in pulses

b. Partial stem parasite eg: *Loranthus* in fruit crops

Crop associated weeds: These are also crop specific due to mimicry, need for specific micro climate and ready contamination with the crops.

Mimicry

If weeds morphologically look exactly like crops & complete their life cycle, *Echinochloa colonum* (Jungle rice) mimic the rice crop. *Avena fatua* (wild oat) and *Phalaris* *minor* (canary grass) both mimic the wheat and *Loranthus* in tea gardens. For example *Avena fatua* (wild oats) tends to grow to the height of winter grains and adjusts its ripening period to the crop overa a wide varietal range and this type of mimicry is called phenotypic mimicry. Need for specific micro climate *Cichorium intybus* (chicory) and *Coronopus didymus* (swinecress) requires shady, moist & cool micro climate for their growth and development and which is available in Lucerne and berseem crops.

Ready contamination with the crops: If the weed seed mature at the same time & same height of the crop, then it contaminates the crop (also morphologically same) easily Eg. Little seed canary grass (*Phalaris minor*) in wheat and wild onion, wild garlic (*Allium spp)* in onion

Classification based on nature of stem

Depending upon development of bark tissue on their stems and branches weeds are classified into woody, semi-woody and herbaceous weeds.

Woody weeds: Weeds include shrubs and under shrubs are collectively called brush weeds. *Lantana camera, Prosopis juliflora* (mesquite) *Zizyphus rotundifolia* (wild plum) are examples for brush weeds.

Semi-woody weeds: *Croton sparsiflorus* is semi woody weed.

Herbaceous weeds: Weeds have green, succulent stems are of most common occurrence around us. Eg. *Amaranthus viridis and Chenopodium album.*

Based on soil pH

Based on pH of the soil the weeds can be classified into three categories. Acidophile weeds habitat acid soils. Eg. *Rumex acetosella, Pteridium spp Basophile* weeds dominate saline & alkaline soil. Eg. *Taraxacum stricta. Salsola spp* dominate saline soils where as *Cressa erecta*, *Sporobolus diander* are dominant in alkaline soils.

Neutrophile: Weeds of neutral soils eg. *Acalypha indica*

Spergula arvensis will grow luxuriantly on low pH soils. *Tribulus terrestris* and *Euphoorbia spp* are dominant on coarse texture soils, where as *Sorghum halepense* grows abundantly on heavy soils.

Classification based on life cycle / ontogeny

Based on life span (ontogeny), weeds are classified as annual, biennial and perennial weeds.

1. Annuals again they are classified into

   a) Kharif season annual

   b) Rabi season annual

c) Summer season annual and

d) Multi season annual

2. Perennials again they are

a) Simple perennial

b) Bulbous perennial

c) Creeping perennial

Annuals: Completes its life cycle within one year or one season and propagate by seeds. They may be Kharif annuals, winter annuals and summer annuals.

Summer and kharif annuals:	*Trianthema spp.*	(carpet weed)
	Digera arvensis	(digera)
	Setaria glauca	(Yellow fox tail)
Winter annuals:	*Grangea maderas patana*	
	Vicia sativa	(vetches)
	Avena fatua	(wild oat)
	Phalaris minor	(little seed canary grass)
Multi-season annual	*Echinochloa colonum, Eclipta alba*	
(All seasons)	*Eleusine indica, Phyllanthus niruri*	

Amaranthus viridis eventhough it is a summer / kharif annual, is also seen throughout the year, when irrigation is available. Ephemerals are short lived annuals which complete their life cycle within 2-4 weeks Eg. *Phyllanthus niruri*. Simple annuals whenever they are cut from ground level, they can't regrow again. Whereas *Parthenium, Lantana* and *Pluchea spp* appears like perennials, when cut at ground level. It will again regrow from crown buds.

Biennial weeds: Complete their life cycle within two years / two seasons, 1st year vegetative growth – Rosette stage. Second year produced inflorescence called "Bolting". They may propagate either by seeds or vegetative parts or by both. Biennials generally do not come up in annual crop fields but they infest perennial crop fields, pastures, lawns and orchards. Eg. *Daucus carota, Circium vulgare, Cichorium intybus, Taraxacum stricta, Alternenthra echinita* but *Cichorium intybus* bolts every year.

Perennial weeds

Grow more than two years. Reproduce vegetatively from underground and specialized organs. First time they come to flowering in second year and there after flowering every year. Difficult perennial weeds also known as pernicious weeds. Eg. *Cynodon dactylon* (Bermudagrass) and *Agropyron repens* (quack grass) are shallow rooted perennials where as *Cyperus rotundus*. (Purple nut sedge), *Sorghum halepense* (Johnsongrass) are deep rooted Perennials

Simple perennials: These reproduce solely by seeds but when roots or crown are cut, the cut pieces may produce new plant Eg. *Ipomoea carnea* and *Lantana camera*

Bulbous perennials: They propagate by bulbs or bulblets as well as by seeds. Eg. Wild onion and wild garlic (*Allium vineale*).

Creeping perennials: These propagate by means of rhizomes, stolons, spreadingroots as well as seeds. Eg. *Convovulus arvensis* (deer's foot), *Apropyron repens* (quack grass) and *Sorghum halepense* (Jhonson grass).

Special classification

Besides the various classes of weeds, a few others deserve special attention due to their specificity. They are **a.** Poisonous weeds, **b.** Parasitic weeds and **c.** Aquatic weeds

Poisonous weeds: The poisonous weeds cause ailment on livestock resulting in death and cause great loss. These weeds are harvested along with fodder or grass and fed to cattle or while grazing the cattle consumes these poisonous plants. Eg. *Datura fastuosa, D.stramonium* and *D. metel* are poisonous to animals and human beings. The berries of Withania somnifera and seeds of *Abrus precatorius* are poisonous. *Lochnera pusilla* is poisonous to cattle,while *Solanum nigrum* is poisonous to children in rare occasions.

Parasitic weeds: The parasite weeds are either total or partial which means, the weeds that depend completely on the host plant are termed as total parasites while the weeds that paratially depend on host plant for minerals and capable of preparing the food from the green leaves are called as partial parasites. Those parasites which attack roots are termed as root parasites and those which attack shoot of other plants are called as stem parasites. The typical examples o different parasitic weeds are

1. Total root parasite – *Orabanche cernua* on Tobacco
2. Partial root parasite – *Striga lutea* on sugarcane and sorghum
3. Total stem parasite – *Cusuta chinensis* on pulses, leucerne and onion
4. Partial stem parasite – *Loranthus longiflorus* on mango and other trees.

Aquatic weeds

Unwanted plants, which grow in water and complete at least a part of their life cycle in water are called as aquatic weeds. They are further grouped into four categories as submerged, emerged, marginal and floating weeds.

Submerged weeds: These weeds are mostly vascular plants that produce all or mostof their vegetative growth beneath the water surface, having true roots, stems and leaves. Eg. *Utricularia stellaris, Ceratophyllum demersum, Hydrilla Verticillate* and *Vallisneria spiralis*

Emerged weeds

These plants are rooted in the bottom mud, with aerial stems and leaves at or above the water surface. The leaves are broad in many plants and sometimes like grasses. These leaves do not rise and fall with water level as in the case of floating weeds. *Typha latifolia. Eg. Nelumbium speciosum* and *Nymphaea pubescens.*

Marginal weeds

Most of these weeds are emerged that can grow in moist shoreline areas with a depth of 60 to 90 cm water. These weeds vary in size, shape and habitat. The important genera that come under this group are; *Typha, Alternanthera, Ipomoea* etc.

Floating weeds

These weeds have leaves that float on the water surface either singly or in cluster. Some weeds are free floating and some rooted at the mud bottom and the leaves rise and fall as the water level increaseor decrease. Eg. *Eichhornia crassipes, Pistia stratiotes, Salvinia* and *Nymphaea pubescens*

Facultative Weeds

Also called apophytes. Weeds that grow primarily in wild community and migrated to crop fields or cultivated environment and associating themselves closely with the man's affairs, behave like more competitive weeds. Eg. *Opuntia dilleni*.

Obligate weeds

Occur only on cultivated land or otherwise disturbed land. They cannot withstand competition from volunteer vegetation in a closed community. Less competitive obligate weeds can't survive and can't withstand and disappear when the land is not disturbed for 2-3 years and kept as fallow. Obligate weeds may also be over taken by facultative weeds. Eg. *Convolvulus arvensis*.

Noxious Weeds

These weeds are arbitrarily defined as being undesirable, trouble some & difficult to control. They have immense capacity of reproduction & high dispersal capacity. They adopt tricky ways to defy man efforts to remove them. These weeds are also known as special problem weeds.

Eg. *Cyperus rotundus. Cynodon dactylon, Circium arvense, Parthemium, Eichhornea crassipes, Lantana camera, Saccharum, spontaneum, Imperata cylindrica* and *Striga spp.*

Objectionable weed

It is a noxious weed, seed of which is difficult to separate from the crop seed after contamination is called objectionable weeds. *Cleome viscosa*

Based on Ecological affinities

Weeds of dry lands: These are usually hardy plants with deep root system. They are adapted to withstand drought on account of mucilaginous nature of the stem and hairiness. Eg. *Tribulus terrestris* and *Convolvulus arvensis* .

Weeds of wetlands: They are tender annuals with semi- aquatic habit. They can thrive well under waterlogged and in partially dry condition. Propagation is chiefly by seed. Eg. *Ammania baccifera* and *Eclipta alba*

Weeds of irrigated uplands (garden lands): They are intermediate between dry land and wet land weeds with respect to their water requirement. They neither withstand waterlogged situation nor the extreme drought. Eg. *Trianthema portulacastrum & Corchorus trilocularis* and *Digeraarvensis.*

Based on Edaphic Factors

Some of the weed species are closely associated with a particular type of soil though not in a strict sense. Sometimes the same species may also occur in other soil types.

Black cotton soils: The weed species are mainly associated with dry conditions. Eg. *Aristolochia bracteata* and *Hibiscus vitifolius.*

Red soils: The weeds predominantly occur in the irrigated uplands. Eg. *Commelina benghalensis* and *Leucas aspera*

Light sandy or loamy soils: Weeds such as, *Mollugo oppositifolia, Oldenladia umbellata* and *Leucas aspera* occur in soils having good drainage.

Laterite soils: Some of the weeds are specific to laterite to laterite soils. Eg. *Bidens polosa, Lantana camera* and *Spergula arvensis.*

5.1 Weed losses in Agriculture

Reduction of crop yield has a direct correlation with weed competition. Weeds compete for water, light, nutrients and space. Weeds compete for water in dry land and for nutrients in irrigated crops. It includes reduction in crop yields and production efficiency and erosion of crop quality.

Reduction in crop yields and production efficiency is direct effect due to weeds. It varies from 34.3% to 89.8% depending upon the crop. In rice (30-35%), Wheat (15-30%), Maize, sorghum, pulses, oilseeds (18-85%), sugarcane (38.8%), cotton (47.5%), sugar beet (48.4%) and onion (90.7%).

Besides the direct reduction in crop yields there are many indirect ways by which the weeds may be troublesome in agriculture. For example: in weedy fields management practices become cumbersome. Harvest may be difficult when the field is invaded with wild safflower (*Carthamus oxycantha*), Canada thistle (*Cirsium arvense*), Cocklebur (*Xanthium* *strumaruim*). Cowage (*Mucuna pruriens*) cause itching to the labour. Harvesting becomes troublesome when the field bindweed (*Convolvulus arvensis*) and morning glory (*Ipomoea spp*) bind the crop plants together. The weeds at harvest may increase the excessive wear and tear of the farm machines and there by increase the cost of production to separate the weed seeds from the grain and other farm produce.

Fig 5.1: Crop Weeds.

Erosion of crop Quality

Weeds may reduce the quality of farm produce in many ways. In dry land agriculture weeds cause severe moisture and force the food grains to shrivel. The vegetables and fruits are discoloured and de shaped in the presence of weeds. Contamination of food grains with poisonous weed seeds fetches low price. Foundation or certified seed is rejected if weed seeds exceed 2% and also the market value is reduced. The quality of the sugarcane crop is also reduced due to the presence of the parasitic weed striga litura. Whereas leaves of loranthus (*Dendrophthoe falcate*) impair the quality of tea. Leaves of *Mikania micrantha* create problem in tea plantation. In cotton the dry weed fragments adhere to the lint and hinder its spinning process. In India Cocklebur (*Xanthium strumarium*) reduce the quality of wool in sheep. Oil quality of mint was impaired by *Cirsium arvense*.

Weed menace in Animal Husbandry

Milk gives odd smell when animal fodder crops are mixed with wild onion and wild garlic, *Cichorium intybus, Argemone Mexicana*. Certain weeds cause sickness and death of animals due to high levels of alkaloids, tannins, oxalantes, glucosites or nitrates. Death of herds of sheep occurs due its high oxalate content of Halogeton (H. *glomeratus*). It is dominant weed of arid and semi arid regions. Leaves of Lantana cause acute photosensitivity and jaundice in animals was due to the toxic principle of "Lantradene". Puncture wine (*Tribulus terrestris*) a weed of dryland induces extra sensitivity to light in sheep and puncture of the animal skin. In Kashmir Rhododendron cause diarrhea and showed blood strains in milk. *Crotalaria spp*. is fatal to chick ,where as sweet clover (*Melilotus alba*) contains 'dicumarin' which act as anti blood coagulant.

Weeds as alternate hosts to crop pests and diseases in rice crop *Echinochloa* and *Panicum* act as alternate host for stem borer, whereas *Vernonia cineria* a host for thrips in chillies . *Crotalaria spp*. act as a main host for hairy caterpillar which effect castor crop.

Diseases

Xanthium strumarium act as alternate host for powdery mildew in blackgram.Whereas *leersia hexandra* act as lternate host for BLB disease in rice

Reduction in land value

Land unsuitable for economic crop production when land infested with *Cyperus rotundus, Cynadon dactylon*. Thousand of hectares of cultivable area in rice growing regions of India have been abandoned or not being regularly cultivated due to severe infestation of nutgrass (*Cyperus rotundus*) and other perennial grasses.

Weed Menace to Human Health

Hay fever and asthma aggravated by pollens of *Ambrosia artemissifolia. Parthenium hysterophous,* Poison ivy (*Rhus spp*), common rag weed (*Ambrosia artemissifolia*) are responsible for respiratory problems and skin allergies (dermatitis). Aqutic weeds like water lettuce (*Pistia strtiata*), salvinia (*Salivina auriculata*), alligator weed (*Alternanthera spp*) act as alternate host and vectors of malaria, yellow fever, encephalitis, dengue fever and filariasis. Wheat flour contaminated with seeds of cocklebur give bitter taste to the bread and irritates the gastric tract of the consumer. When the Mexican poppy seeds (*Argemene mexicana*) crushed with mustard seeds cause death and blindness of people. Milk from animals feed on the Mexican poppy weed can cause 'Glaucoma' in humans. The Argemone toxicity is due to an alkaloid called 'Sanguinarine' and 11- oxotriacontanoic acid.

Weed Menace to Aquatic Ecosystems

Aquatic weeds make the appearance of water bodies repulsive and decline their recreational value. Weeds hinder the navigation, fishing and slow down the flow in irrigation channels. Aquatic weeds upon decomposition emit offensive odour and pollute the drinking water bodies.

Weed Menace to Forest and Pasture Lands

In Karnataka and Andhra Pradesh large forest area come under the grip of Parthenium hysterophorus. In West Bengal 11% of forest area and 38% of plantation forest have been affected by *Mikania micrantha* (mile-a-minute weed).

Limits Choice of Crops

Crops differ in their ability to compete with weeds. In many instances, the presence of a particular weed in the field limits the choice of crops to be grown. Heavy weed infestation renders some economically important crops, particularly pulses, Vegetables, Cotton, Jute and forage crops unsuitable or less suitable for cultivation.

Benficial effects of weeds or economic uses of weeds

Several weeds have been put to certain economic uses since ages. Typha and *Saccharum spp* used for making ropes and thatch boards. *Cichorium intybus* roots are used for adding flavor to coffee powder. *Amaranthus viridis*, *Chenopodium album* and *Portulaca spp*. used as leafy vegerable. In north India *Saccharum spontaneum* used in breeding programme for developing the noble canes. Incorporation of *Crotalaria, Parthenium, Calotropis* and *Eichhornia* reduced root knot nematode population in the soil as they exhibited nematicidal properties. Hariyali grass(*Cynodon dactylon*) and *Cenchrus ciliaris*, *Dichanthium annulatum* weeds of grass land serve as food for animals.

People in China and Japan consume *Chlorella pyrenoides* (algae)as protein supplement. Weeds act as alternate host for predators and parasites of insect pests which feed on the weeds. For example *Trichogramma chilonis* feed upon eggs of castor semi looper which damage the castor plants. Some weeds useful to identify the metals (Indicator geobotany) through satellite images Eg. *Commelina spp* (Copper), *Eichhornia crassipes* (Copper, zinc, lead and cadmium) in water bodies. Several species of weeds *Tephorsia purpurea* and *Croton sparsiflora* in S. India used as green manures. Whereas *Eichhornia crassipes* and *Pistia stratiotes* are used for composting. *Argemone Mexicana* used for reclamation of alkali soil. No_2 and SO_2 air pollution determined by wild mustard and chich weed respectively. Aquatic weeds are useful in Paper, pulp and fiber industry. *Chenopodium album* used as mulch to reduce evaporation losses, Where as *Agropyron repens* (quack grass) used to control soil erosion because of its prolific root system. Weeds like *Lantana camera, Amaranthus viridis, Chenopodium album, Eichhornia crassipes* used for beautification. *Agropyron repense* used for soil conservation, where as *Dicanthium annulatum* stabilizing field bunds. *Opuntia dellini* used as biological fence.

Some weeds have medicinal properties and used to cure snake bite (*Laeucas aspera*), gastric troubles (*Calotropis procera*), skin disorders (*Argemone mexicana*) and jaundice (*Phyllanthus niruri*) and *Striga orobanchioides* to control diabetes. In addition to the above agarbathis (*Cyperus rotundus*), aromatic oil, (*Andropogan spp & Cymbopogon spp*) are prepared from weeds.

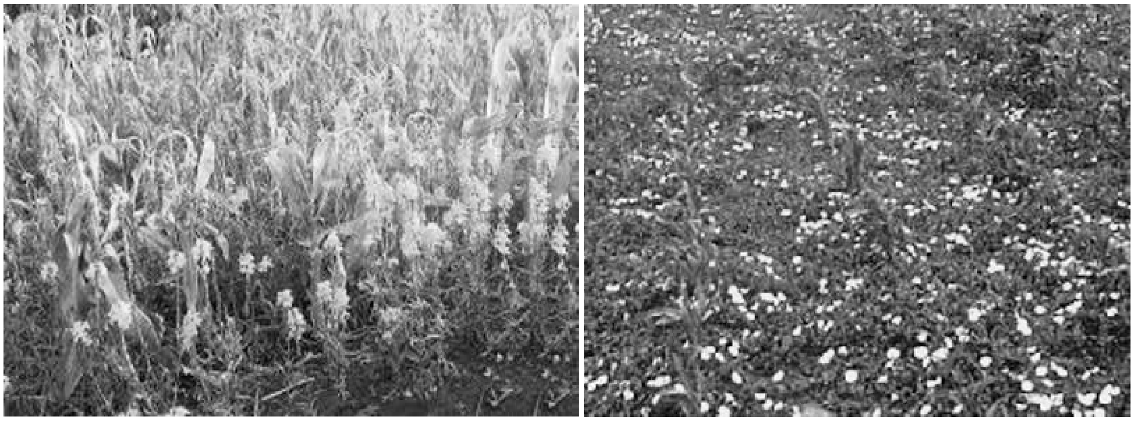

Fig 5.2 Maize field infested with striga and field bind weed.

5.2 Crop Weed Association and Competition

Competition is struggle between two organisms for a limited resource that is essential for growth. Water, nutrient, light and space are the major factors for which usually competition occurs. Competition between crop plants and weeds is most severe when they have similar vegetative habit common demand for available growth factors.

Weeds appear much more adapted to agro- ecosystems than our crop plants. Without interference by man, weeds would easily wipe out the crop plants. Generally, an increase in one kilogram of weed growth will decrease one kilogram of crop growth.

Principles of crop weed competition are

1. Competition for nutrients

2. Competition for moisture

3. Competition for light

4. Competition for co_2

Competition for Nutrients

It is an important aspect of crop weed competition. Weeds usually absorb mineral nutrients faster than crop plants. Usually weeds accumulate relatively larger amounts of nutrients than crop plant Nutrient removal by weeds leads to huge loss of nutrients in each crop season, which is often twice that of crop plants.

Amaranthus accumulate over 3% nitrogen in their dry matter and this fall under category of nitrophylls. *Digeraria spp* accumulates more phosphrous content of over 3.36 %.

Chenopodium and *Portuluca* are potassium lovers, with over 4.0% k_2O in their dry matter. *Setaria lutescens* accumulates as high as 585 ppm of zinc in its dry matter, three times more than by cereal crop.

Competition for Moisture

Crop weed competition becomes critical with increasing soil moisture stress. In general, for producing equal amount of dry matter weeds transpire more water than field crops. Therefore, the actual evapotranspiration from the weedy crop fields is much more than the evapotranspiration from a weed free crop field. Consumptive use of *Chenopodium album* is 550 mm as against 479 mm for wheat crop. Further, it was noted that weeds remove moisture evenly from up to 90 cm soil depth. While the major uptake of moisture by wheat was limited to top 15 cm of soil depth. Weeds growing in fallow land are found to consume as much as 70- 120 ha mm of soil moisture and this moisture is capable of producing 15-20 q of grain per ha in the following season.

Competition for Light (Solar energy)

Plant height and vertical leaf area distribution are the important elements of crop weed competition. When moisture and nutrients in soil are plentiful, weeds have an edge over crop plants and grow taller. Competition for light occurs during early crop growth season, if a dense weed growth smothers the crop seedling, crop plants suffer badly due to shading effect of weeds. Cotton, potato several vegetables and sugarcane are subjected to heavy weed growth during seedling stage. Unlike competition for nutrients and moisture once weeds shade a crop plant, increased light intensity cannot benefit it.

Competition for Space (CO_2)

Crop – weed competition for space is the requirement for CO_2 and the competition may occur under extremely crowded community condition. A more efficient utilization of CO_2 by C4 type may contribute to their rapid growth over C3 type of crops.

Critical Period of Crop- Weed Competition

The period at which maximum crop weed competition occurs called critical period. It is the shortest time span in the ontogeny of crop when weeding results in highest economic returns.

Factors affecting weed-crop interference or critical period of crop weed competition :

1. Period of weed growth.
2. Weeds / crop density.
3. Plant species effects.
   a) Weed species
   b) Crop species and Varieties.
4. Soil and climatic influence.
   a) Soil Fertility

b) Soil moisture status

c) Soil reaction

d) Climatic influences.

5. Cropping practices.

a) Time and method of planting crops

b) Method of planting of Crops.

c) Crop density and rectangularity.

Period of Weed growth

Weeds interfere with crops at anytime they are present in the crop. Thus weeds that germinate along with crops are more competitive. Sugarcane takes about one month to complete its germination phase while weeds require very less time, by that time crop plants are usually smothered by the weeds completely. First ¼ - 1/3 of the growing period of many crops is critical period. In direct sown rice weed competition severe than transplanted rice. However in a situation, where weeds germinate late, as in dry land wheat and sorghum, the late stage weeding is more useful than the early weeding.

In general, for most of the annual crops ** first one third duration of weed free period is very important.

Weeds / Crop Density

Increase in weed density decrease the crop yields. The relationship between the yield and weed competition is ** sigmoidal. In rice density of joint vetch (*Aschynomene virginica*) and barnyard grass, if it is > 10 plants /m² rice yields were reduced by 20 and 11 q/ha respectively.

Crop density also effect the weed biomass production

Increase in plant population decreases weed growth and reduce competition until they are self competition for soil moisture and other nutrients. In wheat reduced row spacing from 20 to 15 cm reduced the dry matter yield of *Lolium* and *Phalaris spp* by 11.8 % and 18.3 %, respectively.

Plant Species Effects

1. Weed Species

Weeds differ in their ability to compete with crops at similar density levels. This is because of differences in their growth habits and to some extent due to allelopathic effects. At early stage of growth, cocklebur (*Xanthium strumarium*) and wild mustard (*Brassica spp*) are better competitors for crops than many grasses because of their fast growing leaves that shade the ground heavily.

In dry areas perennial weeds like Canada thistle (*Cirsium arvense*) and field bind weed (*Convolvulus arvensis*) were more competitive that annual weeds because of their deep roots and early heavy shoot growth. Composite stand of weed spp is always more competitive than a solid stand if single weed spp.

2. Crop Species and Varietal Effects

They differ in their competing ability with weeds. Among winter grains the decreasing order of weed competing ability is barley> rye>wheat>oat. In barley it may be due to more extensive root growth during the initial three weeks.

Fast canopy forming and tall crops are more competitive than slow growing short statured crops (sorghum, maize, soybean, cowpea). Because of their slow initial growth. Late sown dwarf wheat is affected by the late germinating weeds like Canada thistle and wild safflower. (*Carthamus oxycantha*) and Phalaris minor even thogh they escape an initial flush of weeds.

3. Varieties

Smothering crops grow very fast during early stages. Cowpea and horse gram are tolerant to weed competition. When we compare the crop- weed competition between two varieties of groundnut, in spreading groundnut (TMV-3) the yield loss is 15% in weedy plots compared to bunch groundnut (TMV-2) where yield loss is 30%. This is due to smothering effect of spreading groundnut. Like wise long duration rice is more competitive than short duration rice varieties. Wild oat growth increase with increased dwarfness of wheat plant.

4. Soil and Climatic influence

a. Soil fertility

Under limited nutrient conditions, competition exists between the crop and the weed. Soil type, soil fertility, soil moisture and soil reaction influences the crop weed competition. Elevated soil fertility usually stimulates weeds more than the crop, reducing the crop yields. Method and time of application of fertilizers to crop determine whether added fertilizers will suppress or invigorate weed growth in fields. An application fertilizer during early crop growth season when weed growth is negligible was more beneficial. Band application of fertilizers to the crop will be inaccessible to inter row weeds.

b. Soil Moisture Status

Weeds differ in their response to available moisture in soil. Russian thistle Salsola kali showed similar growth in both dry soils and wet soils; whereas, large crab grass *Digitaria sanguinalis* produce more growth on wet soil. When fields are irrigated immediately after planting then weeds attain more competitive advantage over crops. If the weeds were already present at the time of irrigation, they would grow so luxuriantly as to completely over cover the crops. If the crop in irrigated after it has grown 15 cm or more in a weed free environment irrigation could hasten closing in of crop rows thus suppressing weeds. In water logged soils weeds are more competitive than crop plants. In submerged conditions in rice, weeds are put to disadvantage to start with. But if there is a break in submergence, the weeds may germinate and grow more vigorously than the crop, even if fields were submerged later.

C. Soil reaction

Abnormal soil reactions (very high or very low pH) often aggravate weed competition. Weeds offer intense competition to crops on abnormal pH soils than on normal pH soils. In acid soils Rumex acetosella and *Pteridium Spp*, saline alkaline soils *Taraxacum stricta, Agropyron* repens are the dominant weeds.

d. Climatic influences

Adverse weather conditions per se drought, floods and extreme temperature intensify weed-crop interference since most of our crop varieties are highly susceptible to such climatic influences where as the weeds are tolerant to their stresses.

5. Cropping Practices

a. Time of Planting Crops

If the time of planting of a crop is such, that its germination coincides with the emergence of first of weeds, it leads to intense weed-crop interference. Usually longer the interval between emergence of crop and weeds, lesser will be the weed-crop interference.

b. Method of planting of crops may also affect the weed-crop competition

Weed seeds germinate most readily from top 1.25 cm of soil, though it is considered up to 2.5 cm depth. *Avena, Echinochloa, Xanthium* and *Vicia spp*. may germinate even from 15 cm depth. Therefore, planting method that dries up the top 3-5 cm of soil rapidly to deny weed seeds opportunity to absorb moisture for their germination and usually post pone weed emergence until first irrigation. By that time crop establishes well and competes with weeds.

Weed seeds are classified

Deep germinating	:	15 cm
Shallow germinating	:	up to 5 cm
Surface germinating	:	(0.25 cm)

c. Crop Density and Rectangularity

It determines the quantity and quality of crop environment available to the growth of weeds. Wide row spacing with simultaneous high intra row plant population may induce dense weed growth. But square method of planting is ideal to reduce intra row competition. (from the point of weed – crop competition).

Critical period of crop- weed competition

It is the shortest time span in the ontogeny of crop when weeding results highest economic returns,

Critical period of crop- weed competition in some crops

1.	Rice	
	Transplanted	Up to 6 WAT
	Direct sowing	Up to 6 WAS
2.	Wheat and Ragi	Up to 5 WAS
3.	Maize	2 to 6 WAS
4.	Bajra	Up to 4 WAS
5.	Jowar and Sesame	2-5 WAS
6.	Sugar cane	12 to 4 WAS
7.	Sunflower	2 to 4 WAS
8.	Groundnut	4 to 7 WAS
9.	Green gram and Black gram	4 to 6 WAS
10.	Red gram	Up to 7 WAS
11.	Horse gram	3 to 6 WAS
12.	Cotton	6 to 9 WAS
13.	Castor	3 to 9 WAS
14.	Tobacco	Up to 9 WAT

5.3 Methods of Weed Control

Weed control and weed management are the two terms used in weed science. Weed control is the process of limiting infestation of the weed plant so that crops can be grown profitably, whereas, weed management includes prevention, eradication and control by regulated use, restricting invasion, suppression of growth, prevention of seed production and complete destruction thus weed control is one of the aspects of weed management.

Principles of weed Management are

1. Prevention

2. Eradication

3. Control

Prevention

Prevent the entry and establishment of weeds into uninfected area.

Eradication

It is complete removal of all live plant parts and seeds of the weed from an area. It may be a field / farm / village / geographical region depending upon the need. In general eradication of common weed seeds is not practiced as these weeds harbor crop pests or secretes soil nematodicides. They may be useful to hold the soil nitrified against weeds like *Striga, Cuscuta, Lantana* to prevent their dispersal to new areas of useful land and water bodies. Weed eradication programme should begin when the weed growth is limited. If the weed occupy large and continuous areas, eradication is not economical. It should be carried out more than one year. It requires intensive initial efforts to destroy all plant parts and followed by many years of vigilance to prevent the new weed seedlings from establishing into adult plants.

Control

Weed infestations are reduced but not necessarily eliminated. Weed control includes.

- Physical/mechanical.
- Cultural
- Biological.
- Chemical.

Hand Weeding

Removal of weeds either manually or by using tools like khurpi or sickle, when weeds grown upto some extent. Effective against annuals and biennials and controls only upper portion of the perennial. Higher labour is required and is tire some.

Hand Hoeing

Hoe has been the most appropriate and widely used weeding tool for centuries. Taking out the weeds with the help of khurpi or hand hoes. Hoeing by cutting the crown part gives proper control. Annuals and biennials can be effectively controlled. Convolvulus arvensis which has shallow root system can be controlled.

Sickling

Sickling is also done by hand with the help of sickle to remove the top growth of weeds to prevent seed production and to starve the underground parts. These methods are useful for control of tall growing grasses. Especially sickling is useful in irrigation and drainage channels and where undulating topography is present.

Digging

Digging is useful for patch or spot control of obnoxious / perennial weeds. Digging is very useful in the case of perennial weeds to remove the underground propagating parts of weeds from the deeper layer of the soil. They can be eliminated by digging with crowbar or pick axe etc. for large areas. it is not desirable because it is costly and labour oriented.

Fig 5.3 sickling

Fig 5.4 Digging

Mowing

It is cutting of uniform growth from the entire area up to the ground level. It is useful more in non cropped areas than cropped areas. Mowing improves aesthetic value of an area. Effective against erect and herbaceous weeds.

Cutting

Cutting is the topping / cutting of the weeds little above ground level. It is done with help of axes and saws. It is mostly practiced against bushes and trees. In aquatics under water weed cutters are used.

Fig. 5.5 mowing with lawn mower improves aesthetic value

Fig 5.6 Dredging

Dredging

This is used to control aquatic weeds growing in shallow ditches. Mechanical pulling of aquatic weeds along with their roots & rhizomes from the mud.

Chaining

Very big & heavy chain is pulled over the bottom of a ditch with tractors along with embankments of ditch. With rubbing action of chain weeds can be fragmented & collected by nets and hooks.

Burning

It is cheapest method to eliminate the mature unwanted vegetation in non- cropped area and range lands. Coagulation of protoplasm occurs with which plant dies.

Flaming

It is the momentary exposure of green weeds to as high as 1000˚C from flame throwers to control in row weeds. Eg. Flaming is used western countries for selective weed control crops like cotton, onion, soybean and fruit orchards. Dodder is also controlled by flaming in lucern.

Searing

Repeated application of flame to above ground parts destroyed the root system and plant dies.

Fig. 5.7 Burning

Fig 5.8 flame througher (flaming)

Soil Solarization

It is also called solar soil heating.It is effective against weeds which are produced from seeds it doesn’t involve any tillage of the field.Covering the soil with transparent, very thin plastic sheets of 20-25 mm polyethylene (PE) film during hottest part of summer months for 2-4 weeks. This increases theTemparature by 10-12^{0}C over the unfilmed control fields.

Then weeds seeds are desiccted which are present at top 5 cm soil depth. Eg: *Phaliris minor, Avena* and broad leaved weeds controlled by Solarization. Where as *Melilotus spp*. Posses hard seed coat is resistant to solarization treatment.

Cheeling

An implement called cheel (spade like implement with very long handle) with which weeds & soil can be racked up. Generally practiced in tea plantations.

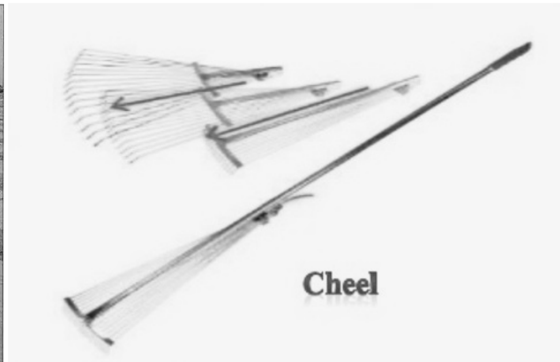

Fig: 5.9 Solarization with polyetheline film Fig: 5.10 Cheeling implement

Tillage

Tillage is done for preparing good seedbed, conservation of soil moisture &weed control. Tillage removes weeds from the soil resulting in their death. It may weaken plants through injury of root and stem pruning, reducing their competitiveness or regenerative capacity: Pre plant tillage helps in burying the existing weeds. Bring the sees to th soil surface for germination and their subsequent destruction by suitable secondary tillage implements. Incorporation of pre-plant herbicides. Post plant tillage (row cultivation) helps in mixing of manures and fertilizers & control of weeds, soil and water conservation.

Fig:5.11 Pre Plant Tillage. Fig:5.12 Inter Tillage.

Mulching

Principle is exclusion of sunlight rom environment. Polythene sheets, natural materials like paddy husk, ground nut shells, saw dust etc., are used as mulching material.

The thickness should be enough to cut off light (i.e., 10-15cm). The efficiency of polythene sheet is more (more polythene) if it is applied in continuos sheet rather than in particle farm. It is effective against annual weeds and perennial weeds like *Cynodon dactylon* and *Sorghum halopense*. Mulching is used in high value crops like coffee, tea plantations by using guatemala grass (*Tripsacum laxum*) and citronella grass (*Cymbopogan spp)*.

Fig: 5.13 Mulching

Fig: 5.14 Inter cultivation with blade harrow.

Flooding

Flood kills weeds by excluding oxygen from their environment. Flooding is a worldwide crop husbandry method of controlling weeds in rice fields.

Fig: 5.15 Hand cultivator.

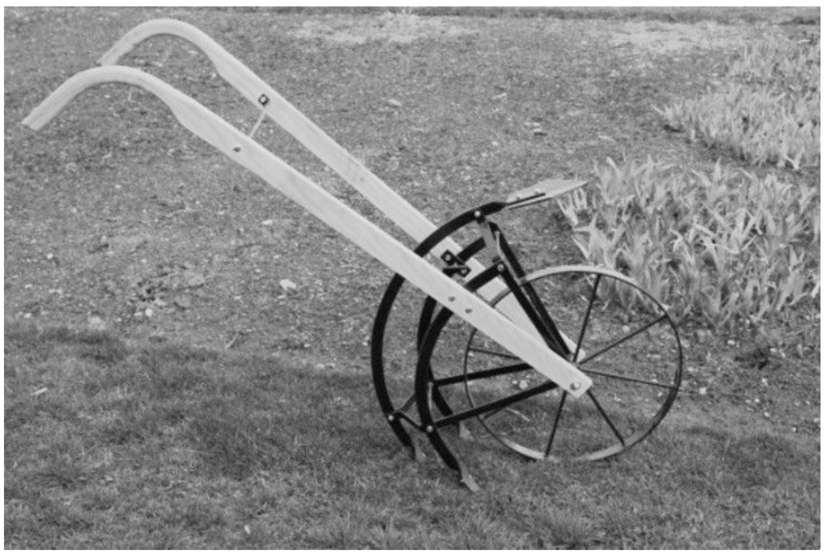

Fig: 5.16 Push Hoe.

Fig: 5.17 Weeding Fork.

Cultural Practices / Crop Husbandary Practices

Principle behind this is giving competitive advantage to the crop. Cultural methods, alone cannot control weeds, but help in reducing weed population. They should, therefore, be used in combination with other methods.

1. Proper crop stand and early seedling vigor.
2. Selective crop simulation.
3. Proper planting method.
4. Planting time.
5. Crop rotation.
6. Stale Seedbed.
7. Smother crops.
8. Minimum tillage.
9. Summer fallowing.
10. Lowering area under bunds.
11. Flooding and drainage.

Proper Crop stand and Early Seedling Vigor:

Lack of adequate plant population is prone to heavy weed infestation, which becomes, difficult to control later. Therefore practices like a). Selection of most adopted crops and crop varieties, b). Use of high viable seeds, c). Pre plant seed and soil treatment with pesticides, dormancy breaking chemicals and germination boosters, d). Adequate seed rates are very important to obtain proper and uniform crop stand capable of offering competition to the weeds.

Selective Crop Simulation

In crop weed competition, competitive advantage is achieved by selective simulation of crop growth. Vigorous crop plants compete better with weeds as they close the ground very quickly. Selective simulation can be achieved by a) application of soil amendments like gypsum or lime may correct the soil conditions in favour of crop growth, b). addition of FYM or synthetic soil conditioners to very light or heavy soils may improve the soil structure and maintaining better air water relationship and ultimately it improves the crop growth, c). Manures and fertilizers application of proper kind in adequate quantities improve the crop growth, d) Inoculation of crop seeds with suitable nitrogen fixing and phosphorous solubulising organisms may helps in selective simulation of some crops Eg: Legume crop and non legume weed. Selective simulation in wide row crops like maize, sugarcane, cotton can be achieved by foliar application of nutrients.

Proper Planting Method

Any planting method that leaves the soil surface rough and dry will discourage early growth. Plough planting (minimum tillage) methods proved to be very useful to reduce early weed growth. In summer, furrow planting of crops reduce the weed problems. Because in this method irrigation water restricted initially to the furrow only. In transplanted crops farmers get opportunity to prepare weed free main field.

Fig: 5.18 Surface irrigation method.

Fig: 5.19 Furrow method of irrigation.

Planting Time

Peak period of germination of seasonal weeds coincides with crop plants. So, little earlier or later than normal time of sowing is beneficial by reducing early crop weed competition. Eg: Using photo insensitive varieties we can make adjustments with regarding to time of planting.

Crop Rotation

Growing of different crops in recurrent succession on the same land is called as crop rotation. Monocropping favours persistence and association of some weeds. Crop rotation is effective in controlling of crop associated and crop bund weeds such as, *Avena fatua* in wheat and *Cucuta* in pulses. Wheat-pea and gram break the *Avena* in wheat, rice-rice crop rotation control *Cuscuta*. The obnoxious weeds like *Cyperus rotundus* can be controlled effectively by including low land rice in crop rotation.

Stale Seedbed

It is the one where one or two flushes of weeds are destroyed before planting of any crop. This is achieved by soaking a well prepared field with either irrigation or rain and allowing the weeds to germinate. These weeds are controlled by using contact herbicides like paraquat and by mechanical methods then sow the crop. Here the advantage is the crop is germinated in weed free environment. In this way, weed seed bank is exhausted.

Smother Crop / Competitive Crop

This crop germinates very quickly and develop large canopy, capable of efficient photosynthesis within short period. They possess both surface and deep roots. Competitive crop smother the ground quickly than non competitive crop. Eg: Cowpea, Lucerne, Beseem, Horsegram.

Fig: 5.20 Cow pea (smother crop)

Fig: 5.21 Inter cropping.

Growing of Inter Crops

Inter cropping suppresses weeds better than sole cropping and thus provides an opportunity to utilize crops themselves as tools of weed management. Many short duration pulses viz., green gram and soybean effectively smother weeds without causing reduction in the yield of main crop.

Minimum Tillage

Deep and frequent tillage may be useful for some reasons but it serves to bring more of dominant weed seeds and rhizomes to the soil surface, preserve the new weed seeds deep in the soil for the future. Zero tillage completely avoids burying of weed seeds and reduces persistence of annual weeds but it induces vigorous growth of perennial weeds.

Summer Fallowing

The practice of summer tillage or off –season tillage is one of the effective cultural methods to check the growth of perennial weed population in crop cultivation. In the month of April, May and June farmers expose their lands to sun in order to control many soil borne pests, including weeds, roots, rhizomes and tubers of shallow rooted perennials like bermuda grass and nutsedge.

Fig: 5.22 Summer Tillage. Fig: 5.23 Zero Tillage.

Lowering Area under Bunds

Bunds are made in field for the purpose of irrigation or ideal places for the rapid growth of weeds. One way to tackle the problem of weeds on bunds is to level the land well so that less no. of bunds is needed to irrigate the field.

Flooding and Drainage

Flooding is worldwide crop husbandry method controlling weeds in rice fields. Controls terrestrial weeds: To ensure the effectiveness of flooding the weeds should be submerged sufficiently for a longer period (i.e., for 2 weeks or more). Excludes O_2 from environment and kills the weed. In M.P. deep flooding of fallow land is followed in rainy season and water is let out after 2-3 months. This practice locally called Haveli. Drainage is used for controlling aquatic and semi aquatic weeds in rice fields, channels, canals and ponds.

Biological Control

Utilization of natural living organisms, such as insects, herbivorous fish, other animals, disease organisms and competitive plants to limit their growth. In biological control method, it is not possible to eradicate weeds but weed population can be reduced. This method is not useful to control all types of weeds. Introduced weeds are best targets for biological control. The control *Opuntia spp* (prickly pear) in Australia and *Lantana* in Hawai with certain insect bioagents are two spectacular examples of early period biological control of weeds.

Merits

1) Least harm to the environment.
2) No residual effect.
3) Relatively cheper and comparatively long lasting effect.
4) Will not affect non-targeted plants and safer in usage.
5) It is very effective in control of weeds in non cropped areas.
6) Besides this some of the fish, snails and other animals convert weed vegetation into seafood.

Demerits

1) Multiplication is costlier.
2) Control is very slow.
3) Success of control is very limited.
4) Very few host specific bio-agents are available at present.

Chemical Control
Definition

Herbicides are chemicals capable of killing or inhibiting the growth of plants. To day we have 150 herbicides in common use for selective and non selective control in different areas.

Historical Development of Herbicides

Common salt, ash etc., have been used for centuries to control weds on roadsides, fence rows & pathways. But Selective control of weeds in Agriculture was first conceived in 1896 with the chance observation of French farmer that Boardeaux mixture sprayed on Grape vine to control downy mildew damaged certain broad leaved weeds. It was found $CuSo4$ present in the Bordeaux mixture was responsible for its weed killing effect.

Between 1896 and 1908 several inorganic salts as also sulphuric acid were found selective to small grain crops. A real breakthrough in selective weed control was achieved in 1945, with the discovery of 2, 4-D & MCPA in USA & England independently by P.W.Zimmerman and A.E. Hitchkock. Both 2,4-D and MCPA were found highly selective for cereals and phytotoxic to broad leaved weeds.

In agriculturally developed countries, herbicides form over 45% of the total pesticides used. In India, share of herbicides is only 18% of the total pesticides consumed.

The average herbicide usage in India is 40g/ha/year as against 675-1350 g/ha/year in many advanced countries. While in Japan it is as much 5,000g/ha/year. The present annual capacity of herbicides production in India is about 6000 ha^{-1}. About $3/4^{th}$ of the available herbicides in India are used in rice and wheat crops.

Objectives of Herbicides Usage

1. The primary objective of introducing herbicides in Agriculture is to replace the drudgery of manual weeding.
2. The labour power could be utilized more effectively for bringing additional land under cultivation and for improving the overall Agricultural production.
3. Decreasing costs of hired labour and limited supply of fuel for mechanical weed control.
4. Herbicides are not aimed at substituting the Physical, Biological or good crop husbandry methods. These are only meant to bridge the gap in these methods.
5. In water bodies herbicides can be efficiently employed to free them of their weedy vegetation that hinder the proper water use.

Advantages of Herbicide Usage in Agriculture

1. Herbicides are useful in areas where incessant rain fall may hinder the physical weeding during monsoonal season.
2. Herbicide usage reduce the competition for labour during early stages of crop growth.
3. They control germinating weed and thereby make the crop weed free and more competitive during early stages.
4. They are useful to control weeds which mimic crop plants.
5. Herbicides doesn’t dictate strict row spacing.

6. They have long lasting effect on control of brush weeds and perennial weeds.
7. Convenient to use on thorny/spiny weeds.
8. They are more efficient to control weeds on aerodable soils where tillage may accelerate soil and water erosion.
9. They kill the weeds insitu without dissemination of vegetative propagules.
10. Herbicide sprays easily reach the weeds growing in obstructed situation under fruit trees and on undulating areas.
11. Fewer labour problems.
12. Greater possibility of mechanization.
13. Easy crop harvesting.
14. Weeds controlled in crop rows.
15. Increased water use efficiency in dry land agriculture and less crop failures due to drought.

Disadvantages

1. No automatic signal to stop farmer who may applying the chemical inaccurately.
2. Contaminate the environment.
3. They interact with environment to produce unintended results like drifts, runoff and wash off.
4. So many herbicides are needed to control weeds depending upon farm diversity.
5. Skill is needed in the use of herbicides.
6. In sequence cropping, the herbicide used for first crop may affect the 2nd crop (see that they don't damage the 2nd crop). Here selectivity is a major problem.
7. Military use of herbicides 2,4-D & 2,4-T (Vietnam, Chemical Warfare) for defoliating forests.

Integrated Weed Management

System approach also called as integrated weed management. "Integrated method is a system which brings all feasible methods of weed control harmonizing them into a single and coordinated system designed to maintain weeds below those levels at which they cause economic loss".

Principles of Integrated Weed Management (IWM)

1. IWM place the crop in competitive advantage over the weeds by manipulating the crop habitant by utilizing some biological differences between crops and weeds.
2. In IWM measures should be directed to reduce the survival mechanism of weeds in the soil.
3. Crop cultural practices should be incorporated to discourage the establishment of the perennial and parasitic weeds. Eg: Crop rotation.
4. Any individual element of the weed management should be eco friendly and it should not be harmful to the environment.
5. Weed management practices should be flexible to accommodate possible innovations and experiences of progressive farmers.

Advantages

1. It shifts the crop-weed competition in favour of crop.
2. Prevents weed shift towards perennial nature.
3. Prevents resistance in weeds to herbicides.
4. No danger of herbicide residue in soil or plant.
5. Non environmental pollution.
6. Gives higher net return.
7. Suitable for high cropping intensity.

5.4 Classification of Herbicides

I. Classification Based on Chemical Nature.

Herbicides are primarily grouped into inorganic and organic herbicides. Inorganic herbicides donot contain carbon atoms in their molecules. They were the first chemicals used for weed control. Arsenic acid, sulphuric acid are acid type of inorganic herbicides. Whereas sodium arsenate, sodium chlorate, copper sulphate etc., are inorganic salts.

Organic herbicides:

These herbicides contain carbon atoms in their molecules. They may be oils or non oils. Eg. Diesel, Xylene type of aromatic oils. Majority of present day herbicides are non oils.

There are about 150 herbicides are available. They differ each other like behaviour in soil, plants, mode of action etc., based on this chemical nature, the herbicides are grouped into 31 classes.

Based on chemical nature:

Sl. No.	Group with examples
1.	Aliphatics .eg.dalapon
2.	Amides&acetamides.eg.butachlor,alachlor
3.	Benzoics.eg.dicamba
4.	Bipyridiliums.eg.paraquat,diquat
5.	Carbamates.eg.asulam
6.	Thiocarbarmates.eg.benthiocarb
7.	Triazinones.eg. metribuzin.
8.	Nitriles.eg.bromxynil,ioxynil
9.	Dintroanilins.eg.fluchoralin,pendimethalin
10.	Phenols.eg.dinoseb
11.	Phenoxy acids.2,4-D.2,4-T
12.	Traizines.eg.atrazine,simazine
13.	Ureas.eg.diuron,isoproturon
14.	Uracils.eg.terbacil,bromacil
15.	Diphenyl ethers.eg.oxyfluorfen,nitrofen
16.	Aryloxy phenoxy propionates.eg.fenxapropethyl,quizlafopethyl
17.	Cyclohexanediones.eg.clethodim,sethoxydim
18.	Imidazolines.eg.imazethapyr,imazamox
19.	Isoxazolidinones.eg.clomazone
20.	Oxadiazoles.eg.oxadiargyl
21.	Oxadiazolides.eg.methazole
22.	N-Phenyl thalamides.eg.flumiclorac
23.	Phenyl Pyridazines.eg.pyridate
24.	Phthalamates.eg.naptalam
25.	Pyrazoliums.eg.difenzoquat
26.	Pyridines.eg.dithiopyr.thiazopyr
27.	Quinolines.eg.quinclorac
28.	Sulfonylureas.eg.bensulfuron,chlorimuron
29.	Triazolinones.eg.carfentrazone
30.	Cineoles.eg.cinmethylin
31	Triazolopyrimidines eg.penoxsulam,cloransulam
32	Oxyacetamide eg flufenacet
33.	Others/unclassified eg.glyphosate,glufosinate

II Classification Based on Methods of Application of Herbicides:

Methods of application of herbicides are decided largely by their modes of action and selectivity. Important methods of application of herbicides to crop and non-crop land are given, as follows:

Soil-Activeherbicides eg.pendimethalin
Foliage-Active Herbicides.cyhalfopbutyl
Soil&foliageActive Herbicides.eg oxyfluorfen

III Classification based on l

Time of Application of Herbicides Pre-Plant Treatment.

Any herbicide treatment made any time before the crop is planted is called a preplant treatment. There are two types of preplant treatment, namely (a) preplant desiccation and (b) preplant incorporation treatment. In the former method herbicides are applied to destroy the standing vegetation as an aid to seedbed prepartation. Field preparation is done after the application. Eg: Paraquat, Glyphosate. In the preplant incorporation method (PPT), on the other hand, herbicides are mixed with the soil in weed-freeseed-beds to obtain residual control of weeds during the crop season. Eg. Fluchloralin, Pendimethalin, Trifluralin.

Pre emergence treatment:

Application of herbicides soon after planting of a crop is called pre emergence treatment. But sometimes, a pre emergence treatment is further specified as pre emergence to weeds, when it may be applied to standing weed free crop rows, benthiocarb in rice, atrazine in maize, diuron in cotton pendimethalin, butachlor (Pre emergence selective herbicide). Pre emergence application of herbicide for irrigated dry crop and paddy fields.

Fig: 5.24 Pre emergence herbicide application.

Post Emergence Treatment:

Post emergence treatment is the application of herbicide after the emergenceof both the crops and the weeds. But when the weeds grow before the crop plants have emerged through the soil, and these are knocked with an herbicide. The treatment is called early Post Emergence treatment.

Fig: 5.25 Post emergence herbicide application

Herbicides used for the early post emergence treatment are usually non-residual types, eg. paraquat and diquat. Propanil in rice at 25 DAT 2,4-D at 30 DAT of paddy. Isoproturon both pre and post emergence in wheat Lay-by application: It is the application of herbicides after the last cultivation in crops, such as, after ridging in sugarcane and cotton.

Herbicides

Selective	**Non-Selective**	
Fliage applied/active	Soil applied (root active).	
Contact	Trans located (Systemic) Mobile in plants.	
Ex. Propanil	2,4-D	Ex. Atrazne.
Bromoxynil	MCPA	Diuron.
Dinoseb	2,4-DB	Alachlor.
Atrazine	2,45-T	Anilophos.

Non- Selective

Foliage applied / Active

Contact	Translocated (Systemic)
Paraquat	Glyphosate
Diquat	2,4,5-T
Glufosinate	Dalapon
Amitrole	

Non-mobile in plants

Ex: Nitrofen.
Trifluralin.
Endothall.
Soil applied.

Residual	Non-Residual	Fumigant	Permanent soil sterilant
2-4 weeks	DSMA	(Volatile)	Atrazine
Ex. 2,4-D	Paraquat	Temporary	Bromoxil
EPTC	Amitrole soil sterilent	Borate Diquat	Upto 16 Weeks Arsenicals
Ex. Metham			Dazomet.

5.5Chemical Weed Control in Different Crops:

Rice

Rice is grown by direct and transplanted conditions. Weed competition is more in direct seeded rice. Reduction in yield to the tune of 34% in transplanted rice, 45% in direct seeded low land rice and 67% in upland rice are reported. Weed competition in direct seeded rice is greatest during the first three weeks. The critical period for weed free condition for higher productivity is reported to be 30-35 days in transplanted rice where as, direct seeded low land and upland condition the weed free period ranges from 40-60 days.

Fig: 5.26 Chemical weed control in paddy

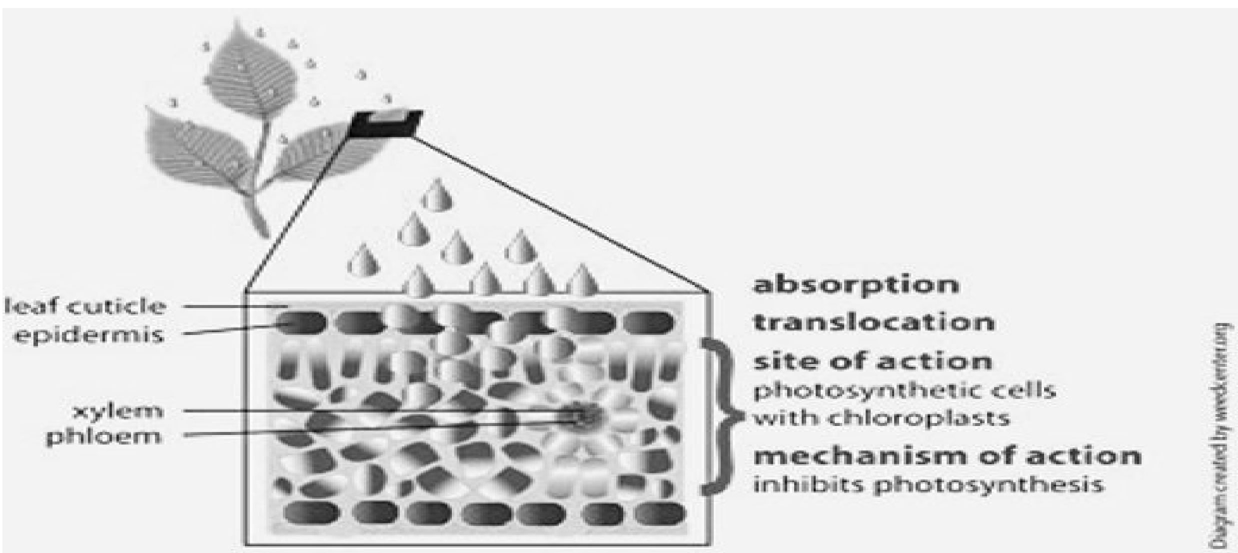

Fig: 5.27 Mode of action.

The major weeds observed in rice crop are grasses which includes E.*colonum, E.crusgalli, Eleusine indica, Setaria glauca, Cynodon dactylon,* the sedges *Cyperus rotundus* and *Firmbristylis spp* and the broad leaved weeds and aquatic weeds. Trianthema portulacastrum, *Cynotis axillaris, Digera arvensis, Euphorbia hirta, Phyllanthus niruri, Eclipta alba* and *Chara spp(*Algae*)*

Nursery

Controlling weeds at the nursery level itself is rewarding. Hand pulling is the common method of weed control in nurseries. Application of butachlor (0.75-1.0 kg./ha) or pretilachlor+safenor (sofit)(0.75kg/ha), anilofos (0.25-0.5 kg/ha) at 4-7 days before or after sowing through ponded water. Whereas or cyhalofop butyl (clincher) 0.1 kg a.i/ha (for gasses control) bispyribac sodium 20g a.i/ha(for grasses and broad leaf weeds) on 15th day after sowing results in effective control of weeds. .

Upland Rice

In upland drilled rice a suitable pre emergence herbicides are butachlo1.0kg/ha or pendimethalin 0.75kg/ha to control annual grasses and broad leaved weeds (BLW).

Post emergence herbicides to control grasses and BLW is bispyribac sodium 20g a.i/ha effective at 2-3 leaves stage. 2,4-D @ 0.5-1.0 kg a.i/ha effective to control established broad leaved weeds and sedges to some extent

In addition to this for broad leaved weed control ethoxysulfuron (sunrise) @ 20g a.i/ha) applied at 20 days. Chlorimuronethyl +metsulfuron methyl @ 4.0g/ha respectively to control broad leaved weeds. .

Low Land Transplanted Rice

Pre emergence application butachlor @ 1.0-1.5, anilophos 0.25-0.30, oxadiargyl 0.080-0.100 kg/ha to control grasses and broad leaved weeds, where as 2,4-D ester 4% granules (0.8-1.2 kg/ha) controls sedges and broad laved weeds to control broad leaved weeds. Herbicides should be applied 3-5DAT. The field should not be drained till 3 days to obtain satisfactory weed control.

Post emergence herbicides are effective at 4-6 weeks after transplanting. The field should not be drained before the application of post emergence herbicide. cyhalofop butyl 0.100 kg/ha to control grasses, bispyribac sodium0.020kg/ha for control of grasses and BLW and ethoxysulfron 0.02 kg/ha for broad leaved weeds should be applied 20-25 DAT. Where as, 2,4-D sodium salt @ (0.800 kg/ha) used to control sedges and broad leaved weeds.

For controlling unwanted algal growth in the rice fields copper sulphate and copper oxy chloride @8-10 kg/ha have been used since long time. But now more effective products like brestan-60 (0.07-1.7kg a.i/ha) and potasium azide are available for this purpose.

Maize & Millets

Maize

Critical period of weed competition is upto 40-45 DAS. Maize yield was reduced as much 25-80%.

Control measures include

1. Selective crop stimulation.
2. 1-2 row cultivations twice at 25 and 40 DAS. It should be started with 15cm crop whorl height and continue up to 60 cm crop height.
3. Pre-emergence application of atrazine @ 1.5-2.0 kg/hato controlanual grasses and broad leaved weeds.
4. Alachlor @ 1-2 kg/ha as pre-emergence effective against annual grasses but weak on broad leaf weeds.
5. Pendimethalin @ 1-1.5 kg ai/ha for control of annual grasses and broad leaved weeds

Post Emergence

1. Atrazine @1.5 kg/ha or 2,4-D sodium salt 0.8 kg/ha at 25-30days to control the broad leaved weeds.
2. Topramezone @0.024kg/ha or tembotrione@0.06kg/ha to control grasses and BLW at 20-25 days

Sorghum

1. Critical period is 30-45 days. Yield losses due to weeds upto 40%
2. Atrazine @ 1.0-1.5 kg/ha are effective as pre emergence.
3. 2,4-D is a versatile post emergence herbicide @ 0.8kg/ha to control broad leaved weeds. It is also used to prevent striga.

Striga Control

1. Crop rotation with legumes or other trap crops. Trap crops helps to germinate striga seeds but makes striga not to form haustoria. Cotton, sunflower, groundnut and pigeonpea are trap crops.
2. Catch crops are sorghum maize and millets to reduce seed bank in the soil.
3. Post emergence application 2,4-D @ 1.0 kg a.i/ha as at 5th week after sowing is more effective.

Groundnut

Critical period for weed growth is 20-45 DAS. Losses as high as 70%

1. Below 40 days 1-2 hand weedings followed by intercultivation for bunch type of groundnut.
2. Pre-emergence application of Pendimethalin 0.75kg/ha or butachlor 1.0 kg/ha for control of annual grasses and broadleaf weeds
3. Post-emergence application of Fluazifop butyl @0.125 – 0.250 kg/ha or Quizalofopethyl 0.4-0.5 kg/ha at 20-25days after sowing groundnut against grasses especially Cynodon dactylon.
4. Imazethpyr @ 0.050 kg/ha for control of mixed growth of grasses and broadleaved weeds.

Sunflower

1. Critical period is 4-6 weeks after sowing. Yield losses26-50%

2. Pre-emergence application of Pendimethalin @0.75 kg/ha or Alachlor @1.0-1.5kg/ha or. Butachlor @1-1.5 kg/ha

3. Post-emergence application of Fluzifop-P butyl @ 0.25 kg/ha 21-25 DAS to control grasses.

Castor

1. Critical period is 6-8weeks after sowing.yield losses 30-45%

2. Pre-emergence application of alachlor @1-1.5 kg/ha.
   or pendimethalin @ 1.0 kg/ha.
3. Post-emergence application of quizalfopethyl0.050 kg/ha for control of grasses

Chickpea

1. Critical period is 4-5 weeks after sowing. Yield losses30-70%

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2. Pendimethalin as pre-emergence herbicide @ 0.75 kg a.i/ha.
3. Quizalofopethyl @ 0.04-0.05 kg/ha as post-emergence to control annual grasses.

Greengram and Blackgram

1. Critical period varies from 30-40 days. Yield reduction upto 50%.
2. Need two intercultivations at15 days and 30 days give effective control of weeds.
3. Pre-emergence application of alachlor @ 1.5 kg/ha or pendimethalin @ 0.75 kg/ha
4. Post emergence application of or imazethapyr 0.05 kg/ha to control grasses and broad leaved weeds.
5. Post-emergence application of fluazifop-P butyl @ 0.25-0.375 kg/ha or clodinafop propargyl @ 0.075 kg/ha or quizalofopethyl @ 0.05 kg/ha for control of grasses.

Pigeonpea

1. Critical period for weed competition upto60 days after sowing.yield losses 50-75%
2. Being a long duration crop it require 2-3 intercultivations.
3. Pre-emergence application of pendimethalin 0.75 kg/ha or alachlor (1-1.5kg/ha) to control grasses and broad leave weeds.
4. Post-emergence application of quizalofopethyl @ 0.04-0.05 kg/ha for control of annual grassess.
5. Post emergence application of or imazethpyr 0.05 kg/ha to control grasses and broad leaved weeds.

Cotton

1. Critical period for weed competition upto60 days after sowing.yield losses 50-85%
2. Being a long duration crop it require 2-3 intercultivations.
3. Pre-emergence application of pendimethalin 0.75 kg/ha or alachlor (1-1.5 kg/ha) to control grasses and broad leaved weeds.
4. Post-emergence application of quizalofopethyl @ 0.04-0.05 kg/ha for control of annual grassess.
5. Post emergence application of quizalofopethyl 0.05+pyrithiobac0.05kg/ha to control grasses and broad leaved weeds when in intercultivation not possible

Sugarcane

1. For germination sugarcane take about 20 to 30 days .Critica1period for weed Competition upto 90 days after planting.yield losses 15-72%
2. Being a long duration crop it requires 3-4 intercultivations.
3. Pre emergence application of atrazine2.0 kg/ha for the control of broad leaved weeds.
4. Pre emergence application of pendimethalin @ 1.0-1.5 kg/ha.
5. Metribuzin 0.75kg/ha a superior pre-emergence to control grasess and broad leaved weeds.
6. Post emergence application of 2,4-D @ 1.0 kg/ha as semi directed spray about 8 weeks age of the cane effectively controls the BLW
7. Post emergence application of metribuzin@ 1.25+2,4-D sodiumsalt @1.25kg/ha at 40 days after planting as semi directed spray found to be effective in controlling grasses and broadleaved weeds

Tobacco

First 9 weeks after transplanting is critical period.Yield losses upto 40-50%

Fumigants (in nursery)

1. MB @ 5-10 kg per 100 m^2 broad leaved weeds grass weeds are effective. Metham @ 2-5 kg/100m^{22}
2. MB a very volatile liquid is applied beneath a plastic gas proofing cover. Exposure below the cover should be for 1-2 days. The beds should be aerated 2-4 days before sowing seeds.

3 Metham should be applied 3 weeks before planting and watering needs to be done after application.

4. Post emergence application of fenoxapropethyl@0.056g/ha at 25-30 DAS for control of grasses.

Main Field

1. 2 or 3Criss cros intercultivations will effectively control weeds

.

2. Pre planting application of Pendimethalin @ 1-1.5 kg/ha for control of annual grasses and BLW.
3. Post emergenc application of fenoxapropethyl@0.056kg/ha at 25-30 DAP for control of grassy weeds

Orobanche

1. Lossess due to Orabanche is upto 35%.
2. Soil fumigtion with DMTT @ 300-350 kg/ha 30-40 day before transplanting.

Post-emergence

3. Glyphosate @ 50-500 g/has directed spray

.

5. Allyl alcohol @ 0.1-0.2 % (2-4 weeks after transplanting).

Vegetables

Vegetables are initially slow growing crops incapable of offering competition to the aggressive weeds. Hand weeding is the most common practice.

Nurseries

1. Metham 1 kg/20m^2 Treat the beds then drench with water for 48 hr. cultivate 5-7 latter and sow the seed 7-15 days after it.
2. Methyl Bromide 1 kg/20m^2 furmigate for 24 hrs and sow the seed 3 days later.

Vegetable Crops
Chilli

a) Direct sown chillies: critical period upto 90 days.yield losses upto60%

1. Pre emergence application of pendimethalin @0.5kg/ha or alachlor @1.0kg/ha
2. Intercultivation 3 or 4 times for control of weeds
3. Post-emergence application of quizalofopethyl @ 0.04-0.05 kg/ha for control of annual `grassess

b)Transplanted chillies.critical period upto 60 days after planting.yield losses upto40-50%

1. Pre planting application of pendimethalin @0.75kg/ha or alachlor @1.5kg/ha
2. Intercultivation 3 or 4 times for control of weeds
3. Post-emergence application of quizalofopethyl @ 0.05 kg/ha for control of annual `grassess

Onion

Pre-emergence (in nursery 3 DAS)	Oxyfluorfen@0.05 kg/ha.
Pre-planting (Transplanted Crops 2 DAS)	Alachlor (1.5 kg/ha), butachlor (1.0 kg/ha), Pendimethalin (0.75-1.0 kg/ha), Oxyfluorfen (0.125kg/ha),
Post-emergence (25-30 DAS)	Oxyfluorfen @0.125 kg/ha)

Okra

Pre-plant	Fluchloralin (1.0-1.5 kg/ha)
Pre-emergence	Pendimethalin @0.75 kg/ha,
Post-emergence	fenoxapropethyl@0.056kg/ha at 25-30 DAS

Tomato

Pre-planting: Alachlor 1.0 kg/ha), Trifluoralin (0.75 kg/ha).

Herbicides Recommended in Orchards.

Banana	Alachlor@1.5kg/ha,pendimethalin, 1.0 kg/ha.
Citrus	Alachlor@1.5kg/ha,pendimethalin, 1.0 kg/ha
Mango	oxyfluorfen@0.125kg/ha.

Directed spraying of glyphosate@1.0kg/ha

Summary:

Weeds are unwanted plants and compete with crop plants for nutrients, light, $CO_2$and water. Harmful effects and loss caused by them are well documented. Based on the morphology and other parameters the weeds are classified so that their control is made moreeasier and scientific. The stage at which the weed competition causes economical loss is called critical stage and measures are to be taken at this stage to avoid the losses.

Prevention, eradication and control are three basic principles followed in weed control system. Prevention is not possible or not economical. Therefore control is the best option.

Various methods viz., mechanical, cultural, biological and chemical are used based on appropriate situation.

Herbicides are classified into organic and Inorganic and other sub groups where in they are used as per crop weed selectivity.

Weed control package in crops and cropping system is well documented and recommended to farmers.

Short Answer Type Questions:

1. Define weed?
2. What are the loses due to weeds?
3. What is crop weed competition?
4. Write chemical weed control in Rice?
5. Write chemical weed control in Maize?
6. Write chemical weed control in Groundnut?
7. Write chemical weed control in Sugarcane?
8. Write chemical weed control in Chilli?
9. Write chemical weed control in Tomato?
10. Write chemical weed control in Mango?

Long Answer Type Questions:

1. Write the classification of weeds based on morphology, lifecycle and habitation?
2. Write the herbicide classification based on time of application?
3. Write about integrated weed management?
4. What are the principles of weed management?

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UNIT 6

Sustainable Agriculture

Introduction

Over the history of human settlements on the planet earth, agriculture has transformed in tune with the growing population and its challenging needs. The transformation has been quite remarkable since the end of World War II. Food and fiber productivity spared up due to adoption of new technologies Viz, HYV, farm mechanization, increased fertilizer & pesticide use, specialized farming practices, water resource development & improved irrigation practices and Government policies that favored maximizing production. It was in the early 1960s, the Green Revolution took shape in developing countries, especially in India. It led to the attainment of self- sufficiency in food grain production. This has been described by Donald Plukett (1993), scientific adviser to the CGIAR, as the greatest agricultural transformation in the history of humankind and most of it has taken place during our lifetime. The change was brought about the rise of Science-based agriculture which permitted higher and more stable food production, ensuring food stability and security of a constantly growing world population. A major problem was that these benefits have been poorly distributed. Many people have missed out and hunger still persists in many parts of the world. Estimates by the FAO and WHO (1992) and the Hunger Project (1991) suggest that around 1 billion people in the world have diets that are too poor to abstain the energy required for healthy growth of children and minimal activity of adults. The causes are complex and it is not entirely the fault of overall availability of food. Nonetheless, the process of agricultural modernization has been an important contributing factor, in that the technologies have been more readily available to the better-off.

Modern agriculture begins on the research station, where researchers have access to all i.e., necessary inputs of fertilizers, pesticides and labour at all the appropriate times. But, when the package is extended to farmers, even the best performing farms cannot match the yields the researchers get. For high productivity per hectare, farmers, need access to the whole package- modern seeds, water, labour, credit, fertilizers and pesticides. Many poorer farming households simply cannot adopt the whole package. If one element is missing, the seed delivery system fails or the fertilizer arrives late, or there is insufficient irrigation water, then yields may not be much better than those for traditional varieties. Even if farmers want to use external resources, very often delivery systems are unable to supply them on time.

Where production has been improved through these modern technologies, often there have been adverse environmental and social impacts in both advanced and developing countries including India. These include the following:

Adverse effects of modern high – input agriculture

- Overuse of natural resources, causing depletion of groundwater, and loss of forests, wild habitats and of their capacity to absorb water, causing waterlogging and increased salinity
- Contamination of the atmosphere by ammonia, nitrous oxide, methane and the products of burning, which play a role in ozone depletion, global warming and atmospheric pollution.
- Contamination of food and fodder by residues of pesticides, nitrates and antibiotics.
- Contamination of water by pesticides, nitrates, soil and livestock water, causing harm to wildlife, disruption of ecosystems and possible health problems in drinking water.
- Build up of resistance to pesticides in pests and diseases including herbicide resistance in weeds.
- Damage of farm and natural resources by pesticides, causing harm to farm workers and public, disruption of ecosystems and harm to wildlife.
- Erosion of genetic diversity – the tendency in agriculture to standardize and specialize by focusing on modern varieties, causing the displacement of traditional varieties and breeds.
- New health hazards for workers in the agrochemical and food – processing industries

Added to the above adverse effects, the increasing human as well as cattle population is imposing intense pressure on available natural resources. Accordingly, a challenge has emerged that required a new vision, holistic approaches for ecosystem management and renewed partnership between science and society.

In December 1983, the UN General Assembly established the world Commission on Environment and Development. In 1987, on 27th of April, at the queen Elizabeth Hall in London, the Prime Minister of Norway, Mrs. Brundtland, who is also the Chairman of the World Commission of Environment and development, released the publication of "Our Common Future" by the world Commission on Environment and Development (WCED) and said:"Securing our common future will require new energy and openness, fresh insights, and an ability to look beyond the narrow bounds of national frontiers and separate Scientific disciplines. The young are better at such vision than we, who are too often constrained by the traditions of former, more fragmented world.

We must tap their energy, their openness, their ability to see the interdependence of issues… "she suggests that we must adopt a new paradigm based on a completely new value system. " Our generation has too often been willing to use the resources of the future to meet our own short- term goals. It is a debt we can never repay. If we fail to change our ways, these young men and women will suffer more than we, and they and their children will be denied their fundamental right to a healthy productive, life- enhancing environment.” Her speech made it clear that we are consuming resources, which must be transferred to the next generation. We must recognize that, because resources are limited, we need a sustainable way of life.

Almost at the same time the realization of prime importance of staple food production for achieving food security for future generations has brought the concept of “Sustainable Agriculture” to the forefront and began to take shape in the following three points.

1. The interrelatedness of all the farming system including the farmer and the family.

2. The importance of many biological balances in the system.

3. The need to maximize desire biological relationships in the system and minimize the use of materials and practices that disrupt these relations.

Sustainability of agricultural systems has become a global concern today and many definitions so Sustainable Agriculture has become available.

Definition of Sustainable Agriculture

Sustainable Agriculture refers to a range of strategies for addressing many problems that effect agriculture. Such problems include loss of soil productivity from excessive soil erosion and associated plant nutrient losses, surface and ground water pollution from pesticides, fertilizers and sediments, impending shortages of non- renewable resources, and low farm income from depressed “sustainable” implies a time dimension and the capacity of a farming system to endure indefinitely. (Lockertz, 1988).

The successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the Natural resource-base and avoiding environmental degradation (TAC-CGIAR, 1988). A sustainable Agriculture is ‘ a system of agriculture that is committed to maintain and preserve the agriculture base of soil, water and atmosphere ensuring future generations the capacity to feed themselves with an adequate Agriculture system in one that can indefinitely meet demands for food and fiber at socially acceptable, economic and environment cost’ (Crosson, 1992).

A broad and commonly accepted definition of sustainable Agriculture in as follows:

Sustainable Agriculture refers to an agricultural production and distribution system that:

- Achieves the integration of natural biological cycles and controls
- Protects and renews soil fertility and the natural resource base
- Reduces the use of nonrenewable resources and purchased (external or off-farm) production inputs
- Provides an adequate and dependable farm income.
- Optimizes the management and use of on-farm inputs
- Promotes opportunity in family farming and farm communities and
- Minimizes adverse impacts on health, safety, wild life, water quality and the environment.

6.1 Factor affecting Ecological Balance

Technology generated and implemented for increasing Agricultural productivity during past three decades resulted in depletion of natural resource base besides creating several environmental and ecological problems. In contrast, the demand scenario features a growth rate in food requirements to meet the ever- increasing demand of the growing population. The total food grain demand of India by 2030 is estimated at 355 million tones as against the present 250 million tonns (2016-17) which has to come from the almost static net cultivated area of about 142 million ha. This improvement in food grain production has to be achieved while dealing with the factors affecting the ecological balance and sustainability of Agricultural resources.

Major factors affecting the ecological balance and sustainability of agricultural resources are:

a) Land / soil related problems

- Soil degradation
- Deforestation
- Accelerated soil erosion
- Siltation of reservoirs
- Wind erosion

b) Irrigation related problems

- Rise in groundwater table & water logging
- Soil salinization & alkalization
- Over- exploitation of groundwater

c) Indiscriminate use of agro- chemicals

- Fertilizer pollution
- Pesticide pollution

d) Environmental pollution

- Greenhouse effect
- Depletion emissions
- Methane emission
- Eutrophication

e) Erosion of genetic biodiversity

- Land / soil related problems

• Soil degradation

Soil degradation refers to decline in the productive capacity of land due to decline in soil quality caused through process induced mainly by human activities. It is a global problem. The Global Assessment of the Status of Human- induced soil Degradation (GLASOD) was the first worldwide comparative analysis focusing specifically on soil degradation. Worldwide around 1.96 billion ha are affected by human induced soil degradation, mainly caused by water and wind erosion (1.094 and 548 million ha respectively.) Chemical degradation accounted for 240 million ha, mainly nutrient decline (136 million ha) and salinization (77 million ha), physical degradation occurred on 83 million ha, mainly as a result of compaction, sealing and crusting.

Fig. 6.1 Wind Erosion

It is also a very important problem in India, which shares only 2.4 % of the world's land resource and supports more than 18% of the world's human population and 15% of livestock population. Estimates of soil degradation are varied depending upon the criteria used.

The soil degradation through different processes is shown in Fig.6.2. The processes leading to soil degradation are generally triggered by excessive pressure on land to meet the competing demands of growing population for food, fodder, fiber and fuel.

Fig.6.2 Water Erosion

Therefore, the direct cause for soil degradation is unsustainable land use and inappropriate land management. The most common direct causes include:

- Deforestation of fragile lands
- Over cutting and grazing of vegetation
- Extension of cultivation on to lands of low capability / potential
- Improper crop rotations
- Unbalanced fertilizer use
- Non- adoption of soil conservation practices
- Inadequacies in planning and management of irrigation resources
- Overdraft of groundwater in excess of capacity to recharge

The strategies for improving soil quality and sustainability include –skilled management, crop rotation, soil and water conservation, conservation tillage integrated nutrient management, integrated water management, integrated pest management and integrated (crop & livestock system) farming systems,

Deforestation

Deforestation, in strict sense of the term, refers to the transfer of forest land to non-forest uses and includes all land where the forest cover has been stripped off and the land converted to such uses as permanent cultivation, shifting cultivation, human settlements, mining, reservoirs etc. Deforestation continues to threaten and erode the area under forest cover in several countries of the world.

The underlying causes of deforestation are rooted in a complex web of social, economic and institutional problems. They include:

(i) The combined effects of poverty, skewed land distribution, and rising population pressure

(ii) Increased demand for tropical timber and Agricultural products, and

(iii) International debt obligations, which can lead developing countries to accelerate the pace of forest exploitation in order to earn needed foreign exchange.

The forest area in India has shrunk from 33% in 1947 to 22.6 % at present. As per the recommended norms of the National forest Policy 1988, about 33% of the geographical area should be under the forest cover, which comes to about 110 million ha compared to 68.83 million ha presently under the forest cover in India

Deforestation, together with over grazing, is modifying the climate, and accelerating the erosion of biodiversity, which in turn posing the threat to ecological sustainability and food security.

Fig. 6.3 Deforestation

India has established an organization called the National Afforestation and Ecodevelopment Board (NAEB) in 1992 to take up afforestation programmes and bring back the productivity from the degraded forestlands

What is deforestation?

Deforestation is the process of clearing large areas of forest across the earth and involves the cutting down, burning, and damaging of forests.

Fig. 6.4 Deforestation

Accelerated Soil erosion

Agricultural productivity depends largely on the topsoil (up to 20 cm thickness), as it serves many functions such as, support for rooting, supply of plant nutrients, storage and release of soil moisture etc. The loss of the topsoil usually instigated by the activities of man, termed as accelerated soil erosion, is the most serious form of land degradation. Some erosion, however, takes place through natural processes slowly but some natural processes of decay and regeneration replace this loss. A balance is maintained between soil loss and soil formation, but when vegetation is stripped away, as in deforestation and shifting cultivation, the soil becomes vulnerable to damage by wind and water and the slow rate of natural erosion is accelerated. Under accelerated erosion, soil loss takes place much faster than new soil can be formed as result soil productivity goes down.

India is one of the few countries in the world, which has an audit of land degradation due to soil erosion, soil erosion estimates in India are given below in the table

Soil Erosion estimates in India

Table:1

Parameter	**Erosion (Million Tonnes)**	**Percent**
Total Soil from one place	5334	100
Transported soil from one place	3282	61
Deposited in reservoirs	480	10
Lost into the sea	1572	29

The analysis of the existing soil loss date indicate that soil erosion takes place at average rate of 16.35 tonnes/ha/year totalling 5.334 million tonnes/year. Nearly 29% of the total eroded soil was permanently lost to the sea and nearly 10% was deposited in multipurpose reservoirs, resulting in the reduction of their storage capacity by 1-2 % annually.

The remaining 61% of the eroded soil was transported from one place to another. Along with the eroded topsoil, three major plant nutrients viz., Nitrogen, phosphorus, and potassium from 4.4 to 8.4 tonnes are also lost. Crop yields are reduced by erosion through less supply of plant nutrients, shallow depth of soil, poor structure, surface sealing and crusting, which leads to reduced water infiltration and poor seedling establishment, In addition to this on-site effects, the off-site effects of erosion are also of serious concern for the sustainability of Agricultural productivity.

Siltation of Reservoirs

Siltation of reservoirs is the major off-site effect of soil erosion by water. The process of deposition of soil particles carried by water is called sedimentation or siltation. Sedimentation or siltation is both a serious and growing problem, but its severity varies from one reservoir to another. Usually, every reservoir is provided with certain storage capacity to accommodate for the natural sedimentation rate, which capacity is called its dead storage. Sediment accumulation is not controlled of the reservoirs and they are irreversibly getting filled with sediment and constitute the most non- sustainable water resource system in India today.

Table:2. Soil losses in different catchments of India.

Catchment	Loss of soil (t/ha/year)
Snow clad deserts	5.0
Shiwalik hills	80.0
Ravines of Chambal and other river	4.0
Western Ghats	20.0-30.0
Shifting cultivation of N.E. states	740.0

The life of many irrigation reservoirs has been reduced by accelerated soil erosion in the catchment area (Table 2) and increased the rates of siltation more than the assumed rates of the planning stage (Kanwar,2000). These increased rates of siltation are adversely affecting capacity of the reservoirs to sustain the gains in productivity achieved over the past decades. In addition to the drastic reduction in life of the projects involving huge investments, these accelerated rates of siltation causing floods that effect life and property quite often. The area annually are causing floods that effect life and property quite often. The area annually flooded, including cropland, has increased from an average of 6.86 m ha in fifties to 16.57 m ha in the eighties. Published data on 116 large dams showed that by the year 2020 over 20% of India's reservoirs will loss 50 % of their storage capacity due to fast rates of silting up.

Table:3 Trends in flood havoc in India

Decade	**Av. Annual area Affected (m ha)**	**Av. Annual flood affected population**	**Av. Annual total flood damage (m Rs)**
1950's	6.86	2.08	923
1960's	5.86	2.47	1041
1970's	11.19	5.55	6741
1980's	16.57	6.91	15904

Source: Centre for Science and Environment, 1991

Efficient reservoir maintenance calls for thorough survey of the factors affecting sediment load from the catchment area and to take up measures to prevent sedimentation. Soil type degree of vegetative cover in the catchment area mostly influence the rate of siltation (Table 3).

Table: 4.Rate of sedimentation in some reservoirs

Name of the Reservoir	**Sedimentation rate (ha-m/100 km²/ year**	**Area covered (1% of the catchment)**		
		Forest	**Clay soil**	**Red soil**
Kalyani	0.57	9	1	1
Kinnerasani	0.62	90	2	3
Wyra	4.51	30	10	60
Osman sagar	5.02	20	10	70
Kotapally	5.43	30	5	65
Nizam sagar	6.67	22	57	21
Pampa	6.70	24	57	19
Himayatsagar	6.94	20	57	23
Upper Manair	8.53	8	80	12
Sriramsagar	9.07	3	94	1

Reservoir	Period of Assessment	Sedementation Rate	
		M m^3/year	**ha-m/100 km^2/year**
Somasila reservoir	1987-2002	1.60	0.764
Srisailam	1976-2004	23.71	0.846

The rate of sedimentation is some reservoirs is less if forest cover mostly covers the catchment's area. In general, the erosion hazard of cropland is estimated to increase sharply from class I through class IV soils.

Sedimentation rate of reservoirs as influenced by soil type in the catchments

The conditions indicative of high sediment yield potential from cropland and other sources in the catchment's area are given below:

(i) Cropland

- Long slopes farmed without terraces or run- off diversions.
- Crop rows planted up and down on moderate or steep slopes.
- No crop residues on soil surface after seeding a new crop.
- No crop cover between harvest and establishment of new crop canopy.
- Poor crop stands or poor quality of vegetation.

(ii) Other sources

- Gullies.
- Residential or commercial constructions.
- Road or railway tract construction.
- Poorly managed range, wastelands or wooded lands.
- Un-stabilized road or railway tract banks.
- Surface mining areas, etc.,

Usually, it is better to take steps that prevent sedimentation, either engineering or agronomic, rather than clearing the sediments mechanically, which is not only very expensive but also highly impractical. Some engineering and agronomic measures suggested for prevention of salutation reservoirs are given below:

(a) Engineering Measures

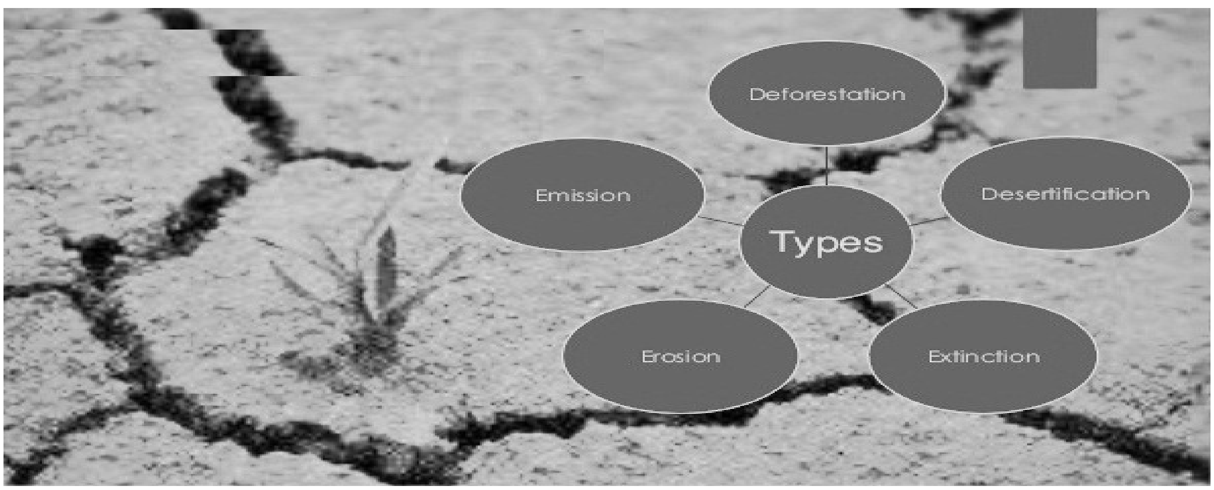
• Provision of scour sluices in the body of dam and whose opening from time to time to clear of sediments.

• Construction of small impounding tanks in the valley upstream to break up water flow reaches final storage.

(b) Agronomic Measures

- Cover crops
- Afforestation
- Pastures
- Contour cultivation
- Contour bunding
- Live bunding
- Grassed waterways

Effects – Social economic and crop production Although India has successfully achieved self- sufficiency in food grain production, the problem of resource degradation poses a serious threat and challenge to our ability to do so in future. The tragedy of the depletion of our natural resource and its impact can be shown below (Fig.6.5). Although precise and quantitative estimates of the impacts of degradation are lacking, there are several pointers to the overall effects.



Fig/ 6.5 Vicious circle of natural resource degradation

6.2 Elements of Sustainability

There are many ways to improve the sustainability of a given farming system, and these vary from region to region, However, there are some common sets of practices among farmers trying to take a more sustainable approach, in part through greater use of on-farm or local resources each contributing in some way to long-term profitability, environmental stewardship and rural quality of life.

(a) Soil conservation- Many soil conservation methods, including contour cultivates, contour bounding, graded bounding, vegetative barriers, strip cropping cover cropping, reduced tillage etc. help prevent loss of soil due to wind and water erosion

(b) Crop diversity- Growing a greater variety of crops on a farm can help reduce risks from extremes in weather, market conditions or crop pests. Increased diversity crops and other plants, such as trees and shrubs, also can contribute to soil conservation, wildlife and increased populations of beneficial insects.

c) Nutrient management – Proper management of nitrogen and other plant nutrients con improve the soil and protect environment. Increased use of farm nutrient sources such as, manure and leguminous cover crops also reduces purchased fertilizer costs.

d) Integrated pest management (IPM)- IPM is a sustainable approach to manage pests by combining biological, cultural, physical and chemical tools in way that minimizes economic health and environmental risks.

e) Cover crops- Growing plant such as, sun hemp, horse gram, pillipesara in the off season after harvesting a grain or vegetable crop can provide several benefits, including weed suppression, erosion control and improved soil nutrients and soil quality.

f) Rotational grazing – New management – intensive grazing systems take animals out barn into the pasture to provide high-quality forage and reduced feed cost.

g) Water quality & water conservation – water conservation and protection have important part of Agricultural stewardship. Many practices have been developed conserve Viz., deep ploughing, mulching, micro irrigation techniques etc.., protect quality of drinking and surface water.

h) Agro forestry – Trees and other woody perennials are often underutilized on covers a range of practices Viz., agri-silvicuture, silve-pastoral, agri-silvi-pastorial-horticulture, horti/silvipastoral, alley cropping, tree farming, lay farm that help to conserve soil and water.

i) Marketing- Farmers across the country are finding that improved marketing way to enhance profitability direct, marketing of agricultural product from farmer to consumers is becoming much more common, including through Rythu bazaar, road side stands.

6.3 Organic Farming

Definition

Organic farming "is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives'. To the maximum extent feasible, organic agriculture systems rely upon crop rotations, crop residues, animal manure, legumes, green manure, off-farm organic wastes, mechanical cultivation, mineral bearing rocks, and aspects of biological pest control to maintain soil productivity, tilth, to supply plant nutrients, and to control insects, weeds, and other pests". (USDA,1980).

The concept of the soil as a living system which must be "fed" in a way that does not restrict the activities of beneficial organisms necessary for recycling nutrients and producing humus is central to this definition.

"Organic agriculture is a holistic production management system which promotes and enhances agro- ecosystem health, including bio-diversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using wherever possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system" (Codex, 1999).

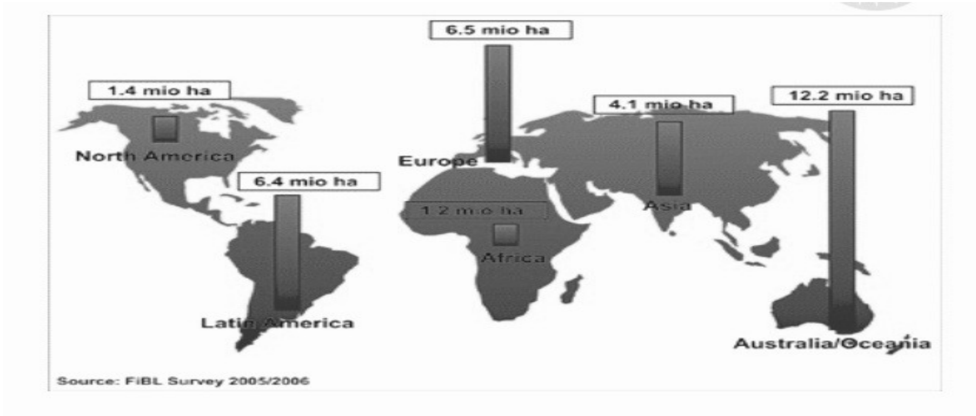


Fig. 6.6 Organic farming in world

Principles of organic farming

1. To produce food of high nutritional quality in sufficient quantity.
2. To interact in a constructive and life enhancing way with all natural systems and cycles.
3. To encourage the biological cycles within the farming system, involving micro- organisms, soil flora and fauna, plants and animals and careful mechanical intervention.
4. To maintain and increase long-term fertility soils.
5. To promote the healthy use and proper care of water, water resources and all life therein.
6. To help in the conservation of soil and water.
7. To use, as far as possible, renewable resources in locally organized agricultural systems.
8. To works, as far as possible within a closed system with regard to organic matter and nutrient elements.
9. To work, as far as possible, with materials and substances which can be reused or recycled, either on the farm or elsewhere.
10. To give all livestock conditions of life which allow them to perform the basic aspects of their innate behaviour.
11. To maintain all forms of pollution that may result from agricultural practices.
12. To maintain the genetic diversity of the production system and its surroundings including the protection of wild life habitats.
13. To allow everyone involved in organic production and processing a quality of life confirming to the UN Human Rights Charter, to cover their basic needs and obtain an adequate return and satisfaction from their work, including a sage working environment.
14. To consider the wider social and ecological impact of the farming system.
15. To produce non- food products from renewable resources, which are fully degradable.
16. Weed, disease and pest control relaying primarily on crop rotation, natural predators, diversity, organic manuring, resistant varieties, and limited (preferably minimal) thermal, biological and chemical intervention.
17. To create harmonious balance between crop production and animal husbandry.
18. To encourage organic agriculture associations function along democratic lines and the principle of division of powers.

19. To progress towards an entire production, processing and distribution chain which is both socially just and ecologically responsible.

Relevance of organic farming

Interest in organic agricultural methods is growing, especially in areas where the present modern farming system has unleashed many agro-ecological and environmental problems both on and off the farm, which threaten food security. The following are some examples:

a) Degradation of soil quality (structured & fertility).
b) Pollution of soil, water and food with pesticides and nitrates.
c) Health effects on farmers, farm workers, farm families, rural communities (apart from concerns about the non-intended effects of pesticides on human beings in general, sound use of pesticides requires a technical knowledge which is often lacking in developing countries).
d) Resistance of pests to pesticides.
e) Dependence on off- farm agricultural inputs which can increase poor farmers' dependence on credit facilities (to purchase synthetic fertilizers, pesticides and seed), which may result in decreased local food security and self- reliance.

Further consumer awareness of the environmental costs of agriculture is increasing. The awareness of environmental quality and health is often promoted by environmental groups, especially in developed countries. The resulting demand for organic products creates the opportunity to sell organic products at premium prices, enabling organic farmers to continue, and often expand. Some governments have begun to recognize the possibility that it may be cheaper to support organic agriculture that to rectify problems associated with certain resource- destruction production practices. For this reason, several governments have introduced subsidies for organic agriculture. For example, in Indonesia where, after a period of subsidies on pesticides, the use of this input was prohibited while efforts were put in IPM programmes. In China, pesticide problems in products both on the domestic and export market has resulted in government involvement in certification organizations for "green food", including also a small amount of organic produce. Both these policies facilitate a shift towards organic agriculture.

Relative characteristics of Modern and Organic Farming systems

Production Factor	Modern	Organic
Productivity	High	High
Sustainability	Low	High
Farming system	Simple	Complex
Bio-diversity	Uniform	Diverse
Production orientation	Market	Subsistence/market
Usage of external inputs	High	Low
Fertilization	Inorganic	Organic

Components of organic farming

Thus organic agriculture is comparatively free from the complex problems identified with modern agriculture. It is basically a farming system, devoided of chemical inputs, in which the biological potential of the soil and the underground water resources are conserved and protected from the natural and human induced degradation or depletion by adopting suitable cropping models including agro-forestry and methods of organic replenishment, besides natural and biological means of pest and disease management, by which both the soil life and beneficial interactions are also stimulated and sustained so that the system achieves self regulation and stability as well as capacity to produce agricultural outputs at levels which are profitable, enduring over time and consistent with the carrying capacity of the managed agro- ecosystem.

Crop production and health in organic farming systems is attained through a combination of structural factors and tactical management components to ensure products of sufficient quality and quantity for human and livestock consumption.

Diverse crop rotations: crop diversification can deliver many agronomic and ecological benefits simultaneously, while maintaining or enhancing the scale and efficiency of production.

Benefits of diverse crop rotations include yield stability, reduction in disease incidence & severity, reduced pest incidence. Improved weed control, reduced soil erosion, recycling of nutrient reserves, transfer of nitrogen from nitrogen fixing species, structural improvement etc., there are many different forms of crop diversification viz., rotational cropping, sequential cropping, intercropping, multistoried cropping system etc., and in practice these can be combined within the farming system. Crop and variety choice and their spatial and temporal design are critical in ensuring an effective rotation. The inclusion of crops, which are able to fix atmospheric nitrogen through symbiotic relationship with N-fixing bacteria that nodulate on crop roots, enables organic farming systems to be self sufficient in nitrogen.

Soil Fertility Management: The aim of nutrient of soil fertility management within organic farming systems is to work, as far as possible, with in a closed system. Organic farming aims to manage soil fertility through use of organic manures (FYM &farm compost, vermicompost), recycling of crop residues such as straw, plant residues, grasses etc., dung and urine from domesticated animals and wastes from slaughter houses, human excreta & sewage, biomass of weeds, organic wastes from fruit and vegetable production & processing units and household wastes, sugarcane trash, oil cakes, press mud and fly ash from thermal power plant. Biological nitrogen fixation through blue green algae, azolla for rice, rhizobium for legumes, azatobactor & azospirillum for other crops, green manuring & green- leaf manuring, manure form biogas plants, legumes in crop rotations & intercropping systems.

Weed control: Organic farmers often identify weeds as their key problem. Within organic systems as integrated approach to weed control using a combination of cultural and direct techniques is necessary. Appropriate soil cultivation viz., deep ploughing in summer, harrowing, intercultivation using mechanical hoes and harrows, and the timing of field operations and good crop establishment are vital for successful control of weeds. Mulching the soil surface can physically suppress weed seedling emergence. Soil solarization, to heat field soil under plastic sheeting to temperatures high enough to kill weed seeds (>65˚C) can also be used for weed, control in some parts of India. Good seedbed preparation, timely sowing, line sowing, crop rotation, smoother crops & intercropping systems etc., suppress the weed growth and favour normal growth and development of crops in organic systems.

Natural Pest and Disease Control: One of the important features of organic farming is the exclusion of plant protection chemicals for pest and disease control. The system relies on the on-farm diversity, improved health of the soil and crops protective influence of beneficial soil organisms against soil borne pathogens and use of plant based insecticides and biological control measures. The population of naturally occurring beneficial insects and other organisms which act as bio control agents multiplies making natural control of pests possible when the system is free from the indiscriminate use of chemicals.

Few examples are

(a) Manipulation of crop rotations, to minimize survival of crop- specific pests (in the form of, for example insect eggs, fungi) which can infest the next crop.
(b) Strip cropping, to moderate spreading of pests over large areas.
(c) Manipulation of the moisture level or P^H level of the soil (in irrigated areas).
(d) Manipulation of planting dates, to plant at a time most optimal for the crop, or least beneficial for the pest.
(e) Adjustment of seeding rate, to achieve an optimal density given the need to check weeds or avoid insects.
(f) Use of appropriate plant varieties for local conditions.
(g) Biological control methods, to encourage natural enemies of pests by providing habitat or by breeding and releasing them in areas where they are required.

- *Bacillus thuringensis* against caterpillars of Heliothis, Earias, Spodoptera etc.,
- *Pseudomonas fluoroscenes* against Pythium spp. Rhizoctonia spp Fusarium spp.
- Nematodes like Green commandoes and Soil commandoes against caterpillars & grubs.
- Nuclear Polyhedrosis virus (NPV) against caterpillars.
- *Trichoderma virdi* against many common diseases of vegerables and spices.
- Weevils Neochitina &N. bruchi against water hyacinth.
- Beetle *Zygogramma bicolorata* against Parthenium.

h) Trapping insects, possibly with the use of lures such as pheromones.

i) Use of domesticated birds.

j) Biological pesticides (for example neem oil, nicotine) of which the active ingredient is short- lasting, and which may be produced locally.

Integrated nutrient management

Integrated nutrient management system envisages conjunctive use of organic manures, crop residues, biofertilizers, legumes in crop rotation and green manuring. It combines traditional and improved technologies to gain from the symbiosis and synergy of crop – soil- environment bio-interactions.

The concept is for optimization of all available sources of plant nutrients to improve soil fertility availing nature's gifts.

Development of INM system involving and appropriate mix of organics, biological N fixation, phosphate solubilising microbes, and need based chemical fertilizers would be crucial for sustainability of production and soil as a resource base for it.

Bulky Organic Manures: In India, the estimated production of rural compost is about 226 million tons and urban compost of 6.6 million tons annually. Aggregate stability, decrease in P^H, resistance to compaction, infiltration and water holding capacity. Proper methods of preparation of FYM/ Compost therefore have to be popularized.

Recycling of Organic Wastes: Substantial quantities of crop residues (350 million tons) are produced in India every year. Crop residues in combination with organics have been shown to improve availability of plant nutrients, soil organic matter, aggregate stability, infiltration rate, microbial population etc.,

Bio- fertilizers: Bio –fertilizers such as rhizobium culture is an effective source of N supply to leguminous corps. Azotobacter and Azospirilium help in N fixation and supply to crops like rice, wheat, sorghum, maize, cotton, sugarcane, fruit crops and vegetables. Phosphate solubilising bacteria viz.,Bacillus aspergillus help in making available soil P to the crops and increase the solubility of indigenous sources of P like rock phosphate. Blue green algae and Azolla have shown promise in low land rice. These are renewable and environment friendly supplementary sources of nutrients and are presently being used in quantities between 8-10 tons per year. Vesicular arbuscular mycorrhiza (VAM) has beneficial of water, production of plant hormones and microbial activity are the prime benefits of mycorrhizal inoculations.

Soil Fertility Management

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e) Adjustment of seeding rate, to achieve an optimal density given the need to check weeds or avoid insects

f) Use of appropriate plant varieties for local conditions

g) Biological control methods, to encourage natural enemies of pests by providing habitat or by breeding and releasing them in areas where they are required.

Green manuring:

Green manuring is a cheapalternative to the use of fertilizer N. The process also makes a positive contribution to the maintenance of soil organic matter at a satisfactory level. The stem nodulating green manure plant, Sesbania rostrata (Dhaincha) can fix 100-250 kg/N/ha in 45 to 55 days and has great scope in rice culture. There is also greater scope for green-leaf manuring for rice and other crops from the lopping of various multipurpose trees popularized through afforestation and agro-forestry systems.

Popularization of bio-gas plants, encouraging legumes in crop rotation and intercropping system and use of sewage, sludges and effluents for agriculture can also be the components of INMS.

Fig: 6.7 Principles of Organic Farming.

6.4 Biocontrol Agents and Bio Pesticides.

By keeping in view the above facts, in mind, it becomes imperative concentrate on alternate methods of pest control without the negative impact of plant protection measures on the ecosystem. Among various approaches adopted in pest control, Biological control based Bio-intensive Pest management (BIPM) of crop pests is found to be the most important and practically feasible one in considering the present scenario of Indian agriculture. These tested ecofriendly measures of pest management are of certain importance in the era of sustained agriculture.

Applicability of Biological control and non-chemical methods to fit in sustainable agriculture situations.

Several non-insecticidal methods of pest control such as Biological control ,use of Pheromones, Cultural Control and use of botanical insecticides started gaining importance in IPM programmes with biological control as an integral component was done in important crops to work out the economic feasibility of these eco friendly inputs. Application of these biological pest management inputs in sustainable agriculture is well justified as the basic concept of sustainable agriculture highlights the fact that it envisages the alternate production system which avoids or largely excludes the use of synthetic fertilizers, pesticides and growth regulating hormones. In case of BIPM it proved to be two way process wherein bio intensive pest management (BIPM) acts as a potential tool in sustainable agriculture while sustainable agriculture enhance the potentiality of BIPM.

Biological control agents and their categories

The efforts aimed at increasing the naturally occurring biotic agents against the pest, both qualitatively and quantitatively can be termed as biological control and the pest management programmes where these inputs from the core component is designated as Bio Intensive Pest Management (BIPM). The most commonly used bio agents in BIPM are:

Parasitoids: Due to their high multiplication rates they are of vital importance in the biological control of insect pests. The parasitoids successfully being used in India are:

1. Trichogramma egg parasite against eggs of gram pod borer, rice stem borer, castor semi looper, cabbage diamond black moth etc.
2. Bracon hebetor against insect pests of coconut and sugarcane.
3. Brachymeria against the pupae of several pests of plantation crops.

Predators:

They are external feeders and will be consuming several of the insect pests during their life cycle and hold a key role in minimizing pest population in field conditions. The important predators put to use in biological control are:

1. Chrysoptera sps against several of the soft bodied insects such as aphids, leaf hoppers etc.
2. Lady bird beetle against aphids and mealy bugs.
3. Spiders – against a number and types of insects especially in the ecosystem.

Microbial Organisms:

The micro organisms exploited in biological control of insects pests re (a) Insect viruses (b) Bacteria (c) Entomo Pathogeic Fungi (d) Entomo Pathogenic Nematodes and other oganisms like Protozoans and rickettsia etc., while several antagonistic fungi and bacteria are being successfully used in minimizing the plant disease incidence. Nematode pest management by using biotic agents is also one of the most promising areas and gaining much deserved importance in the current scenario of sustainable agriculture.

(a) Insect Viruses

Nucleo Polyhedrosis Virus: Effective against only lepidopteron insects individually in different crops. Ha NPV is used for the management of Helocoverpa armigera while SINPV is meant for Spodoptera litura. Similarly, castor semi looper is managed by Ach NPV and red history caterpillar by an NPV.

Granulosis Virus (GV) and Cyto Plasmic Viruses are being extensively used against insect pests of sugarcane.

(b) Bacteria

Most commonly and widely used bio pesticide in insect control operations is Bacillus thuringiensis. This bacterium is highly effective against several insect pests of Lepidoptera. They cause disease due to which insect black and die. The bacteria come in several commercial formulations such as Dipel, Delfin, Halt, Spicturin, Biolep, Bio Asp etc.,

(c) Fungi

Several fungi such as, beauveria bassiana, Metarhizium anisopliae and Verticillium lecani are used against important pests like gram pod borer, tobacco, caterpillar and sucking pests like thrips, aphids and mealy bugs. The fungi develop hyphae inside insect system as a result insect dies due to mechanical congestions. This mode of action makes these organisms to perfectly suit to the needs of sustainable agriculture. In certain cases they produce toxins to kill the insect.

(d) Entomopathogenic Nematodes

These nematodes harbor certain bacteria which act as toxins to insects system. Mainly exploited entomo pathogenic nematodes in insect control operations are – Heterorhabditis sp, Steimernema sp.

Other than these micro organisms protozons such as Variomorpha sp and others were also found to be effective against insect pests and can be effectively be incorporated as tools in sustainable agriculture.

Antagonistic Organisms for Plant Disease Management

Biological control of plant diseases is also very important in the eco-friendly management of the crop pests. The most commonly and widely used organisms for these purposes are Trichoderma viride, Pseudomonas fluorescens and Bacillus subtilis which are used for controlling the diseases caused by different pathogens viz., Phythium, Phytophthora, Rhizoctonia, Fusarium etc., These antagonistic organisms certainly give efficient, practical and cost effective plant disease control without causing any abnormal and adverse effect in the ecosystem. In addition to control of plant diseases, several of the disease antagonistic bio control agents play several other important roles such as, plant growth promoting (Pseudomonas fluorescens), decomposition of crop residues in to organic matter (Trichoderma viride) and for extracting certain enzymes and other commercially viable metabolites.

Weed Management through Biological Control

Biological control of the weeds through biotic agents is gaining momentum in the recent years as the weed menace in cultivated lands as well as in waste lands posing serious health problems to the mankind besides reducing the yield levels considerable in agriculture. Mexican beetle, *Zygogramma bicolorata* is being used for reducing the menace of Congress grass, Parthenium hysterophorus. Water hyacinth is reported to *beattacked by Neochitina bruchi (weevil) and Orthogalumna trerbrantis (mite), Rust fungus, Puccinia spegazzini* is exploited for suppression of *Mikania micrantha.*

Bottlenecks in use of Biological and bio rational methods and possible solutions.

Agricultural ecosystem is ever changing and highly dynamic. This situation never does allow any management strategy to be the ultimate answer for pest problems. The techniques last for more time are considered as the techniques of success. In this process the Bio control is struggling with certain practical problems. They are:

1. Mass production and sources of availability Bio gents and Bio pesticides.
2. Proper Formulation technology and economic feasibility.
3. Quality maintenance and monitoring of biological inputs.
4. Shelf life concerns and handling precautions.
5. Lack of awareness in proper application technology among farming community.
6. Competition from chemical pesticides.

The possible solutions available

1. Mass production techniques for several parasitoids, predators and bio pesticides have been standardized for commercial scale production.
2. Several Government programmes are in progress highlighting importance of Bio control. Similarly failure of insecticides compelled the farmers to turn to Biological control thus giving it a change to prove its worth.
3. Research efforts to expand the killing spectrum and to improve the environmental stability of microbial bio agents are moving towards fruitful results.
4. Modification of entomo pathogens to grow on artificial media and also to propagate host tissues to be used as media is being actively worked out to bring down the cost of mass production of these organisms.

5. In the days to come bio pesticides are going to substitute for chemical pesticides. This is evident from the fact that several Multinational companies are already in the production of Bio pesticides.

With the growing awareness about alternate protection technologies among farming community and with positive initiative from government machinery, the days are not far where in biological control and other eco friendly approaches can offer an effective substitute to chemical pesticides. The scope of these bio rational methods of pest management as an integral part of sustainable agriculture is evident from the fact that they are practically being used as an effective component of IPM in several major crops grown in India and can be effectively incorporated as sustainable tool in sustainable agriculture.

Table:5 Certain Bio rational components being practically used in the management of economically important pests of different crops.

Crop	Pests	Bio Agent	Dosage
Cotton	Bollworms A p h I d s Helicoverpa	Trichogramma C h r y s o p e r l a Carnea Ha NPV	1,50,111/ha - 8 times 14,000/ha - 1 time 500LE - 3 times
Rice	Stem borer	Trichogramma	50,000/ha - 6 releases Starting at 35 days
Chilli	Helicoverpa spodoptera	Trichgramma SI NPV	50,000/ha - 6 releases 250LE/ha
Sugarcane	ESB TSB SB/IB	Trichogramma Trichogramma Trichogramma	50,000/ha -4-6 release Starting at 45 days 50,000/ha -4-6 release Starting at 60 days 50,000/ha -4-6 release Starting at 90days
Maize	Stem borer	Trichogramma	50,000/ha - 6 release Starting at 45 days

Summary

Population of the country as well as world is increasing day by day, whereas the land and per capita land availability is decreasing. During 1950 the food grains production was much lower than the requirement. However, the green revolution took place in 1960 and the usage of inorganic fertilizers increased in may folds. Subsequently the few are many essential plant nutrients are depleted in the soil. Consequently the sustained crop yields are not being realized. Further the excess usage of chemicals led to ecological imbalance. In view of this, the need has arisen to look into the element that preserves sustainability. Soil conservation, crop diversity, integrated nutrient management, integrated pest management and raising cover crops etc are some of the interventions that improves soil sustainability.

Recently demand is increasing for organic foods. All management practices such as soil fertility management, weed control, pest and disease management etc shall be done through organic sources. Therefore organic farming not only attracts premium market price to produce but show way out for sustainable agriculture.

Short Answer Type Questions

1. Define sustainable Agriculture?
2. Write about nutrient management in organic farming?
3. Write about weed control in organic farming?
4. Write about the importance of organic farming?

Long Answer Type Questions

1. What are the adverse effects of modern high input agriculture?
2. What are the elements of sustainability? Explain how they help in sustainable agriculture?
3. Write about the factors effecting ecological balance?
4. Write about the principles of organic farming?

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CROP PRODUCTION & MANAGEMENT

Paper - II

SOIL AND WATER MANAGEMENT

INDEX

UNIT 1

Soil in relation to plant growth

Structure

1.0 Introduction

Soil is the loose top layer of the Earth's surface, consisting of rock and mineral particles mixed with decayed organic matter (humus), and capable of retaining water, providing nutrients for plants, and supporting a wide range of biotic communities.

1.1 Components of a mineral soil

Mineral soil consists of four major components i.e., inorganic or mineral materials, organic matter, water and air. In this, the solid mineral particles comprise about 45% of the soil volume and organic matter 5%. The pore space is divided into 25 %, of volume being water and 25 % of air. These four soil components occur thoroughly in mixed condition and this mixture causes interactions with in the and between the groups and promotes growth of the plants.

1.1.1 Mineral Matter: This is the inorganic content of soil and varying in size and composition. The Inorganic portion of soils is quite variable in size and composition. It is composed of small rock fragments and minerals of various kinds.

Table: 1.1 Characteristics of Soil separates

S. No	Diameter(in mm)	Soil separates	Soil characteristics
1	2.0 - 0.2 mm	Coarse sand	Very gritty
2	0.2 - 0.02 mm	Fine sand	Gritty
3	0.02 - 0.002 mm	Silt	Powdery
4	< 0.002mm	Clay	Sticky

1.1.2 Organic Matter: Organic matter in soil is an accumulation of partially decomposed plant and animal residues and other organic compounds which are synthesized by soil microorganisms during the decaying organic matter decomposition process occurs continuously by soil organisms and lasts from few hours to several hundred years. The plant and animal residues added to the soil are acted upon by various soil microbes and get converted into black colloidal substance called **Humus**. Humus being the source of hormones and vitamins that stimulates the growth of plants and microbes, has great influence on soil fertility.

1.1.3 Soil Water: Soil water is held in soil pores with varying levels of tension. The amount of water held in soil pores depends up on the amount of water present and size of the pores (macro and micropores). Soil water with its soluble constituents (nutrients) makes up soil solution, which is the critical medium for supplying nutrients to growing plants. Soil water is held in soil as capillary water, which is mostly available to the plants.

1.1.4 Soil Air: Soil air occupies those soil pores not filled with water. The content and composition of soil air are determined largely by the water content of the soil. Soil air always differs from atmosphere air in composition because of moisture content, root and microbial activities. Proper aeration in the soil promotes bacterial activity, respiration of plant roots, proper drainage and improves soil aeration.

1.1.5 Soil organisms: Soil organism break down the raw organic matter in the soil into humus and then to simple products which can be utilized by the plants as food. Soil organism are grouped into two classes *viz.,*

1) Microorganisms: Fungi, bacteria

2) Macroorganisms: Earthworms, rodents, insects

1.2 Soil reaction:

Soil reaction is an important property of the soil for the growth of the plants and microorganisms *i.e.* whether the soil is acidic, neutral and alkaline. Pure water contains H^+ ions (acidic) and OH^- ions (basic) in equal proportions. Therefore, pure water is neutral in reaction. The soil reaction describes the degree of acidity or alkalinity of a soil. Thus when the hydrogen ion $[H^+]$ concentration of an aqueous solution increases, its hydroxyl ion concentration decreased to maintain the ionic product of water.

1.2.1 Soil pH: pH, is the standard measure of acidic or alkaline of a solution. It is defined as the negative logarithm of hydrogen ion concentration in the soil solution. It is measured on a scale from 0 – 14. pH of 7 is neutral, pH less than 7 is acidic, and pH greater than 7 is basic.

1.2.2 Soil Alkalinity: Alkalinity is a condition when the concentration of hydroxyl ions is greater than hydrogen ions in the soils. Alkalinity of natural waters is primarily due to the presence of water soluble mineral salts. Bicarbonates represent the major form of alkalinity in natural waters.

1.2.2.1 Types of alkalinity

Characteristics of saline soils: Saline soils contain neutral soluble salts of chlorides and sulfates of sodium, calcium and magnesium. The electrical conductivity of saturated extract of the soil is more than 4 dS m^{-1}. ESP is less than 15 and pH is less than 8.5. Because of the presence of excess salts and low amount of Na+, these soils are in a flocculated state and their permeability is higher than alkali soils. Their physical condition is good and water can pass through them. These soils have a white crust of salts on their surface. Salinization refers to the accumulation of neutral soluble salts in soils.

Characteristics of saline - Alkali soils: These soils have both soluble salts and exchangeable sodium. The soil reaction becomes strongly alkaline because of hydrolysis of exchangeable sodium. The physical condition of the soil is deteriorated. The EC of saturated extract is more than 4 dS m^{-1}, ESP is more than 15 and pH is around 8.5. They are transitional soils that they may be converted into saline or into sodic soils.

Characteristics of alkali or sodic soils: Most of the Na^+ is in exchangeable form. EC of saturated extract is less than 4 ds m^{-1}. ESP is more than 15 and pH more than 8.5. Such soils are not in a good physical condition and the surface of these soils is sometimes black due to dispersion of organic matter and humus. Such soils if ploughed when wet, turn into slick furrow slice referred to as slick spots.

1.2.2. 2 Remedies for salt affected soils

- Deep ploughing to break the impermeable layer in soil profile to improve the internal drainage of the soil and to facilitate the transportation of salts dissolved in water to deeper layers.
- Profile inversion can be adopted only under conditions where surface soil is good but the soil below is sodic or saline.
- Scraping is adopted to remove the few centimeters of salt encrustation.
- Leaching the salts below the root zone
- Application of gypsum to replace the sodium by another cation (calcium) and then leaching of the desorbed sodium salts out of the root zone with good quality irrigation water
- Application of FYM, pressmud and other organic materials

1.2.3 Soil acidity: Soil acidity refers to presence of higher concentration of hydrogen ions [H^+] than hydroxyl ions[OH^-] in soil solution .

Table: 1.2 The ranges in soil pH and associated degree of acidity

pH range	**Nature of acidity**
3-4	Very strong
4-5	Strong
5-6	Moderate
6-7	Slight

Remedies for acid soils

- Acid soils can be managed by either growing crops suitable for particular soil pH
- Ameliorating the soils through the application of amendments which will counteract soil acidity

- Acid soils are made more suitable for agricultural use by liming which raises the soil pH

1.3 Soil texture and structure

1.3.1 Soil texture

Soil texture may be defined as the relative proportion of particles of various sizes (Soil separates) such as sand, silt and clay. Soil texture is the permanent property of the soil and may change slowly with time.

Table:1.3 Soil separates classified based on their size

Soil Separates	**Diameter in mm**
Very Coarse Sand	>2.00mm
Coarse Sand	2.00 – 0.20 mm
Medium Sand	0.50 – 0.25 mm
Fine Sand	0.20 – 0.02 mm
Very Fine Sand	0.10 – 0.05 mm
Silt	0.02 – 0.002mm
Clay	< 0.002 mm

Significance of Soil Texture:

1. Soil texture is important to assess the value of the land
2. Land capability and methods of soil management are determined by soil texture.
3. Texture determines the land usage to different crops in different seasons.
4. Texture determines the total pore space and the distribution of macro and micro pores of soil, which in turn influence the movement of water as well as air.
5. Soil texture governs the nutrient supplying abilities of the soils.
6. It is the most stable property and used as an index of several other properties of soils, which determines the agricultural potential of the soils.
7. Soil texture has pronounced effect on soil temperature.

1.3.2 Soil structure

Soil Structure may be defined as the arrangement of primary particles (sand, silt and clay), secondary particles (aggregates) and voids (pores) in to a certain definite pattern under field conditions. The primary particles do not exist as such but are bound together with varying degrees of tenacity in to larger units or aggregates usually termed as Secondary Particles.

Importance of soil structure

- Influences the amount and nature of porosity of soils.
- Governs the water and air permeability in to soils.
- Influences water holding capacity, soil-water relationship and growth of microorganisms.
- Influences soil drainage and availability of plant nutrients.

1.4 Soil organic matter and its effects on soil properties, C:N ratio

1.4.1 Soil Organic Matter

Soil organic matter is the organic matter component of soil, consisting of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by soil organisms. Soil organic matter is necessary for productive soil. It promotes healthy crops, supplies resources for microbes and other soil organisms, and regulates the supply of water, air and nutrients to plants.

1.4.2 Functions of organic matter in soil

Organic matter contributes to plant growth through its effect on the physical, chemical, and biological properties of the soil. It has a :

- It serves as a source of N, P for plant growth
- It profoundly affects the activities of microflora and microfaunal
- It promotes good soil structure.
- Increasing water holding capacity in sandy soils.

1.4.3 Carbon to Nitrogen ratio (C:N)

Carbon to Nitrogen ratio (C:N) is a ratio of the mass of carbon to the mass of nitrogen in a substance. For example, a C:N of 10:1 means there is ten units of carbon for each unit of nitrogen in the substance. It is important to understand these ratios when planning crop rotations and the use of cover crops in agricultural systems.

Table; 1.4 Carbon to Nitrogen ratios of crop residues and other organic materials

Material	**C:N Ratio**
Wheat straw	80:1
Oat straw	70:1
Corn stover	57:1
Pea straw	29:1
Ideal Microbial Diet	**24:1**
Rotted barnyard manure	20:1
Legume hay	17:1
Young Alfalfa hay	13:1
Soil microbes (average)	8:1

1.5 Soil fertility and Soil productivity

The nature of soil fertility and productivity depends not only on chemical and physical characteristics of the soil, but also biological processes resulting from the many and valued activities of soil organisms.

1.5.1 Soil fertility: is the inherent capacity of the soil to provide nutrients in proper quantities and in a balanced way for the growth of plants. A fertile soil should have the correct proportion of plants nutrients and optimum pH

1.5.2 Soil productivity: is the capacity of the soil, in its normal environment to support plant growth under a defined set of management practices. Soil fertility greatly affects soil productivity. A fertile soil always leads to high soil productivity. Sometimes a fertile soil need not necessarily a productive one due to adverse climate, waterlogging, soil reaction etc.

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In farming, soil fertility may lost through many ways, some of these ways are as a result of human activities while others are through natural process.

1.5.3 Soil fertility and Soil productivity

Table: 1.5 Difference between Soil fertility and Soil productivity

Soil fertility	**Soil productivity**
It is the inherent capacity of the soil to provide essential chemical elements for plant growth	Soil productivity emphasizes the capacity of soil to produce crops and is expressed in terms of yield.
A combination of soil properties and an aspect of soil – plant relationships.	An economic concept and not a property of soil.
Soil fertility is vital to a productive soil. But a fertile soil is not necessarily be a productive soil. Many factors can limit production, even when fertility is adequate. For eg., soils in arid region maybe fertile but not productive.	Soil fertility is one factor among all the external factors that control plant growth like air heat (temp.), light, mechanical support, soil fertility and water. Plant depends on soil for all these factors except for light.
Organic matter in the soil improves soil fertility by mineralization of nutrients.	Organic matter also improves soil productivity by improving soil porosity, aggregation and physical condition of soil thus modifying the soil environment for crop growth.

1.6 Soil fertility management

Soil fertility is the capacity to receive, store and transmit energy to support plant growth. It is the component of overall soil productivity that deals with its available nutrient status, and its inherent ability to provide nutrients and through external applications for crop production. Following are the methods for soil fertility management:

1. Conservation tillage: Conservation tillage practices reduce erosion, surface runoff by protecting the soil surface and allowing water to infiltrate instead of running off. It also contribute to soil fertility by increasing the organic matter of the soil. Conservation tillage practices are grouped into three types:

- **No-till:** Planting crops directly without any tillage and residues remaining (no-till) or has been tilled only in narrow strips with the rest of the field left untilled (strip-till).

- **Ridge- till**: planting row crops on ridges about 0.1 m high. The previous crop's residue is cleared off on ridge-tops into adjacent furrows for the new crop being planted on ridges.
- **Mulch-till**: Reduced tillage system that leaves at least one third of the soil surface covered with crop residues.

2. Crop rotation: Crop rotation is one of the oldest and most effective cultural control strategies. Crop rotation is the planned order of specific crops planted on the same field. In crop rotation the succeeding crop belongs to a different family than the previous one. The planned rotation may vary from 2 or 3 year or longer period. It is beneficial against erosion, pests and diseases, weeds, and helps maintaining soil fertility.

3. Soil cover : A permanent year round soil cover is central to conservation agriculture. It protects the soil from rain, wind and sun, therefore reducing erosion and increasing soil moisture; it suppresses weeds and enhances soil fertility and the organic matter content.
There are two main types of soil cover:

- **Living plant material**: crops and cover crops
- **Mulch, or dead plant material**: crop residues and pruning's from trees and shrubs

4. Crop residues: Crop residue left on the surface protects the soil from rain and wind until emerging plants provide a protective canopy. Crop residue also improves soil tilth and adds organic matter to the soil. It is associated with reduced tillage, which limit soil compaction and saves the farmer time and fuel.

5. Organic manures: Organic manures includes FYM, vermicompost, green manure, slurry, worm castings, peat, seaweed, humic acid, guano, sewage sludge, compost, blood meal, bone meal. Many organic materials serve both as manures and soil conditioners: they feed the soil and the plants. This is one of the most important differences between a chemical approach and an organic approach toward soil care and manuring. Soluble chemical fertilizers contain mineral salts that plant roots can absorb quickly. However, they do not provide a food source for soil microorganisms and earthworms. Therefore using organic manures has a positive impact on water pollution, soil erosion and soil fertility.

6. Fertilizer application: Time, quantity and method of application have to be chosen to suit the particular nutrient, the crop, as well as the method of cultivation. Fertilizers can be uniformly spread or placed in soil at a specific place. Timing of fertilizer application has a significant effect on crop yields. Proper timing increases yields, reduces nutrient losses, increases nutrient use efficiency and prevents damage to the environment. One of the most important recommendations is to select a slow-release fertilizer which provides steady growth and water quality protection.

SummaryThe mechanical analysis of the soil shows that soil has constituents like mineral matter, organic matter, soil air, soil moisture and soil organisms.

1. Humus is the plant and animal residues added to the soil are acted upon by various soil microbes and get converted into black colloidal substance
2. Soil pH denotes the acidity, alkalinity of the soil. It is the negative logarithm of hydrogen in concentration of the solution.
3. Soil texture is the relative proportion of the sands, silt and clay in given soil. Soil structure is the arrangement of soil particles in the soil.
4. Soil organic matter is the store house of nitrogen and other plant products.
5. Carbon to Nitrogen ratio (C:N) is a ratio of the mass of carbon to the mass of nitrogen in a substance.
6. The inherent capacity of the soil to provide essential plant elements is called soil fertility. The capacity of soil to produce crops under a defined set of management practices is soil productivity.

7. Terms used in this chapter

1. Organic matter, 2. Soil separates, 3. Humus, 4. Mineral matter, 5. Soil Texture, 6. Soil Structure, 7. Soil pH, 8. C:N ratio, 9. Soil fertility, 10. Soil productivity.

Short type questions

1. Write definition of soil and different components of a mineral soil
2. Define soil pH.
3. Define soil alkalinity and explain different types of soil alkalinity
4. What are the remedies for soil alkalinity
5. Define soil acidity
6. Define soil texture and soil structure
7. Distinguish between soil fertility and soil productivity

Long answer type questions

1. Explain the effect of soil organic matter on soil properties and C:N ratio
2. Explain about the soil fertility management

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UNIT2

Mineral nutrition, Manures and fertilizers

Structure

2.0 Introduction

Plants generally derive their inorganic nutrients from soil, water and atmosphere. The absorption, distribution and metabolism of various mineral elements by plants are called mineral nutrition. Plants tend to absorb different kinds of nutrients from soil but all of these elements are not essential for their growth. Plants require 16 essential elements. Only sixteen elements are found to be essential in plant nutrition.

2.1 Essential elements – Classification, functions and deficiency symptoms

2.1.1 Essential elements

The essential nutrients are chemical elements that are absolutely needed by plants for their growth and development. Only 16 or so elements are truly essential for plant growth. The rest of the elements present in plant tissue are largely taken up in small quantities incidentally as plants take up the nutrient elements that are need for growth and reproduction.

Their essentiality have been established based on the following criteria formulated by D. I. Arnon and P. R. Stout (1939)

1. Essential elements are required for the completion of the life cycle of the plant.
2. They cannot be replaceable by another element.
3. They be directly involved in plant metabolism, to perform specific physiological function.

2.1.2 Classification of essential nutrients: Nutrients are chemical compounds needed for growth and metabolic activities of an organism. The essential plant nutrients may be divided into macronutrients (primary and secondary nutrients) and micronutrients.

A. Macronutrients: Macronutrients or major nutrients are so called because they are requiredby plants in larger amounts. These are found and needed in plants in relativelyhigher amounts than micronutrients. They include Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur.

Carbon, Hydrogen and Oxygen constitute 90 – 95 per cent of the plant drymatter weight and supplied through carbon dioxide and water. Remaining six macronutrients are further sub divided intoprimary and secondary nutrients.

i) Primary nutrients: Nitrogen, phosphorus and potassium are termed as primary nutrients because deficiencies of the nutrients are corrected through the application ofcommercial fertilizers of which these are the major constituents

ii) Secondary nutrients: Calcium, magnesium and sulphur are termed as secondary nutrients because of their moderate requirement by plants, localized deficiencies and their inadvertent accretions throughcarriers of the primary nutrients. For example, the phosphatic fertilizer, single super phosphate (SSP) contains major nutrient Phosphorus but also both Calcium and Sulphur as secondary. Similarly, ammonium sulphate, contains Nitrogen as major but also supplements Sulphur.

B. Micronutrients: Micronutrient is an element that is required in relatively smallquantities but is as essential as macronutrients. These elements have often been called trace elements. They are again classified into micronutrient cations (eg. Iron, Manganese, Zinc and Copper) and micronutrient anions (eg., Boron, Molybdenum and Chlorine) depending upon the form in which they are available.

2.1.3 Functions & Deficiency Symptoms of nutrients

Nitrogen (N)

Functions

1. Nitrogen plays an important role in the growth phase of plants
2. It is an essential constituent of proteins and chlorophyll and is present in protoplasm
3. It brings about profuse vegetation development with luxuriant growth and tillering
4. Its effect in crops are quickened and striking
5. The foliage looks dark green

6. Produces rapid early growth
7. Increases protein content of food and fodder crops
8. Excessive nitrogen makes the tissue soft and plants becomes susceptible to pests and diseases. It also delays flowering
9. Nitrogen is taken in the form of nitrates by plants

Deficiency symptoms

1. Stunted growth may occur because of reduction in cell division.
2. Pale green to light yellow color (chlorosis) appearing first on older leaves, usually starting at the tips.
3. Depending on the severity of deficiency, the chlorosis could result in the death and/or dropping of the older leaves.
4. Reduced N lowers the protein content of seeds and vegetative parts.
5. In severe cases, flowering is greatly reduced.
6. N deficiency causes early maturity in some crops, which results in a significant reduction in yield and quality.

Phosphorus (P)

Functions

1. The function of phosphorus is mainly in the reproductive phase and seed formation
2. It is found in every living cell and concentrated in the seed
3. It is a constituent of nucleic acid and phospholipids
4. It hastens flowering and maturity, strengthens the straw and prevents lodging in cereals
5. It promotes root development in the early stages
6. It improves the quality of crops and increases the weight of grain and straw
7. It activates rhizobia when applied to legumes
8. It can rectify the defects of excessive nitrogen the effects of phosphates can not be easily asserted by external appearance.

Deficiency symptoms

1. P is relatively mobile in plants and can be transferred to sites of new growth, causing symptoms of dark to blue-green coloration to appear on older leaves of some plants.
2. Under severe deficiency, purpling of leaves and stems may appear.
3. Lack of P can cause delayed maturity and poor seed and fruit development.

Potassium (K)

Functions

1. The role of potassium is in controlling the general vigour of plant
2. It is essential for starch formation, sugar translocation and chlorophyll development
3. It hardens the plant tissues and increases the resistance to pests, diseases, cold weather and adverse conditions
4. It promotes good tuber development
5. Regulates water conditions within the plant cell and water loss from the plant by maintaining the balance among anabolism, respiration and transpiration
6. Increases plumpness of grain and seeds
7. Potassium is specially useful to root crops, tuber crops, tobacco and coconut
8. Potassium is taken by plants in the shape of potassium oxide commonly called as potash
9. Potash is also lost to some extent in soluble form by leaching
10. Excess potassium may effect the quality of citrus fruits adversely

Deficiency symptoms

1. The most common symptom is chlorosis along the edges of leaves (leaf margin scorching).
2. This occurs first in older leaves, because K is very mobile in the plant.
3. Plants lacking K will have slow and stunted growth.
4. In some crops, stems are weak and lodging is common if K is deficient.
5. The size of seeds and fruits and the quantity of their production is reduced.

Calcium (Ca)

Functions

1. Calcium has a major role in the formation of the cell wall
2. Calcium is an activator of several enzyme systems in protein synthesis and carbohydrate transfer.
3. It acts as cement between the walls of the cells
4. It is essential to activate growth tips, especially root tips
5. Improves intake of other plant nutrients like nitrogen and trace elements
6. It influences water economy of plants

7. It combines with anions including organic acids, sulfates, and phosphates. It acts as a detoxifying agent by neutralizing organic acids in plants.
8. It is essential for seed production in peanuts.

Deficiency symptoms

1. Calcium is immobile and is not translocated in the plant, so symptoms first appear on the younger leaves and leaf tips.
2. The growing tips of roots and leaves turn brown and die.
3. Newly emerging leaves may stick together at the margins, which causes tearing as the leaves expand. This may also cause the stem structure to be weakened.
4. In some crops, younger leaves may be cupped and crinkled, and the terminal bud dies.
5. Premature flowering in some crops.

Magnesium (Mg)

Functions

1. The predominant role of Mg is as a major constituent of the chlorophyll molecule, and it is therefore actively involved in photosynthesis.
2. It combines with phosphates and helps in the movement of phosphates in plants for the formation of oil seeds.
3. It helps in translocation of starches.

Deficiency symptoms

1. Magnesium deficiency causes interveinal chlorosis and first appears in older leaves.
2. Leaf tissue between the veins may be yellowish, bronze, or reddish, while the leaf veins remain green.
3. In severe cases, symptoms may appear on younger leaves and cause premature leaf drop.
4. Symptoms occur most frequently in acid soils and soils receiving high amounts of K fertilizer or Ca.

Sulphur (S)

Functions

1. Sulphur is essential for formation of plant proteins because it is a constituent of certain amino acids.
2. It is actively involved in metabolism of vitamins like biotin and thiamine and co-enzyme A.

3. It aids in seed production, chlorophyll formation, nodule formation in legumes, and stabilizing protein structure.

Deficiency symptoms

1. Younger leaves are chlorotic with evenly, lightly colored veins.
2. In some plants (e.g., citrus) the older leaves may show symptoms first.
3. Growth rate is retarded and maturity is delayed.
4. Plant stems are stiff, thin, and woody.

Iron (Fe)

Functions

1. Iron is essential in the photosynthesis and respiration.
2. The enzymes involved include catalase, peroxidase, cytochrome oxidase, and other cytochromes.
3. Iron is essential in the synthesis and maintenance of chlorophyll in plants.
4. Iron has been strongly associated with protein metabolism.

Deficiency symptoms

1. Iron deficiency causes Interveinal chlorosis in younger leaves.
2. The younger leaves may become white.

Manganese (Mn)

Functions

1. Manganese primarily functions as part of the plant enzyme system, activating several metabolic functions.
2. It is closely associated with iron intake and movement
3. It is involved in the oxidation-reduction process in photosynthesis.

Deficiency symptoms

1. Symptoms first appear as chlorosis in young tissues.
2. In dicots chlorosis shows up as tiny yellow spots.
3. In monocots, greenish-grey specks appear at the lower base of younger leaves.

Boron (B)

Functions

1. Boron is necessary in the synthesis of RNA and in cellular activities.
2. It has been shown to promote root growth.
3. It is essential for pollen germination and growth of the pollen tube.

4. It has been associated with lignin synthesis, activities of certain enzymes, seed and cell wall formation, and sugar transport.

Deficiency symptoms

1. Generally, B deficiency causes stunted growth.
2. symptomsfirst appear on the growing point and younger leaves.
3. The leaves tend to become thickened and may curl and become brittle.

Zinc (Zn)

Functions

1. Zinc is required for the synthesis of tryptophan, which in turn is necessary for the formation of Indole Acetic Acid in plants.
2. Zinc is present in many enzymes and regulates metabolic activities.
3. Zinc has a role in RNA and protein synthesis.

Deficiency symptoms

1. Interveinal chlorosis occurs on younger leaves.
2. The new leaves are usually abnormally small, mottled, and chlorotic.
3. Fruit formation is significantly reduced.
4. In legumes, stunted growth with interveinal chlorosis appears on the older, lower leaves.
5. Dead tissue drops out of the chlorotic spots.

Copper (Cu)

Functions

1. Copper is essential in several plant enzyme systems involved in photosynthesis.
2. It is part of the chloroplast protein plastocyanin, which forms part of the electron transport chain.
3. It may have a role in the synthesis and/or stability of chlorophyll and other plant pigments.

Deficiency symptoms

1. Copper deficiency causes reduced growth
2. It also causes distortion of the younger leaves, and possible necrosis of the apical meristem.
3. Young leaves become bleached, and eventually there is defoliation and dieback of twigs.

Molybdenum (Mo)

Functions

1. Molybdenum is a necessary component of two major enzymes in plants, nitrate reductase and nitrogenase, which are required for normal assimilation of N.
2. It is required by some soil microorganisms for nitrogen fixation in soils.

Deficiency symptoms

1. Older and middle leaves become chlorotic, and the leaf margins roll inwards.
2. Deficient plants are stunted, and flower formation may be restricted.
3. Deficiency can be common in nitrogen-fixing legumes.

Chlorine (Cl)

Functions

1. Chlorine is essential in photosynthesis, whereis involved in the evolution of oxygen.
2. It increases cell osmotic pressure and the water content of plant tissues.

Deficiency symptoms

1. Chlorosis of younger leaves and wilting of the plant.
2. Deficiency rarely occurs in plants because chlorine is found in the atmosphere and rainwater.

Correction of Nitrogen, Phosphorus and Potassium deficiency

Nitrogen, Phosphorus and Potassium deficiency can be corrected by applying various organic and inorganic fertilizers in appropriate form and quantities.

1. Nitrogen is applied to soil through organic manures and inorganic fertilizers like urea, Ammonium sulphate, ammonium chloride, CAN etc.
2. Phosphorus is applied in the form of super phosphate, triple super phosphate, rock phosphate, Diammonium phosphate and other complex fertilizers which can contain phosphorus.
3. Potash is applied as potassium sulphate or muriate of potash.

Correction of Micronutrient deficiency

The deficiency of micro nutrients can be corrected by the following methods.

1. Soil application: The required quantity of material is finely powdered and applied to soil.

2. Foliar application: Spraying of micronutrients in the form of a solution is taken up when the crops show deficiency symptoms.

2.2 Classification of manures and fertilizers, soil testing

2.2.1 Classification of manures and fertilizers

Manures and Fertilizers

- Organic manures (Natural manures)
  - Bulky: Cattle manure, Sheep manure, Pig manure, Poultry manure, Horse manure, Compost, Green manure, Sewage sludge
  - Concentrated: Oil cakes, Bone manures, Fish manures, Guano, Blood meal, Horn and hoof meal, Ash
- Chemical fertilizers (Artificial manures)
  - Nitrogen: Ammonia gas, A.S.N., C.A.N., Urea, Sodium nitrate, Potassium nitrate, Calcium cyanamide
  - Phosphorus: Super phosphate, Rock phosphate, Basic slag
  - Potassium: Sulphate of potash, Muriate of potash

2.2.1.1 Manures: Manures are the organic substances capable of supplying plant nutrients in available form, bulky in nature and having no definite composition and most of them are obtained from animal and plant waste products.

A) Bulky organic manures: The bulky organic manures are organic manures that are required in huge amounts. All these bulky organic manures are bulky in nature and supply organic matter in large quantities. Eg. FYM, Composts, Green manures, Sewage sludge.

1. Farm yard manure (Cattle manure): The physical composition of cattle manure is called Farm yard manure, which consists of dung and urine of cattle and the litter hay, straw used for cattle. Cattle manure is slow acting, bulky, organic in nature.

2. Compost: Compost is a product obtained from decomposition of plant and animal wastes withvarious additives .The compost had the largest variation of all organic material rangingfrom neglected garbage dumps to carefully composted and treated substances withhigh fertility.

Composting: Composting is a process of converting organic matter in to manure by fermentation process under controlled conditions in a short time is called composting. The organic material that is usually handled for composting are waste vegetative material such as straw, peanut hulls, saw dust, dried leaves etc., stubbles, cotton stalks, tobacco stems, weeds, municipal wastes etc., based on availability.

3. Green manures: Green manures are the green plant with succulent tissues grown in the field or adding green plants with tender twigs or leaves from outside and incorporating them into the soil for improving the physical structure as well as fertility of the soil.

4. Penning: Keeping the animals (cattle and sheep) in the fallow land after the harvest of the last crop, throughout day and /or night provided with suitable food and shelter.

5. Sewage and sludge: Sewage refers to the used up water from towns and cities collected though a drainage system. It consists of solid and liquid wastes from kitchen and bath rooms. Sludge is the sediment that settles down in the activated sludge process. It is dark and powdery material with good manurial value.

B) Concentrated organic manures: Like bulky organic manures, these organic manures contain plant nutrients and considerable amount of organic matter. They have direct effect on plant growth. Eg.Oil cakes, bone meal and horn meal.

1. Bone meal: Bone meal is a white to whitish material produced by treating the bones obtained in abattoirs (Slaughter houses). The bones are dried, crushed, degreased and cleaned to obtain bone grist.

2. Horn meal: Horn powder, horn grist or horn chips can be obtained depending on the degree of crushing and collectively termed as horn meal.

3.Blood meal: Blood is collected from slaughter houses dried and ground to powder and is used as blood meal.

4. Oil cakes: After removal of oil from seeds, the residue is made in to cakes. Oil cakes are used as organic fertilizers since they are rich source of organic nitrogen in protein form. In addition to N, small amounts of P, K and micronutrients. Oil cakes are classified into two groups viz.,

i) Edible oil cakes: Suitable for cattle and poultry feeding and also as a manure /fertilizer but not economical. Eg. Groundnut , Gingelly cakes etc.,

ii) Non –Edible oil cakes: Suitable for crop fertilization. Eg. Castor cake, neem cake *etc.*

2.2.1.2 Fertilizers: A fertilizer can be defined as a mined or manufactured material containing one or more essential plant nutrients in potentially available forms in commercially valuable amounts.

Classification of fertilizers

A. Straight fertilizers: Straight fertilizers are chemical substances that contain only one nutrient element in absorbable form by plants. The straight fertilizers include 1) Nitrogenous, 2) Phoshphatic and 3) Potassic fertilizers.

1. Nitrogenous Fertilizers: Nitrogenous fertilizers are chemical substances that contain the nutrient element nitrogen in absorbable form by plants chiefly as ammonium (NH^{4+}) or nitrate (NO_3^-)**.**

2. Phosphatic Fertilizers: Phosphate fertilizers are chemical substances that contain the nutrient element phosphorus in the form of absorbable phosphate ions (anions).

3. Potassic fertilizers: Potassic fertilizers are chemical substances containing potassium in absorbed form (K^+).

B. Complex Fertilizers: The fertilizers containing two or more major plant nutrients, which are in chemical combination, are called as complex fertilizers. They are solids and homogeneous in nature that each fertilizer granule is guaranteed to contain two or more major plant nutrients in a specified ratio.

2.2.2 Soil testing

2.2.2.1 Collection of samples

Soil sampling is done in order to find out the quantity of essential nutrients present and characteristic of the soil. By soil testing we can know:

1. Whether the soil has adequate quantities of plant nutrients.
2. Whether the soil is acidic or alkaline and
3. The physical and chemical properties of the soil.

The following precautions are taken when soil samples are taken.

1. Soil sampling should be done when there is no crop in the field or prior to raising any crop. Raising season should be avoided as far as possible.
2. Ten to fifteen samples should be taken from an apparently homogenous plot. If the plot is large and has different appearance, the plot is divided into parts and samples are taken from each plot separately.
3. A composite sample should be taken. It is an average soil sample.

4. The samples should not be taken from the extreme corners of the field, areas recently fertilized, field bunds, marshy spots, compost pits etc.
5. Sampling from furrows should be avoided
6. Quantity of a composite sample should not be less than 0.5 kg
7. Fertilizer bags should not be used for keeping soil samples.

2.2.2.2 Procedure:

A composite sample from a field can be taken by following procedure given below.

1. Remove the litter from the surface without much disturbing the soil.
2. Take soil sample from 10-15 random spots in a zigzag pattern in the field, by giving a V-shaped cut up to depth of 25 cm, with a spade or pick axe at each spot. Take a 1.5 to 2.0 cm thick uniform slices and collect them in a clean and dry container.
3. Mix thoroughly the soil collected from different spots of the field.
4. Spread the soil in a disc like shape and divide the soil collected into four parts. Discard one set of opposite quarters.
5. Mix well the remaining soil and repeat this till the sample size is reduced to 0.5 to 0.75 kg. This is called quatering technique.
6. Put the sample in a clean cloth bag free from any contamination of fertilizers, salts *etc.*
7. Air dry the sample under shade.
8. Prepare labels showing the details of the sample and tie it to the neck of the bag.

After taking soil samples as described above the soil is tested to find out the following:

1. Mechanical analysis of the soil
2. Determination of soil texture
3. Determination of soil pH
4. Determination of total soluble salts
5. Determination of Available Nitrogen, Phosphorus and Potassium.

2.3 Biogas plant, Green manuring and Vermicomposting

2.3.1 Biogas plant

Most organic materials undergo a natural anaerobic digestion in the presence of moisture and absence of oxygen and produce biogas. The biogas so obtained is a mixture of methane (CH_4): 55-65% and Carbon dioxide (CO_2): 30-40%.

The biogas contains traces of Hydrogen, Hydrogen sulphide and Nitrogen. The calorific value of biogas ranges from 5000 to 5500 Kcal/Kg (18.8 to 26.4 MJ /m^3). The biogas is used for cooking, domestic lighting, heating and generation of electricity for use in agriculture and rural industry.

Advantages

- The initial investment is low for the construction of biogas plant.
- The technology is very suitable for rural areas.
- Biogas is locally generated and can be easily distributed for domestic use.
- Biogas reduces the rural poor from dependence on traditional fuel sources, which lead to deforestation.
- The use of biogas in village helps in improving the sanitary condition and checks environmental pollution.
- The by-products like nitrogen rich manure can be used with advantage.
- Biogas reduces the drudgery of women and lowers incidence of eye and lung diseases.
- Biogas is produced mainly from
    - Cow dung
    - Sewage crop residues
    - Vegetable wastes
    - Water hyacinth
    - Poultry droppings
    - Pig manure

2.3.1.1 Types of Biogas Plants

1. Fixed dome plant

a) Janata model

b) Deenbandhu model

2. Floating drum plant

a) KVIC model

b) Pragati model

c) Ganesh model

1. Fixed dome type of biogas plant

Raw materials required

- Animal dung
- Poultry wastes
- Plant wastes (Husk, grass, weeds etc.)

- Industrial wastes(Saw dust, wastes from food processing industries)
- Domestic wastes (Vegetable peels, waste food materials)

Principle: Biogas is produced as a result of anaerobic fermentation of biomass in the presence of water.

Construction: The biogas plant is a brick and cement structure having the following five sections:

a) Mixing tank present above the ground level.
b) Inlet chamber: The mixing tank opens underground into a sloping inlet chamber.
c) Digester: The inlet chamber opens from below into the digester which is a huge tank with a dome like ceiling. The ceiling of the digester has an outlet with a valve for the supply of biogas.
d) Outlet chamber: The digester opens from below into an outlet chamber.
e) Overflow tank: The outlet chamber opens from the top into a small over flow tank.

Working: The various forms of biomass are mixed with an equal quantity of water in the mixing tank. This forms the slurry. The slurry is fed into the digester through the inlet chamber. When the digester is partially filled with the slurry, the introduction of slurry is stopped and the plant is left unused for about two months. During these two months, anaerobic bacteria present in the slurry ferments the biomass in the presence of water.

As a result of anaerobic fermentation, biogas is formed, which starts collecting in the dome of the digester. As more and more biogas starts collecting, the pressure exerted by the biogas forces the spent slurry into the outlet chamber. From the outlet chamber, the spent slurry overflows into the overflow tank. The spent slurry is manually removed from the overflow tank and used as manure for plants. The gas valve connected to a system of pipelines is opened when a supply of biogas is required. To obtain a continuous supply of biogas, a functioning plant can be fed continuously with the prepared slurry.

Floating drum type of biogas plant

The floating drum type of biogas plant has the following chambers/ sections:

Mixing Tank: Present above the ground level.

Digester tank: Deep underground well-like structure. It is divided into two chambers by a partition wall in between.

It has two long cement pipes:

i) Inlet pipe opening into the inlet chamber for introduction of slurry.

ii) Outlet pipe opening into the overflow tank for removal of spent slurry.

Gas holder: An inverted steel drum resting above the digester. The drum can move up and down i.e., float over the digester. The gas holder has an outlet at the top which could be connected to gas stoves.

Over flow tank - Present above the ground level.

Working: Slurry is prepared in the mixing tank. The prepared slurry is fed into the inlet chamber of the digester through the inlet pipe. The plant is left unused for about two months and introduction of more slurry is stopped. During this period, anaerobic fermentation of biomass takes place in the presence of water and produces biogas in the digester. Biogas being lighter rises up and starts collecting in the gas holder. The gas holder now starts moving up. The gas holder rises up to a certain level. As more and more gas starts collecting, more pressure begins to be exerted on the slurry. The spent slurry is now forced into the outlet chamber from the top of the inlet chamber. When the outlet chamber gets filled with the spent slurry, the excess is forced out through the outlet pipe into the overflow tank. This is later used as manure for plants. Once the production of biogas begins, a continuous supply of gas can be ensured by regular removal of spent slurry and introduction of fresh slurry.

2.3.2 Green Manuring – Types and crops

Green manuring: Green manuring can be defined as growing of crops to incorporate into soil while green, or after maturity with a view to improve the soil fertility and benefiting subsequent crops.

Objectives of green manuring:

i. To Increase organic matter content of soil

ii. To Maintain and improve soil structure

iii. To Reduce the nutrients loss.

iv. To Provide a source of nitrogen for the succeeding crop

v. To Reduce the soil loss by erosion

Types of green manuring:

The practice of green manuring is adopted in various ways in different states of India to suit soil and climatic conditions. Broadly speaking, the following two types of green manuring can be differentiated.

Classification of Green manuring:

Classified into two groups

I. Green manure *in situ*

II. Green leaf manuring

I. Green manuring *in situ*: In this system, green manure crops are grown and buried in the same field either as a pure crop or as intercrop with the main crop. This is most common green manure crops grown under this system are sunnhemp (*Crotalaria juncea*), dhaincha (*Sesabania aculeata*), Pillipesera (*Phaseolus trilobus*) and guar (*Cyamopsis tetragonoloba*) legumes are mostly used which are fast growing and yield substantial succulent vegetation. There is little or no preparatory cultivation. Sowing is done by broadcast, adopting a heavy seed rate. Green manuring can be safely adopted for irrigated and irrigated dry crops *viz.,* rice, sugarcane, tuber crops , vegetables and orchards.

II. Green leaf manuring: Green leaf manuring refers to collecting green leaves and twigs from shrubs and trees grown on bunds, waste lands and nearby forest areas these are added and incorporated into the soil. The common shrubs and trees used are *Glyricidia, Sesbania* species, Karanj (*Pongamia pinnata*) etc.,

Table 2.1 Trees used as a source of green leaf manure

S. No.	Scientific name
1	*Azolla pinnata*
2	*Calotropis gigantea*
3	*Cassia auriculata*
4	*Glyricidia maculate*
5	*Leucaena leucocephala*
6	*Pongamia glabra*
7	*Tephrosia purpurea*

Advantages of green manuring (*in situ*)

1. Green manure crops can be chosen to suit the soil, season, water facility and cropping pattern
2. Reduces expenditure on collection and transportation of green leaf
3. It is easy to incorporate the green manure crop in right time
4. It reduces the loss of nitrogen from the soil

Limitations of green manure crops (*in situ*)

1. There must be sufficient time available for growing the green manure crop, nearly 2-3 months

2. Extra expenditure has to be incurred for growing green manure crop
3. Some of the green manure crops have fodder value.
4. They are susceptible for pests and diseases as such they may harbour them as alternate hosts.
5. Need timely rainfall or irrigation etc., for growing
6. Seeds may not be available in time

Advantages of green leaf manuring

1. All the quantity of green leaf applied is entirely an addition to soil –neither the moisture nor nutrients are utilized from the soil
2. There is no fear of spread of pests and diseases
3. It can be adopted at any time irrespective of the season

Limitations of green leaf manuring

1. The green leaf is not available everywhere except in forest regions and waste lands
2. Green leaf whichever is available has to be used without choice
3. Green leaf may not be available sufficient quantity in all seasons
4. Extra expenditure on collection and transport has to be incurred

Criteria for green manure crop

1. Capacity to fix atmospheric N in good amounts in symbiosis with micro organisms
2. More vegetative growth
3. Succulent vegetative parts
4. Less fibrous material
5. Deep root system to open the soil-for recycling of nutrients
6. Short duration crops with more and faster vegetative growth.

2.3.3 Vermicomposting: Vermicomposting is a method of making compost, with the use of earthworms, which generally live, in soil eat biomass and excrete it in digested form. This compost is generally called Vermicomposting.

Nutrient value: The nutrient value of Vermicompost, there is 1.6 % of Nitrogen, 1.35% Phosphorus and 0.8 % of Potassium.

Materials required for the preparation of Vermicompost

Organic waste material: Organic wastes like debris, leaves, dung, fruits and vegetables waste etc.

Earthworms: Non burrowing earthworms like *Udrilus ugine*, *Eoisenia foetida etc.*

Procedure: It is mostly prepared in either pit or heap method .The dimensions are 3m×1.2m×0.6m.The length and width can be increased or decreased depending on the availability of material but not the depth because the earth worms activity is confined to the 0.6m feet depth only.

First layer is composed of beddingmaterial of 2.5 cm thick with soft leaves. Second layer consists of 22.5 cm thick organic residue layer with finely chaffed material and third layer comprises of equal mixture of dung + water up to 5cm thick .Continued the layer up to above ground level to protect the worms against natural enemies like ants, lizards, snakes, frogs, toads etc., Maintain suitable moisture and temperature by frequent turnings and subsequent staking.After 24 days, 4000 worms are introduced in to the pit without disturbing the pit by regular watering. The entire raw material will be turned into the vermicompost in the form of worm excreta .The turnover of the compost is 75 % (if the total material accommodated in the pit is 1000 kg ;The out turn will be 750 kg).

Indication whether the compost is ready:

1. After the compost is prepared, earthworms will not stay inside. They will come up and stick to gunny bags.
2. A coffee powder like compost is seen at the top as a layer.

Uses of vermicompost:

2 to 3 tonnes of vermicompost is applied per hectare in fruit orchards.

2.4 Bio-fertilizers

Introduction

Biofertilizers are the substances which contains living microorganisms which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant.

Need of bio-fertilizers

Plant nutrients are lost from soil in different ways, large quantities are removed from the soil due to theharvest of crops, and weeds also remove a considerable quantity of plant nutrient from soil. Nutrientscan also be removed by leaching and erosion. To increase production and productivity, maintain soil health, reduce nutrient losses, improve soil environment and minimize energy consumption, it is necessary to use bio-fertilizers with chemical fertilizers. Bio-fertilizers also help in fixing atmospheric nitrogen, dissolve soil phosphorus and stimulate plant growth through synthesis of growth promoting substances.

Biofertilizers are of 2 types

1. Nitrogen fixing micro-organism (NFM)
2. Phosphorus solubilizing micro-organism (PSM)

1. Nitrogen fixing micro-organism (NFM)

Rhizobium: Rhizobium bacteria are capable of fixing atmospheric nitrogen in association with leguminous crops. Rhizobium species enter the roots of host plants and form nodules on the root surface. Rhizobium supplies nitrogen to the host plant.

Rhizobium is a host species and different crops have different rhizobium species given as below:

Table: 2.2 *Rhizobium* species suitable for different crops

S.No.	*Rhizobium* species	Crop
1	*R. leguminosarum*	Pea, lathyrus, lentil
2	*R. trifoli*	Berseem
3	*R. phaseoli*	Kidney bean
4	*R. japonicum*	Soybean
5	*R. meliloti*	*Melilotus*, lucerne, fenugreek

Blue green algae (BGA): BGA can fix atmospheric nitrogen. They are also called as cyanobacteria and are free living organisms. They are photosynthetic nitrogen fixers which derives their energy from photosynthesis to fix atmospheric nitrogen. The most species of BGA are *Anabena* and *Nostoc*.

***Azotobacter* and *Azosprillum*:** *Azotobacter* is capable of fixing atmospheric nitrogen. It can be applied byseed inoculation, seedling dip or by soil application. The inoculum required is 3-5 kg/ha. *Azotobacter*can be used for rice, cotton and sugarcane. *Azosprillum*is mainly used for cereal crops and mainly for sorghum.

2. Phosphorus solubilizing micro-organism (PSM): Bacteria belonging to genera *Pseudomonas* and *Bacillus* and fungi to the genera *Penicillium* and *Aspergillus*have the ability to solubilise the bound phosphate insoil and increase its availability to plant. Inoculationof seed or seedling with phosphorus bio-fertilizers canprovide phosphorous to plants. Vesicular Arbuscular Mycorrihiza (VAM) helps in phosphorus nutrition by not only increasing its availability but also increasing its mobility. VAM are obligate symbiotic fungi and improve the uptake of other nutrients like Zinc, Cobalt, Phosphorous and water.

Advantages of Bio-fertilizers

1. Increases crop yield by 20-30 per cent.

2. Replace chemical nitrogen and phosphorus by25 per cent.
3. Stimulate plant growth.
4. Restore natural soil fertility.
5. Build up soil fertility in the long term
6. Cost effective, *i.e.* reduces the costs toward fertilizers use especially regarding nitrogen and phosphorus
7. Supplement to fertilizers.
8. They are eco-friendly and pose no harmful to the environment.

Disadvantages of Bio-fertilizers

1. Each species is specific to each plant
2. *Rhizobium* spp. Culture does not work well in high nitrate tolerant strains of soybean
3. The acceptability of bio-fertilizers has been rather low chiefly because they do not produce quick andspectacular responses
4. Require skill in production and application
5. Don not have long shelf life
6. Inadequate awareness about its use and benefits

2.5 Fertilizer application methods

In order to get maximum benefit from fertilizers, they are not only be applied in proper time and in right manner but other aspects should also be considered. **Application of fertilizers includes following methods**:

I) Broadcasting: Even and uniform spreading of manure or fertilizers by hand over the entire surface of field while cultivation or after the seed is sown in standing crop, termed as broad casting. Depending upon the time of fertilizer application, there are two types of broadcasting:

A) Broadcasting at planting and

B) Top dressing.

A) Broadcasting at planting: Broadcasting of manure and fertilizers is done at planting or sowing of the crops with the following objectives:

1) To distribute the fertilizer evenly and to incorporate into the plough layer.

2) To apply larger quantities that can be safely applied at the time of planting/sowing with a seed-cum-fertilizer driller.

B) Top dressing: Spreading or broadcasting of fertilizers in the standing crop (after emergence of crop) is known as top-dressing. Generally, N fertilizers are top dressed to the closely spaced crops like wheat, paddy. E.g. Sodium Nitrate, Ammonium Nitrate and urea, so as to supply nitrogen in readily available from the growing plants. Care must be taken in top dressing that the fertilizer should not be applied when the leaves are wet because it may burn or scorch the leaves.

II) Placement: In this, the fertilizers are placed in the soil irrespective of the position of seed, seedling or growing plant before or after sowing of the crops. It includes:

1. Plough sole placement: The fertilizer is placed in a continuous band on the bottom of the furrow during the process of ploughing. By this method, fertilizer is placed in moist soil where it can become more available to growing plants during dry seasons.

2. Deep placement: In this method, fertilizers like Ammonium sulphate and urea, is placed in the reduction zone as in paddy fields, where it remains in ammonia form and is available to the crop during the active vegetative period.

III) Localized placement: It refers to the application of fertilizers into the soil close to the seed or plant. It is usually employed when relatively small quantities of fertilizers are to be applied. It includes methods like:

1. Drill placement: It refers to the drilling of seed and fertilizer together while sowing. It places the seed and small quantities of fertilizers in the same row.

2. Band placement: In this, fertilizer is placed in bands which may be continuous or discontinuous to the side of seedling, some distances away from it and either at level with the seed, above the seed level or below the seed level. There are two types of band placement: It includes hill and row placement.

a) Hill placement: When the plants are spaced 3 ft. or more on both sides, fertilizers are placed close to the plant in bands on one or both sides of the plants. The length and depth of the band and its distance from plant varies with the crop and the amount of fertilizer as in cotton.

b) Row placement: When the seeds or plants are sown close together in a row, the fertilizer is put in continuous band on one or both sides of the row by hand or a seed drill. Higher rates of fertilizers are possible with row placement than hill placement.

3. Pellet application: In this method, fertilizer (N- fertilizers) is applied in the form of pellets 2.5 – 5.0 cm. deep between the rows of paddy crop. Fertilizer is mixed with soil in the ratio of 1:10 and make into dough. Small pellets of a convenient size are then made and deposited in the soft mud of paddy fields.

2.6 Balanced fertilization and Integrated Nutrient Management

2.6.1 Balanced fertilization: concept and definitions

The term balanced fertilization was first introduced by Justus von Liebig in 1840, who stated that farmers have to add those nutrients to the soil that have been removed by harvested crops, to be able to sustain high crop yields.

Basically, balanced fertilization aims at a harmony between agronomy and ecology (environment). Balanced fertilization can be defined as:

(a) The supply of all essential plant nutrients is adjusted in the proper ratios to crop demand;

(b) The supply of plant nutrients equals the uptake of nutrients by the crop; and

(c) The supply of plant nutrients equals the removal of nutrients from the field via the harvested crop.

Crops need many essential nutrients for optimum growth, yield and quality. Nitrogen (N), phosphorus (P), potassium (K), sulphur and zinc are some of the essential plant nutrients. Crops need nitrogen, phosphorus and potassium in large amounts; hence these are applied through fertilizers. Application of plant nutrients in optimum ratio and adequate amounts is called "*Balanced Fertilization*".

Imbalanced Fertilization leads to

- Depletion in soil fertility
- Decrease in crop yields
- Poor crop quality
- Diminishing profits

2.6.2 Integrated Nutrient Management

Integrated Nutrient Management (INM): Integrated nutrient management (INM) is an approach to soil fertility management that combines organic and mineral methods of soil fertilization with physical and biological measures for soil and water conservation. INM adopts a holistic view of plant nutrient management by considering the totality of the farm resources that can be used as plant nutrients. It is based on three fundamental principles:

- Maximize the use of organic material
- Ensure access to inorganic fertilizer and improve the efficiency of its use
- Minimize losses of plant nutrients

Balanced application of appropriate fertilizers is a major component of INM. Fertilizers need to be applied at the level required for optimal crop growth based on crop requirements and agro-climatic considerations.

At the same time, negative externalities should be minimized. Higher doses of fertilizers are economically wasteful and can damage the environment. Lower doses of fertilizers application, can retard crop growth and record lower yields in the short term, and in the long term reduce sustainability through soil mining and erosion. The wrong kind of nutrient application can be wasteful as well. Balanced fertilization should also include secondary nutrients and micronutrients, both of which are often most readily available from organic fertilizers such as animal and green manures.

Nutrient conservation in the soil is another critical component of INM. Soil conservation technologies prevent the physical loss of soil and nutrients through leaching and erosion.

First, practices such as terracing, alley cropping, and low-till farming alter the local physical environment of the field and thereby prevent soil and nutrients from being carried away. Second, mulch application, cover crops, intercropping, and biological nitrogen fixation act as physical barriers to wind and water erosion and help to improve soil characteristics and structure. Lastly, organic manures such as animal and green manures also aid soil conservation by improving soil structure and replenishing secondary nutrients and micronutrients. Improved application and targeting of inorganic and organic fertilizer not only conserves nutrients in the soil, but makes nutrient uptake more efficient

Development of INM technologies:

INM technologies like:

(a) Green manuring (GM) in rice–wheat, rice–mustard, and rice–rapeseed is cost effective and economically viable.

(b) Under constrained water resources, GM produced during the mild-rainy season and applied to rapeseed is more beneficial than rice-applied GM.

(c) Supply of nutrients through the integrated use of GM and fertilizer nitrogen provides advantages over the use of only Fertilizer N, producing greater yields of rice and wheat while reducing the use of nitrogen fertilizer. It significantly reduces nitrogen losses and diminishes the accumulation of NO_3^- in the soil profile.

(d) INM through GM, crop residues and nitrogen fertilizer in a rice-based cropping systems, groundnut-sunflower, soybean-based cropping systems has the long-term benefit of carbon sequestration and improved soil health resulting in high crop yields, help maintain balanced nutrients supply, check multinutrient deficiencies and sustain crop yields at a higher level.

Summary

1. There are 16 essential elements for plant growth. Carbon, hydrogen. Oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, boron, zinc, copper, molybdenum and chlorine
2. The manures and fertilizers are classified into organic manures (Natural manures) and inorganic manures (artificial manures). Organic manures may be bulky (Eg: FYM, compost, green manure) and concentrated (Eg: Oil cakes, bone manures). The inorganic manure or chemical fertilizers may be nitrogenous (Eg: Urea, ASN), phosphatic (super phosphate, rock phosphate) and potassium (MOP, SOP).
3. Soil sampling is done by quatering technique to study the amount of plant nutrients in the soil, to know the pH and physical and chemical properties of soil
4. Most organic materials undergo a natural anaerobic digestion in the presence of moisture and absence of oxygen and produce biogas. The biogas so obtained is a mixture of methane (CH_4): 55-65% and Carbon dioxide (CO_2): 30-40%.
5. Green manuring can be defined as growing of crops to incorporate into soil while green, or after maturity with a view to improve the soil fertility and benefiting subsequent crops.
6. Vermicomposting is a method of making compost, with the use of earthworms, which generally live, in soil eat biomass and excrete it in digested form. This compost is generally called Vermicomposting.
7. Biofertilizers are preparations containing cells of microorganisms, which may be nitrogen fixers, phosphorus solubilizers, sulphuroxidisers or organic matter decomposers. They are bioinoculants which on supply to plants improve their crop growth and yield.
8. Ferilizers are applied by different methods: Broadcasting, Topdressing and Placement
9. Balanced fertilization: application of essential plant nutrients in optimum quantities in right proportions through appropriate method and time of applications suited for a specific crop and agroclimatic situation. This improves quantity and quality of yield.
10. Integrated nutrient management (INM) is an approach to soil fertility management that combines organic and mineral methods of soil fertilization with physical and biological measures for soil and water conservation.

Terms used in this chapter

1. Mineral nutrition, 2. Macronutrients, 3. Micronutrients, 4. Bulky organic manures, 5. Farm yard manure, 6. Soil testing, 7.Quatering method, 8. Biogas plant, 9. Green manuring, 10.

Vermicomposting, 11.Biofertilizers, 12. Balanced fertilization, 14. Integrated nutrient management, 15. INM technologies

Short questions

1. Define essential elements and Arnon's criteria of essentiality
2. Give the classification of essential elements
3. What are macronutrients
4. Write the functions and deficiency symptoms of Nitrogen
5. Write the functions and deficiency symptoms of Phosphorus
6. Write the functions and deficiency symptoms of Zinc
7. Write short notes on biogas plant
8. Enlist the tree species suitable for green leaf manuring
9. What are biofertilizers and write the advantages of biofertilizers

Long questions

1. Give the classification of manures and fertilizers
2. Explain soil sampling procedure
3. Enlist the types of biogas plant and explain briefly about the fixed dome type of biogas plant
4. Explain green manuring types and it's advantages and disadvantages
5. Explain the preparation of vermicomposting
6. Explain different types of biofertilizers
7. Briefly describe different methods of fertilizer application
8. What is balanced fertilization
9. What is Integrated nutrient management and technologies suitable for INM

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UNIT3.

Irrigation Water Management

Structure

3.0 Introduction

The term irrigation water management by definition is a process of integrating the skill of management, engineering, economics, agronomy and sociology for dissecting, storing, supplying, allocating, conveying and applying water for the purpose of food and fibre production. It also includes drainage of excess water.

3.1 Irrigation and Drainage

3.1.1 Irrigation

Definition: It is the artificial application of water to soil for the purpose of supplying the moisture essential for normal plant growth and development.

or

Irrigation is the application of water to the soil for the following purpose.

Objectives of Irrigation

a) To add water to soil to supply the moisture essential for plant growth and development
b) To provide crop insurance against short duration droughts
c) To cool the soil and micro atmosphere providing more favourable crop environment
d) To leach out or dilute salts away from crop root zone
e) To soften hard pans formed by continuous tillage
f) To reduce frost damage
g) To achieve self-sufficiency in food and fibre production.

3.1.2 Drainage

Agricultural drainage is the artificial removal and safe disposal of excess water either from the land surface or soil profile.

or

Removal and safe disposal of excess gravitational water from the crop root zone to create favourable conditions for crop growth to enhance agricultural production.

Objectives of drainage are as follows

1. To control the water at a safe depth below the crop root zone.
2. To regulate soil temperature.
3. To regulate biological activity in the soil.
4. To remove excess salts beyond the crop root zone through leaching from the soil profile.
5. To lengthen the crop growing season by permitting earlier tillage and planting dates.
6. To enhance the crop production.

Table: 3.1 Irrigation projects of Andhra Pradesh

S. No.	Name of the project	River
1	Rajolibanda Diversion scheme	Tungabhadra
2	TBPHL Stage-1 (Tungabhadra project high level canal)	Tungabhadra
3	Vamsadhara project stage-1	Vamsadhara
4	TBLLC (Tungabhadra project lower level canal)	Tungabhadra
5	Yeleru reservoir project	Yeleru
6	Pennar river canal system	Penna
7	KC- canal (Kurnool-Cuddappah canal)	Pennar & Tungabhadra
8	Godavari Delta System	Godavari
9	NSRC	Krishna
10	Krishna Delta System	Krishna

3.2 Soil moisture availability

The soil is a heterogeneous, polyphasic viz., solid, liquid and gaseous, particulate, disperse and porous system. The solid phase constitutes the soil matrix, the liquid phase consists of soil water, which always contains dissolved substances so that it should properly be called the soil solution and the gaseous phase in the soil atmosphere.

The liquid portion of the soil which consists of water, dissolved minerals and soluble organic matter which fills part or most, of the spaces between the soil particles. This water is absorbed by the plant roots and must be periodically replenished by rain or irrigation for the successful production of crops. Thus the soil serves as a reservoir for moisture. This moisture reservoir and knowledge of its capacity are principle factors governing the frequency and amount of irrigation water to be applied to the land.

3.2.1 Field capacity: The field capacity is the amount of water held in the soil after excess water has drained away within 2 – 3 days after a rain or irrigation in soils having uniform texture and structure. At field capacity the soil moisture is held with a tension of 0.33 bars ..It is the upper limit of available soil moisture.

3.2.2 Permanent wilting point: Permanent wilting point is a condition where the water is held so tightly by the soil particles that the roots cannot extract moisture sufficiently at rapid rate to prevent the leaves from witling. Removal of water either by the plant roots of a biologically active crop or due to soil evaporation from an initially wet soil causes the water films surrounding the soil particles become thinner and thinner with the result more of the water held between soil particles in the pores are disappeared. When this condition is reached the soil is said to be in a state of permanent wilting point, at which nearly all the plants growing on such soil show wilting symptoms. The soil moisture tension at permanent witling point is about 15 bars.

3.2.3 Available soil moisture: This is amount of soil moisture held between the field capacity and permanent wilting point. Though considerable soil moisture is present below the permanent wilting point, it is held so tightly by the soil particles that the plant roots are unable to extract it rapidly enough to prevent wilting. Thus practically it is not useful for the plants and forms the lower limit of available soil moisture. Similarly, the water above the field capacity is not available to the plants owing to quick drainage.

3.3 Water Requirement of crops

Because of the high demand for and the importance of water, a plant requires a consistent water source for normal growth and development and for final yield. Anytime water becomes limiting, crop growth and yield is reduced. Hence, water application in right time and in optimum quantity is an essential pre-requisite for obtaining good crop yield. But both the amount of water as well as time may vary in different crops.

3.3.1 Crop water requirement: The quantity of water regardless of its source, required by a crop or diversified pattern of crops in a given period of time for its normal growth under field conditions at a given place. In other words it is the total quantity of water required to mature an adequately irrigated crop. It is expressed in depth per unit time.

WR = ET or CU + Application losses + Special needs

It can also be expressed in supply terms as WR= IRR + ER + S+ GWc

Where:

WR	= Water requirement
ET	= Evapotranspiration
CU	= Consumptive use of water
IRR	= Total depth of irrigation water during crop life
ER	= Effective rainfall received during crop life
S	= Profile water use *i.e.,* difference in soil moisture in the crop root zone at the beginning and end of the crop
GWc	= Groundwater contribution

3.3.2 Effective Rainfall

The primary source of water for agricultural crop production in most parts of the world is rainfall. All the rainwater, however, cannot be useful for a specific purpose. In other terms, effective rainfall means 'that portion of the total annual or seasonal rainfall which is useful directly and/or indirectly for crop production at the site where it falls but without pumping'.

Factors influencing Effective Rainfall

- Rainfall
- Slope of the land
- Infiltration and permeability of soil
- Ground water
- Crop characteristics

3.3.3 Critical Growth Stages

The optimal moisture for plant growth varies with the stage of crop growth *i.e.,* it is low in the initial stages (establishment and early development), increases with the advancement of crop life and attains peak value during reproductive stage, thereafter it decreases towards ripening and maturity phases. Thus, not all the crop growth phases are equally sensitive, certain stages are more sensitive to soil moisture/ stress when compared to other stages. These are known as critical growth stages. Thus critical growth period is the stage or stages of growth of the crop at which moisture stress has the greatest effect on quality and quantity of yield. Therefore, any stress during these stages will irrevocably reduce the yield and provision of adequate water and other management practices at other growth stages will not compensate the yield lost.

Critical stages of various fields, vegetable and fruit crops are presented, which serve as a guideline for management of limited water supplies.

Table: 3.2 Critical growth periods of crops for water supply

Crop	Critical growth period for water supply
Rice	Primordial development, Heading and Flowering
Wheat	Crown root initiation, Tillering and Ear head development
Maize	Tasseling,Silking and Pollination
Sorghum	Booting, Blooming, Milky and Dough stages
Bajra	Heading and Flowering
Barley	End of vegetative stage and Ear head formation
Ragi	Primordial initiation and Flowering
Groundnut	Flowering, peg penetration and pod development
Sesame	Flowering to Maturity
Sunflower	Star formation, flowering and seed development
Safflower	Rosette flowering and Seed development
Soybean	Flowering and Seed formation
Cotton	Flowering and Boll development
Sugarcane	Formative and Stem elongation
Tobacco	Rapid growth and Topping stage
Chillies	Flowering and Fruit development
Potato	Tuber initiation to tuber maturity
Onion	Bulb enlargement to Ripening
Peas	Flowering and pod development
Tomato	Flowering and Fruiting
Citrus	Flowering, Fruit set and Fruit enlargement
Banana	Adequate soil moisture throughout growth period and fruit development
	Flowering and Fruit development
Mango	Flowering and Fruit development
Pomegranate	

3.3.4 Effective Root Zone Depth

It is also referred to as design moisture extraction depth. This is the soil depth from which nearly 90 per cent of the crop water requirement is met. This soil depth is normally taken into account to determine the irrigation water requirements for scheduling irrigation. For best results, it should be the depth from which roots of an average mature plant are capable of reducing soil moisture to the extent that it should be replaced by irrigation.

Root penetration is seriously affected by presence of a hard pan or compacted layer in the soil profile. Thus roots cannot penetrate a hard layer except through cracks. Thus, in shallow soils, crop roots may be confined to a thin layer of soil irrespective of their normal genetic rooting pattern in a soil having uniform structure and texture.

For crops growing in soils made up of layers of sandy material and loamy material, root development usually is much greater in the layers of loamy textured soil than in those of sandy textured soil. Other factors being similar, roots of most crops go much deeper in sandy soils than in clayey soils.

Since roots cannot grow in soil that is depleted in moisture down to and below the permanent witling point, a layer of dry soil below the surface in the profile can restrict root penetration. Likewise a high water table also limits root growth, and a rising water table may kill roots that have previously grown below the new water level.

3.3.5 Soil Moisture Extraction Pattern

The moisture extraction pattern refers to the amount of soil moisture expressed as percentage extracted from different layers in the soil profile. Moisture extraction depths for crops is given under following table:

Table: 3.3 Rooting depths of various crops

Rooting depths	**Crops**
Shallow rooted crops (60cm)	Cauliflower, Cabbage, Onion, Potato, Lettuce, Rice
Moderately deep rooted (90cm)	Carrots, Frenchbean, Gardenpea, Chilli, Muskmelon, Tobacco, Wheat, Castor, banana and Groundnut
Deep rooted (120cm)	Cotton, Tomato, Watermelon, Maize, Sorghum, Sugarbeet, Soybeans, Pearlmillet
Very deep rooted (180cm)	Lucerne, Citrus, Apple, Guava, Grapevine, Coffee, Tea, Sugarcane, Safflower, Mango, Pomegranate

Extraction of water is most rapid in the zone greatest root concentration and under the most favourable conditions of temperature and aeration.

3.4 Water Management Practices for major field and horticultural crops of Andhra Pradesh

3.4.1 Rice

1. The water requirement of rice is higher about 1240 mm
2. An adequate water supply is one of the most important factors in rice production
3. About 50 to 60 per cent of applied water is rice in lost by deep percolation.
4. Percolation rate of 5 mm/ day was favourable for supply of dissolved oxygen, the removal of harmful substances, and the maintenance of root activity.
5. Critical growth stages are primordial development, heading and flowering.
6. Total water requirement of rice includes water needed to raise seedling (40 mm), main field preparation (200 mm) and to grow rice crop from transplanting to harvest (1000 mm).
7. In most areas rice fields are submerged continuously throughout the crop growth period.

Table: 3.4 Optimum depth of submergence at different growth stages of rice crop

Stage of crop growth	Depth of Submergence
1) At transplanting	2 cm
2) After transplanting before 3 days	2 cm
3) 3 days after transplanting to maximum tillering	5 cm
4) At maximum tillering	Drain water for 3 days
5) Maximum tillering to panicle initiation	2 cm
6) Panicle initiation to 21 days after flowering	5 cm
7) 21 days after flowering	Drain water gradually

Total water requirement of rice includes water needed to raise seedling (40 mm), main field preparation (200 mm) and to grow rice crop from transplanting to harvest (1000 mm).

3.4.2 Groundnut

1. In Andhra Pradesh groundnut is grown in all the three seasons viz., *kharif, rabi* and summer. Generally the *rabi* and summer crops are raised under irrigation and give more yields.

2. The crop water requirements of groundnut are maximum during flowering, pegging which are critical stages for moisture supply.
3. First irrigation has to be given after sowing. The second irrigation at the start of flowering.
4. Subsequent irrigations are scheduled at an interval of 8 to 10 days.
5. This is followed irrigation at 90 days after sowing.
6. The total water requirement is around 500 mm.
7. Check basin method of irrigation is followed for groundnut.

3.4.3 Maize

1. The water requirement of maize is higher (400 to 500 mm) but is very efficient in water use.
2. Water logging is highly undesirable. When water table is high maize could be grown without irrigation.
3. Tasseling, silking and pollination are critical stages for moisture supply and any water shortage at those stages considerably reduces the yield.
4. Seedling and flowering stages are very sensitive to excess moisture and yield reduction with even 4 days of soil saturation was to the extent of 50 per cent.
5. Furrow method of irrigation is the most common practice of applying water for maize.
6. One irrigation for uniform filed emergence at the time of sowing is essential. This is followed by two irrigations at an interval of 12 – 15 days.
7. Subsequently between 30 to 95 days after sowing 8 irrigations are given at an interval of 8 – 10 days.
8. Whenever the crop is grown as rainfed, supplemental irrigation during short duration droughts were found to enhance the crop yield considerably.

3.4.4 Redgram

1. Red Gram requires 350-400 mm water, during its entire growth period.
2. The crop is mostly grown under rainfed, but one light irrigation between flowering and pod filling stage increases the seed yield.
3. The critical periods for Irrigation are flower-initiation and pod-filling stages.
4. If there is water stress, protective irrigation may be given in alternate rows at these 3 stages.

5. Intensive cropping of pigeonpea can also be achieved under tube well irrigation, arising at a highest production of 4 tons ha^{-1}

3.4.5 Mango

1. The amount and frequency of irrigation to be given to mango orchards depend upon the type of soil, climatic conditions, especially rainfall and its distribution and age of trees.
2. Generally the young plants with shallow root system require frequent irrigations during the dry period.
3. The newly planted mango grafts require watering every 2 – 3 days.
4. Thereafter, water should be given at 4 – 6 days interval.
5. For 3 – 4 days plants, the irrigation interval could be 10 days with 50m irrigation water depth.
6. However bearing trees develop deep well spread extensive root system and don't require water throughout the year except during fruit development period.
7. This results in increased fruit set, decreased fruit drop, and improvement in fruit size and fruit quality.
8. Irrigation should be stopped at least 2 – 3 months before flowering, otherwise it promotes vegetative growth and adversely affects flowering.
9. The recommended method of irrigation is either ring basin or drip method of irrigation.

3.4.6 Citrus

1. Citrus species are perennial in growth habit.
2. Most citrus species develop a single tap root. Rooting depth varies between 120 to 200 cm. In general 60 % of the roots are reported in the first 50 cm, 30 % in the second 50cm, and remaining 10% below 100cm.
3. Where water supply is adequate, normally 90% of the water is extracted from the first 100cm soil profile but under dry conditions the depth of water extracted below this depth increased.
4. Any effect of water shortage on root and leaf development may impair the number and size of fruits later in the season.
5. When the soil water depletion reaches permanent wilting point, tree growth is terminated and subsequently it affects fruits and leaves, followed by twigs, branches and eventually the whole tree.

6. The flowering period is very sensitive to water deficits.
7. The most common surface method of irrigation followed is ring basin or furrow system. Drip or microjet irrigation may provide a more uniform distribution of water.

3.4.7 Banana

1. Banana is one of the most important tropical fruits in India. Being a long duration crop, the total water requirements of banana are high.
2. Water requirements per year vary between 1200 mm in the humid tropics to 2200 mm in dry regions.
3. The banana plant has a sparse, shallow root system. In general 100 per cent of the water is obtained from the first 0.5 to 0.8m soil depth with 60% from the first 0.3m only.
4. The maximum evapotranspiration being 5 – 6 mm/day, the critical soil moisture level is 35% DASM.
5. Banana requires an ample and frequent supply of water. Water deficits adversely affect crop growth and yields. Water deficits in the vegetative period affect the rate of leaf development, which in turn can influence the number of flowers in addition to the number of hands and bunch production.
6. The flowering period starts at flower differentiation, although vegetative development can still continue. Water deficits in this period limit leaf growth and number of fruits.

Replenishment of 75 % evaporation losses through drip irrigation resulted in better growth and highest bunch weight (2.8kg/plant) in Robusta banana. The irrigation frequency, irrigation water depth and water requirement in different seasons for banana is presented in table below.

Table: 3.5 Water requirement of Banana

Season	No. of Irrigations	Irrigation water depth	Total depth of water
Summer	20	30.84 mm	616.8 mm
Rainy	8	20.56 mm	164.5 mm
Winter	15	20.56 mm	308.4 mm
All seasons exclusive of rainfall	43	-	1089.7 mm

3.5 Methods of Irrigation

Irrigation methods refer to the method of application of water to the cultivated land. Good yields of crops can be obtained from an irrigated land only if the water is applied judiciously to meet the needs of plant, but not in a manner to cause waste and damage. The method of irrigation selected should conserve the soil as well as water.

Irrigation water can be applied to the cultivated land in the following four general ways:

1. **Surface irrigation.**
2. **Sub surface irrigation**
3. **Sprinkler irrigation**
4. **Drip irrigation**

For successful use of any of these methods complete control of water is essential at all times.

3.5.1 Surface Irrigation

In this method water is released in the cultivated field from adjacent irrigation channels wetting the surface either partly or completely. Depending on the features of a land configuration the surface irrigation methods are classified into:

1. Wild flooding or uncontrolled flooding.
2. Controlled flooding.

a. Basin method

i) Check basin

ii) Ring basin

b. Border strip method

c. Furrow irrigation

i) Deep furrow

ii) Corrugations

1. Wild Flooding: This method consists of applying water to the field without any bunds to guide the flow of irrigation water wetting the soil surface completely. Generally it is practiced when irrigation water is abundant and where land leveling is not followed. Sometimes it is also adopted in the initials stages of land development. This method is most commonly used for irrigating crops sown y broadcasting, low value pastures, lawns and millets etc. The principle advantage of this method is that it involves minimum cost in terms of labour and land preparation. However, there are certain disadvantages, such as water losses by deep percolation and surface runoff.

2. Controlled Flooding

a. Basin method

Basin method is of two types

i) Check Basin: In this method of irrigation the field is usually divided into square plots ($4m^2$ to $4000m^2$) surrounded by small bunds of dykes or levers. This method is usually employed in nearly leveled lands and may be used on a wide variety of soil textures. However, it is particularly useful on fine textured soils with low permeability rate where it is necessary to hold the water on the surface to secure adequate penetration. These basins are suitably connected to irrigation channels. This method is used commonly used for irrigating crops like groundnut, finger millet, sorghum, vegetable crops etc.

ii) Ring basin: In this method a circular bund is constructed around each tree/plant or a group of plants/trees to create a basin for irrigation. These basins are suitably connected to irrigation conveyance channel in such a way that either each basin is irrigated separately or group of basins by flowing water from one basin to another through interconnections.

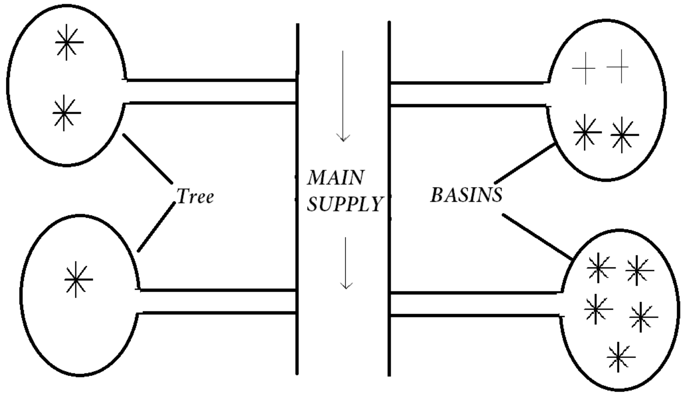

Fig: 3.1. Ring Basin method of irrigation

b. Border strip method: The cultivated field to be irrigated is divided into a number of long Parallel strips, generally 5 to 15 m in width and 75 to 300 m in length, separated by small border ridges or low dykes of about 15 cm high, laid out in the direction of the slope. Irrigation water is released into each strip connected directly to irrigation channel situated at the upstream end of the border strip. This method is suitable for both light and heavy soils by proper selection of border length, stream size and slope. This method is suitable for irrigating a wide variety of close growing crops such as wheat, barley, groundnut and bajra.

c. Furrow irrigation

i. Deep Furrow Method: In furrow method of irrigation the flat bed surface is converted into a slope. The spacing of the furrow is ordinarily determined by the spacing of the row crop. The length of the furrow and slope depends on several factors viz., texture intake rate etc. where the land is too sloppy (more than 5%), the furrows need to be constructed on contours. This method can be used either with small or large streams of irrigation water because it can be directed into any number of furrows. Among the various surface irrigation methods, there is a relative saving of water in furrow method, hence most efficient use of water is possible.

Fig: 3.2. Deep furrow method of irrigation

ii. Corrugations: This is a special method of furrow irrigation. Corrugations or rills are shallow furrows running down the slope from head ditches or laterals, which are sometimes very close to each other. Water moves down through several corrugation set at a time and soaks laterally through the soil, wetting the area between the corrugations. This method is used for irrigating close growing crops which do not require inter culture operations and may also be used in conjugation with border irrigation. Corrugations are often used on fine textured soils that take water slowly and on soils which tend to seal over and crust when flooded.

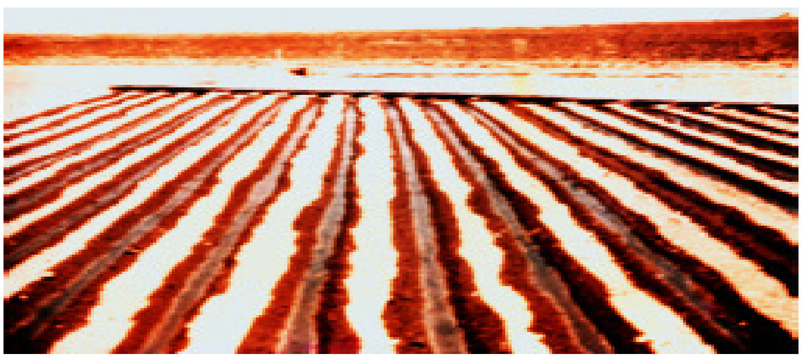

Fig: 3.3. Corrugation method of irrigation

3.5.2 Sub- surface irrigation: Sub - surface irrigation is the method of applying water beneath the soil surface close to the plant roots so that either water seeps from the sides from the sides of the channels towards the plant roots or through capillary movement upward. it is usually 30-70 cm below the gourd, depending upon the texture and rooting characteristics of the crop.

Application efficiencies vary from 30 to 80 percent depending upon the conditions. Water having high salt content cannot be used. This method is expensive, difficult to maintain and operate. This method is suitable for only few crops because of high investment and special conditions required. It has not been widely adopted in India.

3.5.3 Sprinkler irrigation: In this method water is conveyed in pipe lines under desired pressure (0.7 to 10 kg/cm) developed by the pump and is sprayed through nozzles perforation over the land or crop surface in a uniform pattern at a rate (0.06 to 50 l/hr) less than the infiltrability of soil, somewhat resembling the rainfall. Typical sprinkler system consists of a pumping units, main line, lateral, risers and sprinkler heads. Generally three types of sprinkler heads are common:

- Rotating sprinkler heads
- Fixed jets
- Perforated pipes

Sprinkler systems can be permanent installation, semi-portables systems and purely portable systems.

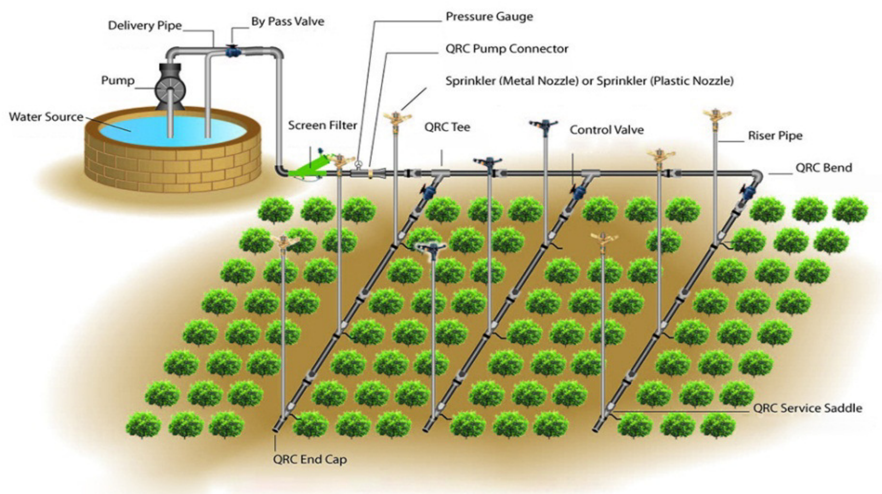

Fig: 3.4. Layout of sprinkler irrigation system

Sprinkler System Components: A typical sprinkler irrigation system consists of a pumping unit, pump connector, non-return valve, water meter, pressure gauge, pressure regulators, mainline & sub-mainlines, laterals, control valves, hydrants, sprinkler base, sprinkler heads, bends, tees, reducers, end plug, nipples, flanges etc.

The most common type of sprinkler system layout is shown below in. The pump unit is usually a centrifugal pump which takes water from the source and provides adequate pressure for delivery into the pipe system.

Advantages of sprinkler systems:

a) Elimination of field channels and their maintenance, which increases the production area.

b) No water losses in conveyance, which is assumed to be 55 per cent in surface irrigation methods.

c) Close control of application *i.e.* no runoff water losses because water is applied below or equal to infiltration rate.

d) Convenient for giving light and frequent irrigations.

e) Areas located at higher elevation than source can be irrigated.

f) Higher application efficiency compared to surface methods of irrigation.

g) Sprinklers give a gentle rain that does not clog or compact the soil ensuring better and quicker germination resulting in more plants per unit area.

h) Fertilizers and soil amendments can be applied in conjunction with irrigation water from the sprinklers.

Disadvantages of sprinkler systems

a) Uneven distribution of water due to high wind velocities particularly during summer season.

b) Higher evaporation losses when operating under high temperatures.

c) Mechanical difficulties such as sprinklers fail to rotate, nozzles may clog, couplers may leak or engine may require repair.

d) Initial investment and recurrent operating costs are much higher than in surface irrigation methods.

e) Moving the portable lines, when the soil is wet results in the destruction of soil structure

f) Use of saline water for irrigation is not possible since it will be harmful to crops

g) Higher water pressure required hence extra energy cost.

3.5.4 Drip irrigation: Drip irrigation utilizes the concept of applying little amount of water with the following characteristic feature:

- Water is applied at low rate
- Water is applied over a long period of time
- Water is applied at frequent intervals
- Water is applied directly into the crop root zone
- Water is applied via a low –pressure delivery system.

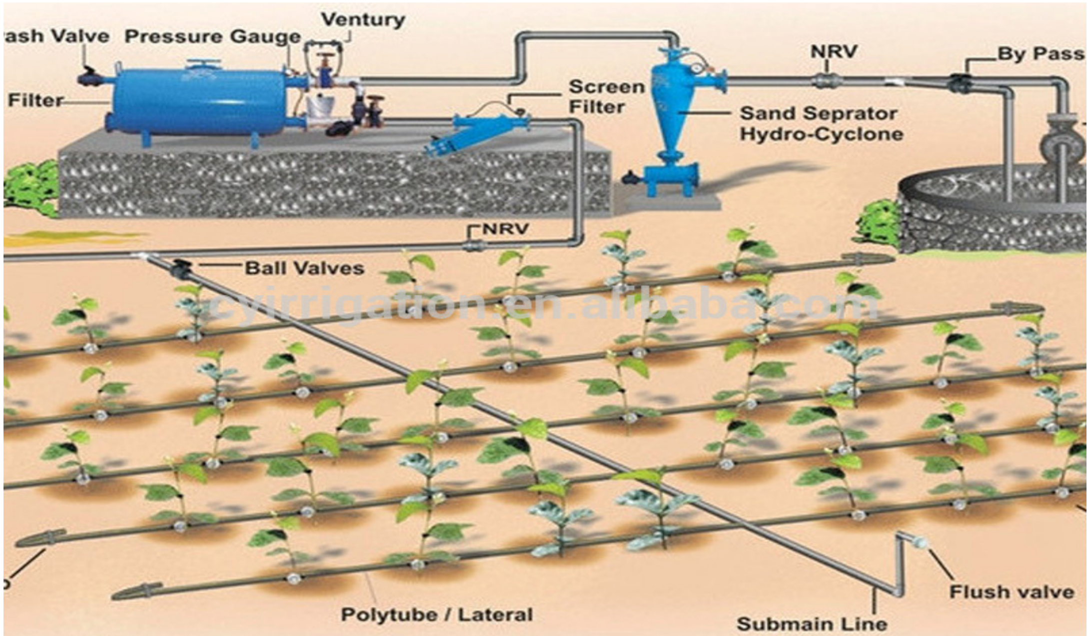

Fig: 3.5. Layout of drip irrigation system

Drip Irrigation System Components

The drip irrigation system consists of three subsystems viz., control head unit, water carrier system and water distribution system besides water source & pumping station.

a) Head control unit – Non return valve, Air release valve, Vacuum breaker, Filtration unit, Fertigation unit, Throttle valve, Pressure gauge, Water meter, Pressure regulator and Pressure relief valve.

b) Water carrier system – PVC main pipeline, PVC submain pipeline, Control valve, Flush valve and other fittings

c) Water distribution system – Drip lateral, Emitters, Grommet, Start connecter, Nipple, End cap.

Each emitter supplies a small, precisely controlled, uniform amount of water, directly into the rest zone of the plant. The distribution system and drip nozzles are placed on the soil surface along the crop or tree rows to be irrigated.

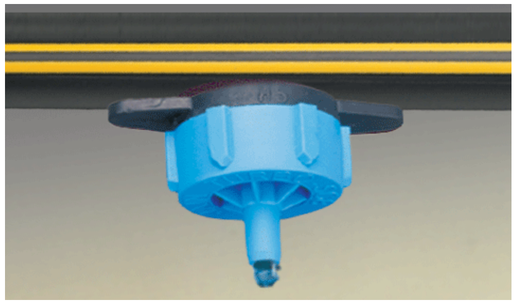

Fig: 3.6. Dripper

Advantages of Drip irrigation

Many reports have listed and summarized potential advantages of drip irrigation as compared to other irrigation methods.

a) Enhanced plant growth, crop yield and premium quality produce
b) Water Saving due to increased beneficial use of available water and higher water application efficiency
c) Precise and uniform delivery of water to crops due to controlled water application
d) Maintenance of higher soil water potential in the root zone
e) Compact and efficient root system
f) Combined water and fertilizer (fertigation) application minimizes nutrient losses and improves fertilizer use efficiency and contributes to fertilizer saving in some crops
g) Reduced salinity hazards to crop plants when low quality saline water is used for irrigation
h) Suitable for irrigating high-value crops raised in greenhouses, plastic tunnels, potted plants and under plastic mulches
i) Lower operating pressures means reduced pumping energy costs
j) Limited weed growth because only a fraction of the soil surface is irrigated
k) Reduced operational and labour costs due to improved weed control and simultaneous application of water, fertilizers, herbicide, insecticide, fungicide and other additives through the drip irrigation system
l) Environmental protection and ecological security

Disadvantages of Drip irrigation

a) High initial installation cost
b) Sensitivity to clogging.

c) High skill required for designing, installation, operation and maintenance.
d) Dry soil and dust formation during mechanical operations.

3.6 Quality of Irrigation Water

Almost all the irrigation water contains some soluble salts in them. In some cases it is very high rendering it unsuitable for irrigation purpose. In some situation, even though the salt content of the water is low, its continued use may gradually built up the salt. Balance quality has to be maintained in the crop root zone through appropriate water management practices for continuous and successful cultivation of crops.

Assessment of irrigation water quality

Irrigation water is commonly assessed in terms of soluble salt contents, percentage of sodium, boron and bicarbonates contents. The major dissolved constituents in natural waters are the salts of sodium, calcium, magnesium as their chlorides, sulphates, carbonates and bicarbonates.

3.6.1 Total soluble salts: Generally the total salt content of the water is expressed using the term electrical conductivity (EC) of the water. It is a measure of salts present in water. EC of a water sample can be measured by using standard wheat stone bridge or direct salinity sensors.

The U.S. Salinity Laboratory (USSL) classified the irrigation water based on electrical conductivity and sodium absorption ratio (SAR).

The various salinity classes of water are as under:

Table: 3.6 Salinity Classes of Water

Salinity Class	**EC micro mhos/cm**
C_1 low salinity water	<250
C_2 medium salinity water	250 -750
C_3 high salinity water	750 - 2250
C_4 very high salinity water	2250 - 5000

The various sodicity classes of water are as under

Table: 3.7 Sodicity classes of water

Sodicity Class	SAR value
S_1 low sodicity	<10
S_2 medium sodicity	10 -18
S_3 high sodicity	18 -26
S_4 very high sodicity	>26

Salt tolerant of different crops: Different crops have different tolerance levels to salinity. Based on several years of research they are classified as under:

Sensitive: Cowpea, citrus, gram, peas and pear
Semi-tolerant: Maize, jowar, bajra, rice, sugarcane, cotton, mango, potato and pomegranate.
Tolerant: Wheat, oats, barley, date palm, coconut and sugarcane

3.6.2 Residual Sodium Carbonate: Presence of carbonate and bicarbonate in irrigation water results in the precipitation of calcium and magnesium present in the soil and thus increases the extent of sodium hazard. The residual sodium carbonate (RSC) expressed as follows:

$$RSC = (CO_3^- + HCO_3^-) - (Ca^{++} + Mg^{++})$$

Where the concentration of ions is expressed as meq/ liter.

Water with more than 2.5 meq/1RSC is not suitable for irrigation purpose. Water containing 1.25 to 2.5 meq/l is marginal and those containing less than 1.25 meq/lRSC is considered safe for irrigation purpose.

3.6.3 Boron concentration: Boron is needed for normal growth of all plants but the quality required is very small. When present in excess quantities, it is toxic to plants.

Table: 3.8 The permissible limits of boron to different crops

Boron content	Crops
Upto 4 ppm tolerant	Sugarbeet, cabbage, onion and carrot
Upto 2 ppm semi-tolerant	Sunflower, wheat, maize, cotton, potato, raddish and barley
Upto 1 ppm sensitive	Grape, orange and lemon

3.7 Drainage system: Agricultural drainage is the artificial removal and safe disposal of excess water either from the land surface or soil profile, more specifically, the removal and safe disposal of excess gravitational water from the crop root zone to create favourable conditions for crop growth to enhance agricultural production.

Benefits of drainage

a) It provides better soil environment for plant growth by creating favourable soil aeration conditions

b) It improves the soil structure and in turn increases the soil infiltration

c) High infiltration capacity reduces soil erosion.

d) It hastens the warming of the soils and maintains desirable soil temperature, which accelerates plant growth and bacterial activity

e) It promotes increased leaching of salts and prevents accumulation of salts in the crop root zone

f) In well drained soils, less time and less labour are required for tillage operations

Problems or effects of ill-drainage

a) Limitation of aeration.

b) Accumulation of CO_2 and toxic substances like H_2S, ferrous sulfide *etc* in the croproot zones

c) Reduced water uptake due to reduced activity of roots as a result of oxygen stress

d) Reduced nutrient uptake

e) Development of soil salinity and alkalinity

f) Anaerobic condition and prevalence of plant diseases

g) Stunted plant growth and development which results in reduced yield

Types of drainage

Broadly drainage systems are of two types:

1. Surface drainage systems
2. Sub-surface drainage systems.

1. Surface drainage systems: Safe removal and disposal of excess water primarily from land surface or cropped area by a net work of surface drains or constructed channels and through proper land shaping is known as surface drainage.

a) Random drain system: This system is usually adopted in areas where the ground surface is characterized by a series and depression (undulating land surface) and where small depressions are to be drained off in such a way to connect one depression to another and water is safely conveyed to lateral drains.

b) Parallel field drain system: In this system the surface of individual fields is graded in such a way that the runoff water drains into field drains, which in turn discharge water into field laterals bordering the field and finally the laterals in turn lead water into the main outlet ditch through protected over falls.

c) Parallel open ditch system: The parallel open ditch system is similar to parallel field drain system in all respects except that the drains are replaced by open ditches which are comparatively deeper and have steeper side slopes than the field drains.

d) Bedding system: It is essentially a tillage operation wherein the land is ploughed into a series of parallel beds separated by dead furrows, which run in the direction of greatest slope lateral drains are located perpendicular to slope.

2 Sub-surface drainage systems: The removal and safe disposal of excess water that has already entered the soil profile is considered sub-surface drainage.

A. Tile drainage systems: The common tile drainage system layout followed is: Random or natural system, Parallel lines system and Cut off or intercepting system.

a) Random system: The random system is used in areas that have scattered wet are as somewhat isolated from each other. Tile lines are laid more or less at random to drain the wet patches.

b) Herringbone system: The system is applicable in places where the main or sub -main is located in a narrow depression i.e., in areas that have a concave surface or a narrow depression with the land sloping to it from both directions.

c) Gridiron and parallel systems: The gridiron and parallel systems are similar to that of herringbone system except that the laterals enter the main or sub-main from only one side.

B. Mole drainage system: Similar to tile drain in layout and operation, instead of permanent tiles a continuous circular mole drain (channel) is prepared below the ground surface in the soil profile at desired depth and spacing using a special implement known as mole plough. The depth of the mole drain varies from 4.5 cm to 120 cm depending on the moling equipment and water table.

Summary

1. Application of water to the soil for the purpose of supplying moisture essential for plant growth and development is called irrigation.
2. Drainage is the artificial removal and safe disposal of excess water from the land surface or soil profile.
3. The field capacity is the amount of water held in the soil after excess water has drained away and the rate of downward movement has materially decreased,
4. Permanent wilting point is a condition where the water is held so tightly by the soil particles that the roots cannot extract it at a sufficiently rapid rate to prevent the leaves from witling.
5. A plant require a consistent water supply for normal growth and development
6. The critical growth period is the stage or stages of crop growth at which moisture stress has the greatest effect on quality and quantity of yield.
7. Irrigation water is commonly assessed in terms of soluble salt content, percentage of sodium, boron and bicarbonate contents.
8. Drainage: Agricultural drainage is the artificial removal and safe disposal of excess water either from the land surface or soil profile, more specifically, the removal and safe disposal of excess gravitational water from the crop root zone to create favourable conditions for crop growth to enhance agricultural production.
9. Mole drainage: A continuous circular mole drain (channel) is prepared below the ground surface in the soil profile at desired depth and spacing using a special implement known as mole plough.

Key terms used

1. Irrigation, 2. Drainage, 3. Field capacity, 4. Permanent wilting point, 5. Available soil moisture, 6. Water requirement of crops, 7. Effective rainfall, 8. Effective root zone depth, 9. Critical stages of irrigation, 10. Drip irrigation, 11. Herringbone system 12. Gridiron and parallel systems

Short answer type questions

1. Define Irrigation
2. Define Drainage
3. What is field capacity
4. What is permanent wilting point
5. What is available soil moisture
6. Define critical stages of irrigation
7. What is effective rainfall and effective root zone depth
8. What is moisture extraction pattern
9. Write the critical stages of irrigation for rice, groundnut, mango and citrus
10. List out the methods of irrigation

Long answer type questions

1. What are the objectives of irrigation
2. What are the objectives of drainage
3. Explain the water management practices for the following crop.
   i. Rice
   ii. Groundnut
   iii. Redgram
   iv. Mango
   v. Citrus
   vi. Banana
4. Explain sprinkler method of irrigation with a neat diagram
5. Explain drip method of irrigation with a neat diagram
6. Briefly describe the assessment of quality of irrigation water
7. Explain types of drainage systems

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UNIT **4**

Dryland Agriculture

Structure

4.0 Introduction

4.1 Characteristics of dryland and rainfed agriculture

4.2 Problems of dryland agriculture-climate and soil

4.3 Soil erosion-water and wind erosion, losses due to erosion

4.4 Soil and moisture conservation agronomic, mechanical and agrostological measures

4.5 Efficient crops and cropping systems for drylands

4.6 Watershed management - Watershed concept, principles of watershed management

4.0 Introduction

The dryland agriculture plays an important role in the progress of agriculture in the Indian economy. Out of total net sown area (136.8 mha) 68 percent is cultivated under dryland spread over 177 districts. Dry land crops account for 48 per cent area under food crops and 68 per cent area under non-food crops. In general, the economic policies of developing countries in past years have had negative effects on development in the dry land regions. Dry land farmers are poorer and politically less influential. Dryland Agriculture may be classified into three groups on the basis of annual rainfall.

4.1 Characteristics of dryland and rainfed agriculture

Dry Farming: Cultivation of crops in areas where annual rainfall is less than 750mm and crop failures are common and occurs due to prolonged dry spells during crop period. Dry farming is practiced in arid regions with the help of moisture conservation practices. Alternate land use system is suggested in this region.

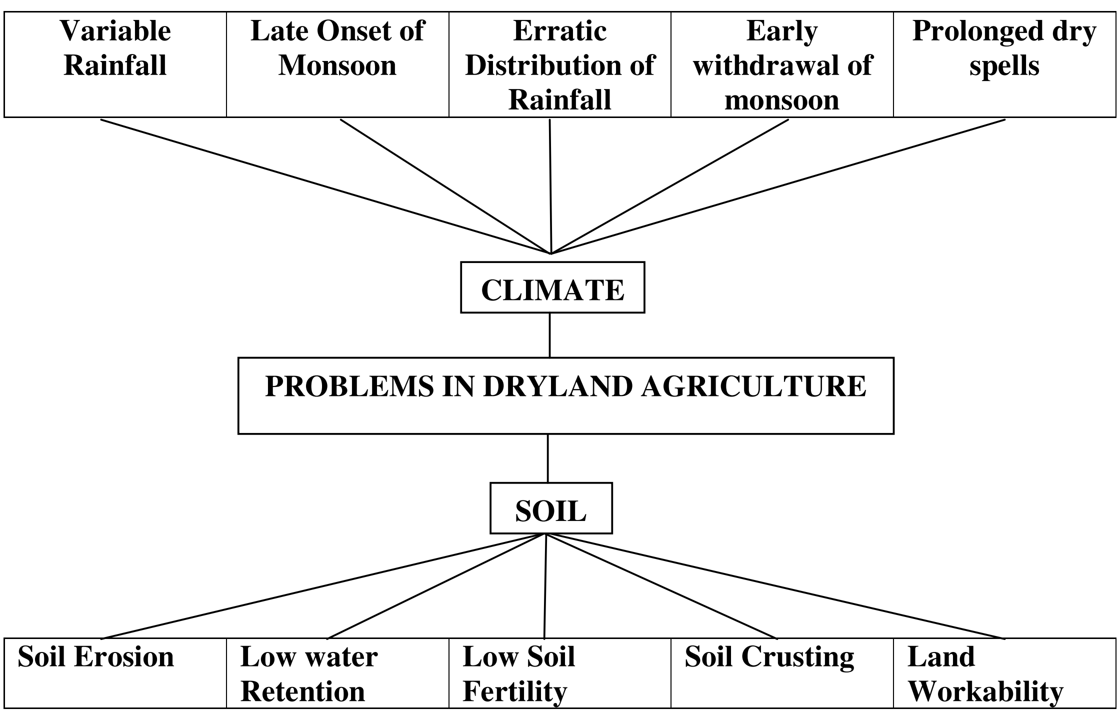
Dry land farming: Cultivation of crops in areas where annual rainfall is more than 750 mm but less than 1150mm is called Dryland farming. Dry spells may occur, but crop failures are less frequent. Evapotranspiratioin is higher than the total rainfall and is the main cause for moisture deficit in these areas. The soil and moisture conservation measures are necessary for dryland farming practices in semi-arid regions. Drainage facility should be provided

Rainfed farming: Refers to cultivation of crops in regions where annual rainfall is more than 1150mm. Crop failures less. There is adequate rainfall and drainage becomes the important problem in rainfed farming.

Table: 4.1 Dryland *vs* rainfed farming

Constituent	Dryland Farming	Rainfed Farming
Rainfall (mm)	750mm to 1150mm	>1150
Moisture availability to the crops	Shortage	Enough
Crop growing season (days)	< 200	> 200
Crop growing regions	Arid and semi arid, uplands of sub humid and humid regions	Humid and sub humid regions
Cropping system	Single crop or Intercropping	Intercropping or double cropping
Constraints	Wind and water erosion	Water erosion

4.2 Problems associated with dryland agriculture



Dry land farming crops are characterized by very low and uncertain yields. Crop failures are quite common. These are mainly due to the following problems.

4.2.1 Climatic problems

1. **Inadequate and uneven distribution of rainfall**
2. **Late onset of rains**
3. **Early cessation of rains**
4. **Prolonged dry spells during the crop period**

1. Inadequate and uneven distribution of rainfall: In general, the rainfall is low and highly variable which results in uncertain crop yields. Besides its uncertainty, the distribution of rainfall during the crop period is uneven, receiving high amount of rain, when it is not needed and lack of it when crop needs it.

2. Late onset of rains: Due to late onset of monsoon, the sowing of crop are delayed resulting in poor yields.

3. Early cessation of rains: Sometimes the rain may cease very early in the season exposing the crop to drought during flowering and maturity stages which reduces the crop yields considerably.

4. Prolonged Dry spells during the crop period: Long breaks in the rainy season is an important feature of Indian monsoon. These intervening dry spells when prolonged during crop period reduces crop growth and yield and when unduly prolonged crops fail.

4.2.2 Soil problems

The major soil problems in dryland crop production are

a) **Low moisture retention capacity**
b) **Low fertility of soils**
c) **Soil crusting**
d) **Soil erosion**
e) **Workability and timeliness of agricultural operations**

a) **Low moisture retention capacity**: The crops raised on red soils, and coarse textured soil suffer due to lack of moisture whenever prolonged dry spells occur due to their low moisture holding capacity. Loss of rain occurs as runoff due to undulating and sloppy soils.

b) **Low fertility of Soils**: Drylands are not only thirsty, but also hungry too. Soil fertility has to be increased, but there is limited scope for extensive use of chemical fertilizers due to lack of adequate soil moisture.

c) **Soil crusting:** One of the biggest challenges in rain fed agriculture is crust formation. As there is little or no moisture in the soil coupled with low organic carbon make the top soil become hard for cultivation.

d) **Soil Erosion:** The high rainfall intensity experienced in the dry lands is the primary cause of serious erosion. Soils are bare and dry when the rainy season commences. High intensity rains then and especially after cultivation but before there is appreciable plant cover to protect the soil, causes large soil losses.

e) **Workability and timeliness of agricultural operations:**
Some heavy textured soils may be easily tilled only over a narrow range of soil water content. That limits the time available for tillage and thus the area that can be cropped by draft animal. The constraint is more serious where only manual labour is used.

4.3 Soil erosion-water and wind erosion, losses due to erosion

4.3.1 Soil Erosion

Soil erosion is defined as the physical removal of topsoil by various agents, including rain, surface water and water through the soil profile, wind, ice or gravitational pull. Erosion is a natural process but is often intensified by human land use practices. Much of the eroded soil is deposited either in low areas of the field or it moves off the farm and eventually enters drainage ditches, streams or rivers.

Causes of soil erosion

Land use: Humans play a major role in soil erosion through their use and abuse of natural resources, for example deforestation, grazing, arable land use, faulty farming systems, high crop intensity, housing and, mining etc.

Climate: The two most important climatic factors having a direct effect on erosion are precipitation and wind velocity. Other climatic factors have an indirect effect on soil erosion, such as water balance, evapotranspiration, temperature and relative humidity. Indirect factors affect the erosivity of rainfall by altering the soil moisture regime and the proportion of rainfall that may become surface runoff. For erosion control it is necessary to investigate physical characteristics of rainfall, including the amount, distribution, intensity, and variability of rainfall.

Soil: The susceptibility of a soil to erosion is influenced by its physical, hydrological, chemical and mineralogical properties as well as its soil profile characteristics. Important soil physical and hydrological properties that affect the resistance of a soil to erosion include texture, structure, and water retention properties.

Hydrology: Infiltration, surface retention, surface flow velocity, and subsurface water flow are important soil erosion components of the hydrological cycle. The different types of flow and their velocities may be steady or unsteady, uniform or non-uniform and influence the extent of erosion

Landforms: Gradients, length and shape of the slope are the important variables of landforms that affect erosion processes for all types of soil erosion, e.g., splash, sheet, rill, and gully erosion.

4.3.2 Types of Soil Erosion

There are two types of soil erosion.

1. **Water erosion**
2. **Wind erosion**

4.3.2.1 Water erosion, types and losses

Water erosion: Water erosion is caused by the kinetic energy of rain falling on the soil surface and by the mechanical force of runoff. Water erosion is classified as following types:

a) Splash erosion: Splash erosion is the first stage of the erosion process. It occurs when raindrops hit bare soil. The rain drops hits the soil and breaks up soil aggregates to individual soil particles get 'splashed' onto the soil surface.

b) Sheet erosion: Sheet erosion is the uniform removal of soil in thin layers by raindrop impact and shallow surface flow. It results in loss of the finest soil particles that contain most of the available nutrients and organic matter in the soil.

c) Rill erosion: Rill erosion is often described as the intermediate stage between sheet erosion and gully erosion. Prolonged sheet erosion causes rill erosion. Rills are shallow drainage lines less than 30cm deep. Rills are small channels, which can be removed by timely normal tillage operations.

d) Gully erosion: It is the advanced stage of rill erosion. Size of the unchecked rills increases due to runoff. Gullies are formed when velocity of runoff water from vast sloping land cut deep and form wide channels. Gullies are the spectacular symptoms of erosion.

e) Ravines: Prolonged gullies leads to ravines. They are typically found in deep alluvial soils. They are deep and wide gullies indicating advanced stage of gully erosion.

f) Landslides: Landslides mainly occur in mountain slopes, where the slope exceeds 20 percent and width is 6m. Generally landslides cause blockage of traffic in ghat roads.

g) Stream bank erosion: Stream bank erosion occurs in small streams, rivers, hill streams. Stream bank erosion was mainly due to obstruction of water flow by vegetation.

Losses due to water erosion

a. Loss of rain water: Rainwater is the only source of water for crop production in dry land agriculture. Runoff water leaving the cultivated land is a loss of an important natural resource.

b. Loss of fertile top soil: The surface soil lost as runoff consists of fertile soils and fresh or active organic matter.

c. Reduction of soil nutrients: The top soil is loaded with nutrients and organic matter which is important for crop growth. Severe erosion reduces water infiltration into the soil, which may result to withering of crops.

d. Silting of reservoirs: When water reaches reservoirs, the flow velocity is reduced and sediment settles on the floor of the reservoir. Depth of the reservoir is gradually reduced.

e. Floods: Uncontrolled water and runoff leads to floods. Flood causes severe loss of crops, animals and human life.

f. Accumulation of sand or other unproductive coarse soil materials on other productive lands: In the plains, fertile lands have been made unproductive by the deposition or accumulation of soil material brought down from the hills by streams and rivers.

g. Silting of drainage and water channels: Deposition of silt in drainage ditches in natural streams and rivers reduces their depth and capacity and overflows and flooding of downstream areas increase with damage to agricultural crops and also man-made structures.

h. Decreases water table: With the increase in runoff, the amount of water available for entering the soil is decreased. This reduces the supply of water to replenish the ground water in wells, the yield of well is reduced.

i. Fragmentation of land: Water erosion especially gully erosion may divide the land into several valleys and ridges and thus fields become smaller and more numerous. Crop rows are shortened, movement from field to field is obstructed and as a result the value of land is decreased

4.3.2.2 Wind erosion, types and losses

Wind erosion: Wind erosion is the removal of soil particles by the force and kinetic action of the wind. These soil particles are transported along with wind and deposited when the wind velocity drops. Wind erosion is classified as following types:

1. Suspension: Movement of fine dust particles smaller than 0.1 mm diameter by floating in the air is known as suspension. Soil moved by suspension is the most spectacular and easiest to recognize of the three forms of movement.

2. Saltation: The size of soil particles moved by saltation is between 0.1 to 0.5 mm in diameter. In saltation, fine soil particles are lifted horizontally into the air by the action of wind. Soil particles move across the surface with increasing in wind velocity.

3. Surface Creep: Coarse particles longer than0.5 to 2.0 mm diameter is moved by surface creep. The large particles which are too heavy to be lifted into the air are moved through rolling and sliding processes called surface creep.

Losses due to wind erosion

1. Loss of fertile top soil
2. Conversion of fertile soils into unproductive sandy soils due to drifting sand
3. Loss of yield due to abrasive action of wind driven soil particles,especially on broad leaved crops.
4. Erosion reduces the capacity of the soil to hold water leading to severe water stress.
5. Erosion contributes to losses of plant nutrients, which wash away with the soil particles.
6. Erosion reduces yields by degrading soil structure, increasing soil erodability, surface sealing and crusting.

4.4 Soil and Moisture Conservation - Agronomic, Mechanical and Agrostological measures

4.4.1 Importance

Soil and water are the basic resources essential for survival of human kind on earth. According to Dr. H.H. Bennett' Soil without water is desert and water without soil is useless'. In fact every kind of farm activity is connected with land and prosperity of nation depends on the prospects of land resources.

Because of human interference, the protective shield of land is disturbed and the land is torn into pieces by the erosion process – starting from splash erosion to formation of gullies and ravines.

4.4.2 Soil Conservation

Definition: The different soil conservation methods are based on the following principles:

1. Checking the velocity of water or wind that causes erosion.
2. Reducing the slope of the land subjected to erosion.
3. Preventing the direct impact of rain, water or wing on the soil.

4.4.2.1 Soil Conservation methods

1. Agronomic Conservation measures

i. **Use of Vegetation:** Crops which cover the ground surface well and have extensive root system reduce soil erosion. Plant canopy protect the soil from the adverse effect of rainfall. As a result, the fertility of soil increases and the physical condition of soil is improved.

ii. **Crop rotation:** Crop rotation is planned sequence of cropping. Rotation of crop is an important method for checking erosion and maintaining productivity of soil. A good rotation should include densely planted small grain crops, spreading legume crop etc. which may check soil erosion.

iii. **Strip Cropping:** It consists of growing erosion permitting crops (e.g. Jowar, Bajra, Maize etc.) in alternate strips with erosion checking close growing crops (e.g. grasses, pulses etc.). It is very effective and practical means for controlling soil erosion, specially for gently slopping land.

iv. **Cultivation of dense plant and grasses:** Sod forming crop such as Lucerne (*Medicago sativa*), Egyptian Clover or Berseem (*Trifoliumalexandrinum*), ground nut (*Arachis hypogea*), Sunhemp (*Crotolariajuncea*), grasses etc. cover the surface of the land and their roots bind the soil particles to form soil aggregates, thus preventing soil erosion.

v. **Vegetation:** The land should not be kept without vegetation. Soil erosion occurs if there is no vegetation on the land. Soil must be covered with good vegetation for reduce soil erosion.

vi. **Afforestation:** Afforestation means growing of forests where there are no forests before owing to lack trees due to adverse factors such as unstable soil, aridity or swampiness.

vii. **Mulching:** Mulches of different kinds such a leaves, straws, paper, stubbles, etc. minimize evaporation and increase the absorption of moisture and protect the surface of the land against the beating action of rain drops.

viii. **Organic manures:** Organic manures improve the soil structure. The crumb and granular structure increases the infiltration and permeability in the soil and conserve the soil water. Consequently soil erosion decreases.

ix. **Control of grazing:** Grazing increases the soil erosion. Restricted and rotational grazing may be helpful in checking soil erosion to some extent. The area open to grazing for sometimes should be closed for the following year to facilitate regeneration of forests and to maintain thick ground vegetation.

x. **Tillage:** Tillage is the mechanical manipulation of soil by different kinds of implements. Tillage makes the soil loose and friable which helps in retention of water. The special method of tillage practices should be followed for the conservation purposes.

2. Mechanical Conservation measures

Mechanical measures include various engineering techniques and structure. The important mechanical soil conservation measures are as follows:

i. **Contour bunding:** Contour bunding consists of building earthen embankment at intervals across the slope and along the contour line of the field. A series of such bund divide the area into strips and act as barrier to the flow of water. As a result, the amount and velocity of run-off are reduced, resulting reducing the soil erosion.

ii. **Terracing:** A terrace is an embankment of ridge of earth constructed across the slope to control run off and to minimize soil erosion. A terrace reduces the length of the hill side slope, thereby reducing sheet and rill erosion and prevents formation of gullies. There are different types of terraces as follows:

iii. **Bench terracing:** It consists of transforming relatively steeps land into a series of level or nearly level strips or steeps across the slope. The soil materials that are excavated from the upper part of the terrace is used in filling the lower part and a small bund is also raised along the outer edge of the terrace to check the downward flow of rainwater and also soil erosion.

iv. **Channel terrace:** It consists of making of wide but shallow channels across the slope of the land either exactly on contour line or with a slight grade (0.1 to 0.2 per cent). In this process, the excavated soil is placed along the lower edge of the channel in the form of low ridge.

v. **Narrow based terrace:** It consists of making a number of narrow based ridges or bunds at a distance of 1m to 2m across the slope of the land at suitable intervals in high rainfall areas.

vi. **Broad based ridge terrace:** It consists of making wide but low bunds on the contour lines by excavating soils from both sides of terrace. This is practiced in areas where the rainfall is relatively low.

vii. **Contour trenching:** It consists of making a series of deep pit (*i.e.* 2ft. wide and 1ft. deep) or trenches across the slope at convenient distance. The soil excavated from the trenches is deposited on the lower edge of the trenches where forest trees are planted.

3. Astrological measures

Grasses prevent soil erosion by interception of rainfall, by their binding power of soil particles and by improving soil structure. A grass-legume association is ideal for soil conservation. Legumes buildup soil fertility by fixing atmospheric nitrogen in their root nodules. Grasses have multiple uses in soil conservation. They are used for stabilizing the surfaces of waterways, contour bunds and front faces of bench terraces. Gully slopes and landslides can be also stabilized. Croplands can be improved by ley farming. Further grasses improve soil structure, porosity and infiltration, besides adding organic matter to the soil. They also serve as fodder crops in dry areas.

The desirable characters of grass for soil and water conservation are perennial in nature, drought resistance, rhizomniferous, good canopy, deep root system, prostrate habit and usefulness in cottage industry. Some of the useful grasses and legumes are:

Grasses

- *Cenchrus ciliaris*
- *Chloris guyana*
- *Cynodon dactylon*
- *Dicanthium annulatum*
- *Hetropogon contortus*
- *Iseilema laxum*

- *Panicum antidotale*
- *Andropoganhaltei*
- *Panicum virgatum*
- *Eragrostic curvula*

Legumes

- *Atylosia scarbaceoides*
- *Centrosema pubescence*
- *Stylosanthus hamata*

4.5 Efficient crops and cropping systems for dry lands

The productivity levels of dry land crops can be increased by focusing the efforts on increase the cropping intensity in dry land areas which was generally 100%, implying that a single crop was taken during the year.

4.5.1 Choice of crops: Crops must be selected based on crop duration to coincide with the length of growing season. Mostly short duration pulses like greengram, blackgram, bengalgram and cowpea may be preferable to the situation. Farmers interested in getting high profits can go for crops having long duration. Long duration crops suitable for drylands with high yields are preferable.

4.5.2 Cropping systems: Selection of cropping system depends on rainfall and soils.

Cropping systems are of 3 types:

1. Monocropping: Growing of single crop is taken in dry farming areas where the annual rainfall is below 500 mm. Crops are being grown on residual moisture in black soils in the post rainy season. Ex: Groundnut every year in Anantapur district

2. Intercropping: Growing two or more crops simultaneously on the same piece of land with a definite row pattern. In areas where rainfall is in range of 600-850 mm.

Ex: Groundnut + Redgram in 7:1 ratio

3. Double cropping: Growing of two crops in sequence on same piece of land in a farming year. Double cropping is feasible in areas receiving rainfall more than 850mm.

Ex: Rice-chickpea, Cowpea-finger millet

Cropping intensities could be increased by practice of inter cropping and multi cropping (sequential) by way of more efficient utilization of resources. The cropping intensity would depend on the length of growing season which in turn depends on rainfall pattern and the soil moisture storage capacity of the soil.

To achieve appropriate land use, efficient inters and sequence-cropping systems were recommended based on soil type, rainfall and length of growing seasons.

Groundnut + pigeonpea (7:1) was widely accepted by the farmers in Rayalseema of Andhra Pradesh. Some of the constraints for wider adoption by the farming communities are preference for fodder genotypes in cereals rather than grains for feed to live stock, lack of suitable farm implements to seed in different ratios, delay in planting of *kharif* for double cropping systems.

4.5.3 Crop diversification in rainfed regions of India

A region is termed rainfed if it has less than 40 per cent net irrigated area. In such regions, crop diversification through technologically feasible and economically viable enterprise seems to be the only option to achieve poverty alleviation through food security by overcoming the problems of land degradation and climatic aberrations.

To be relevant, crop diversification in rainfed regions must address the following issues:

• Efficient cropping systems
• Risk and cost minimization
• High income and employment generation
• Upgradation of natural resources *viz.,* land and water
• Food and nutrition, economical and ecological security
• Poverty alleviation *viz-a-vis* small and marginal holdings

Table: 4.2 Suitable cropping systems based on length of crop growing period

Length of crop growing period	**Cropping system that can be adopted**
<75 days	Perennial vegetation, monocropping of short duration, drought resistant pulses (mungbean, cowpea, mothbean and millets)
75-140 days	Monocropping (in soils with capacity to hold 150 mm of water)
140-180 days	Intercropping (in soils with capacity to hold 200 mm of water)

>180 days	Double cropping (mainly rice – based)

Advantages of crop diversification includes:

- Diversity of crops / products in a region
- Enhanced profits through alternate crops
- Reduced pest problems through crop rotations
- Even distribution of labour throughout the year
- Reduced risks from weather aberrations by different planting & harvesting times

4.6 Watershed Management

4.6.1 Definition

A watershed was defined as a drainage basin or catchment area of land where precipitation collects and drains off into a common outlet, such as into a river, bay, or other body of water.

4.6.2 Concept of watershed management

Watershed management implies the wise use of soil and water resources within a given geographical area so as to enable sustainable production and to minimize floods. Watershed management is the rational utilization of land and water resources for optimum production with minimum hazard to natural resources.

Watershed management has been taken up under different programmes launched by Government of India. The Drought Prone Area Development Programme (DPAP) and the Desert Development Programme (DDP) adopted watershed development approach in 1987. The Integrated Watershed Development Project (IWDP) taken up by the National Wasteland Development Board (NWDB) in 1989 and also aimed at development of wastelands on watershed basis. The major programme based on watershed concept is the National Watershed Development Programme for Rainfed Areas (NWDPRA) under the ministry of Agriculture.

4.6.3 Principles of watershed management

- Utilizing the land based on its capability
- Protecting the fertile top soil
- Minimizing the silting up of the reservoirs and lower fertile lands
- Protecting vegetative cover throughout the year
- *Insitu* conservation of rain water
- Safe diversion of surface runoff to storage structures through grassed water ways

- Stabilization of gullies and construction of check dams for increasing ground water recharge.
- Increasing cropping intensity through inter and sequence cropping.
- Alternate land use systems for efficient use of marginal lands
- Water harvesting for supplemental irrigation
- Ensuring sustainability of the ecosystem
- Maximizing farm income through agricultural related activities such asdairy poultry, sheep, and goat farming
- Improving infrastructural facilities for storage transport and agriculturalmarketing
- Setting up of small scale agro industries and
- Improving socio-economic status of farmers.

Summary

1. Dry farming is the cultivation of crops in regions with annual rainfall less than 750mm
2. Dryland farming refers to the cultivation of crops in regions with annual rainfall more than 750mm.
3. Rainfed farming refers to the cultivation of crops with annual rainfall more than 1150mm.
4. The problems of dry land agriculture be grouped into two basic categories viz. climate and soil.
5. Soil erosion refers to the detachment and transport of soil and soil materials by water, wind, ice or gravity.
6. Types of water erosion are splash, sheet, rill, gully, ravines, landslides and stream bank erosion.
7. Types of wind erosion are suspension, saltation and surface creep
8. Soil conservation methods:

(a) Agronomic measures: Contour cultivation, mulching, contour strip farming.

(b) Mechanical measures: Contour bunding, graded bunding, terracing, gully plugging.

(c) Agrostological measures: Grasses and legumes

9. Crops must be selected based on crop duration to coincide with the length of growing season.
10. Selection of cropping system depends on rainfall and soils: monocropping, intercropping and doublecropping
11. In rainfed regions crop diversification through technologically feasible and economically viable enterprise seems to be the only option to achieve poverty alleviation through food security by overcoming the problems of land degradation and climatic aberrations

12. Watershed is a drainage area on earth's surface from which runoff, resulting from precipitation flows past into a larger stream, a river, a lake or the ocean.

Key terms used

1. Dry farming, 2. Dryland farming, 3. Rainfed farming, 4. Soil crusting, 5. Soil erosion, 6. Crop rotation, 7. Strip cropping, 8. Contour farming, 9. Bench terracing, 10. Watershed

Short answer type questions

1. Differentiate dryland agriculture and rainfed agriculture
2. Define soil erosion
3. What are the causes for soil erosion
4. Write the different types of wind erosion
5. What is mulching
6. What is strip cropping
7. What is crop diversification and write its advantages
7. Define watershed

Long answer type questions

1. Describe the climate problems of dryland agriculture
2. Describe the soil related problems of dryland agriculture
3. Explain briefly the types of water erosion
4. What are the losses due to water erosion
5. Write a note on Agronomic measures of soil conservation
6. Explain the mechanical measures of soil conservation
7. Explain in detail agrostological measures of soil conservation
8. Explain different types of cropping systems suitable for dryland agriculture
9. Explain the concept of watershed management and list the principles of watershed management

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CROP PRODUCTION & MANAGEMENT

Paper - III

FARM MANAGEMENT AND AGRICULTURAL EXTENSION

INDEX

UNIT 1

Learning objectives

1.1 Definition of Farm management
1.2 Nature of Farm management
1.3 Scope of Farm management
1.4 Factors of production (Land, Labour, Capital and Organization)
1.5 Management of a Farm
1.6 Summary

INTRODUCTION

Farm management deals with the organization and operations of a farm with the objective of maximizing profits from the farm business on a continuing basis. In the context of increased accent on commercialization, there is a greater need to improve the managerial abilities of the farmers. The farmer needs to adjust his farm organization from year to year to keep abreast of changes in methods, price variability and resources available to him. The role of farm management, therefore, is to supply the information to the farmers for sound planning of the farm business. All farm management tools are thus helpful to the farmers to make rational decisions in the allocation of resources and the adoption of new technologies.

Farm management draws on agricultural economics for information on prices, markets, agricultural policy, and economic institutions such as leasing and credit. It also draws on agriculture and animal sciences for information on soils, seed, fertilizer and other inputs, on control of weeds, insects, and disease, to decide on the feed and body weight ratios, etc; on agricultural engineering for information on farm buildings, machinery, irrigation, crop drying, drainage, and erosion control systems; and on psychology and sociology for information on human behavior. A farm manager thus integrates the information from the biological, physical, and social sciences, while making rational decisions.

1.1Definitionof Farm management

The term farm management consists of two words, 'Farm' and 'Management', Farm is a modified piece of land held or operated as a unit for production of agricultural products. Management means the art of managing the farm. Farm management, thus means, making and implementing of the decisions involved in organizing and operating a farm for maximum production and profit.

Various authors defined farm management in different ways as presented below:

Farm management is defined as the science that deals with the organization and operation of farm in the context of efficiency and continuous profits (J N Efferson).

Farm management is defined as the science of organization and management of the farm enterprises for the purpose of securing greatest continuous profits (G F Warren).

Farm management is defined as the art of managing a farm successfully as measured by the test of profitableness (Gray).

Farm management is a branch of agricultural economics, which deals with wealth earning and wealth spending activities of farmer in relation to the organization and operation of the individual farm unit for securing the maximum possible net income (Bradford and Johnson).

1.2Nature and characteristics of Farm Management Science:

The farm management science has many distinguishing characteristics from other fields of science. Some important characteristics are as followed.

1) Practical Science: The acceptability of the facts of other physical and biological sciences are tested on the farm and determine whether those are economical and practicable on a given farm situation. Thus farm management is a practical science.

2) Profitability Oriented: The main objective of farm management is to earn maximum profit and hence this science aims to have maximum economic efficiency rather than physical efficiency. Thus, farm management science is profit oriented.

3) Integrating Science: While operating the farm, number of findings of other sciences is actually used. Thus, farm manager has to co-ordinate all the findings of other sciences.

4) Broader Field: The farm management specialist required to have detail information from other Sciences. Hence for successful farming information of one or two sciences is not sufficient as this science is too much broader field.

5) Micro approach: Since this science is related to individual farm, it treats every farm unit unique in available resources. Each farm unit therefore has to be studied and planned individually.

1.3 Scope of Farm management

In actual farming, farm management is concerned with the following problems:

1. Improving practices on existing enterprises.
2. Re-organising existing enterprises and including new enterprises.
3. Determining time horizon of production.
4. Adopting a farm practice, which gives either immediate returns or long term returns.
5. Deciding the best size of farm.
6. Deciding capital goods required and labour to be hired
7. Marketing problems including in what forms, when, where and at what terms to buy inputs and sell output.
8. Expectation of factor inputs and product prices.
9. Credit requirement and sources of credit. `

The field of farm management through research, teaching and training has provided the needed decision – making skills for improving the agricultural income and ultimately the standard of living of the cultivators.

A) Research: The economic problems faced by the farmers needs to be studied. The data are to be recorded. In farm management we study the problems of the cultivators critically and give solution. In research, we cover the following points.

1. Input output co-efficiency
2. Comparative economics of various enterprises
3. Formulation of standard farm plan, optimum cropping pattern for different areas and types of farming.
4. Develop suitable models of mechanization & modernization.
5. Evaluation of prices of agricultural inputs and outputs.

B) Teaching: Farm Management is a younger discipline. Almost in all Agricultural Universities, this course is taught at undergraduate level as a compulsory subject. This subject is also taught at M. Sc. and Ph.D. level.

C) Extension: The results of the farm management research should be known to the cultivators. They should be trained through demonstrations (*ShetkariMela / Kisan Mela*). Short courses in Farm Management for progressive farmers in various types of farm enterprises needs to be conducted.

1.4 Factors of Production

The factors of production are resources that are the building blocks of the economy; they are what people use to produce goods and services. Economists divide the factors of production into four, viz., land, labour, capital and entrepreneurship. They are the inputs needed for supply. They produce all the goods and services in an economy.

1.4.1 Land as Factors of Production

The first factor of production is land, but this includes any natural resource used to produce goods and services. This includes not just land, but anything that comes from the land. Some common land or natural resources are water, oil, copper, natural gas, coal, and forests. Land resources are the raw materials in the production process. These resources can be renewable, such as forests, or non-renewable such as oil or natural gas.

The income that resource owners earn in return for land resources is called rent.

Characteristics of Land

1. It is nature's free gift and fixed in quantity
2. Geographical supply of land cannot be increased but economic supply can be increased by putting the land under intensive and higher use. Land has no supply prices. The prevailing price of the land in the market cannot affect its supply.

3. It is immovable and immobile.
4. It is permanent and cannot be destroyed completely.
5. It is a limiting factor and cannot be increased in size depending on the demand.
6. Land provides place where production takes place.
7. Land cannot be transferred from one place to another.
8. Land has enormous variability in its structure and fertility

1.4.2 Labour as a Factor of Production

The second factor of production is labor. Labor is the effort that people contribute to the production of goods and services. Labor resources include the work done by the waiter who brings your food at a local restaurant as well as the engineer who designed the bus that transports you to school. It includes an artist's creation of a painting as well as the work of the pilot flying the airplane overhead. If you have ever been paid for a job, you have contributed labor resources to the production of goods or services. The value of labor depends on workers' education, skills, and motivation. It also depends on productivity. That measures how much each hour of worker time produces in output.

The income earned by labor resources is called wages.
Characteristics of Labour

1. Labour is inseparable from the human being as it is a living thing. 2. Land cannot be productive without the aid of labour. 3. Labour does not last long and is a highly perishable than any other factors of production, in the sense; the utilization of labour cannot be postponed as it has some relationship with time. 4. Labour cannot be produced but it can be altered to sell its services according to the price offered. 5. Labour sells his services in person and not himself. 6. Labour is much less mobile than capital or any other good.7. Labour differs inefficiency.

1.4.3Capital as a Factor of Production

The third factor of production is capital. In ordinary language, capital means money. The economists regard capital as the part of man wealth other than land which is used in producing further wealth or which yields an income. Anything which is used in production is called Capital. Capital is short for capital goods. These are man-made objectives. Think of capital as the machinery, tools and buildings humans use to produce goods and services. Some common examples of capital include hammers, forklifts, conveyer belts, computers, and delivery vans Capital differs based on the worker and the type of work being done. For example, a doctor may use a stethoscope and an examination room to provide medical services. Your teacher may use textbooks, desks, and a whiteboard to produce education service.

The income earned by owners of capital goods is called interest.

Characteristics of capital

1. Capital is productive or it produces wealth. 2. It yields 'INCOME' to the owner of it. 3. Capital is prospective in the sense that we postpone the present use of it for future date in anticipation of reward.

Forms of capital

1. Fixed Capital

These are the durable-use produces goods which are used in production again and again till they wear out e.g. land machinery, tractors, factories, buildings etc.

2. Working Capital

These are single use produced goods or goods used up in a single act of consumption e.g. **raw material, fertilizers, seeds, wages etc.**

3. Sunk or Specific Capital

When capital is used to purchase highly specialized equipment or machinery, which can be used for only one purpose of textile machinery, cameras, radios etc.

4. Floating or Non Specific Capital

Capital which displays a greater degree or elasticity and can be used for different purpose e.g. money, fuel etc.

1.4.4 Entrepreneur ship/organisation as a Factor of Production

The fourth factor of production is entrepreneurship Entrepreneurship is the drive to develop an idea into a business. An entrepreneur is a person who combines the other factors of production - land, labor, and capital - to earn a profit. The most successful entrepreneurs are innovators who find new ways produce goods and services or who develop new goods and services to bring to market. Without the entrepreneur combining land, labor, and capital in new ways, many of the innovations we see around us would not exist. Entrepreneurs are a vital engine of economic growth helping to build some of the largest firms in the world as well as some of the small businesses in your neighborhood. Entrepreneurs thrive in economies where they have the freedom to start businesses and buy resources freely.

The payment to entrepreneurship is profit/ Loss.

1.5 Management of Farm

Farm management is different from what is commonly confused with the work of a farm manager who manages a government farms as an agronomist. His function is normally limited to supervising and handling the day to day routine of a farm. An intelligent farm manager may go a little further and look after the farm machinery to keep it going. In farm management a major concern is about adjustments which are more suitable and profitable and about exploring new situation and opportunities for maximization of income and satisfying other goals of a farmer. It is the approach under which the opportunity costs of the various resources are evaluated and adjustments in resource-use and enterprise mix are made to secure higher levels of farm income.

Following this approach, the emphasis on yield is ignored, but the greater focus is on the increasing of farm income through a sound business organization. As a business, farming requires the application of business methods and efficient management. To be an efficient manager, one must keep oneself a best of developments in new technology, new practices, price trends and economic outlook. Again, a farm management man should identify the constraints in the external environmental conditions, which hamper a farmer's opportunities and plan for making adjustments in this farm organization and render the technically superior production plan economically unattractive to the farmer.

Farm Management Decisions

Farm management implies decision – making process. The management decisions are broadly classified into organizational management decisions, administrative management decisions and marketing management decisions, which are listed below.

1. Organizational management decisions:
   (i) Operational management decisions: The decisions which involve less investment and are made more frequently are called Operational management decisions. These decisions can be reversed without incurring a cost or with less cost.
      a) What to produce?
      b) How to produce?
      c) How much to produce?

   (ii) Strategic management decisions: These decisions involve heavy investment and are made less frequently. The effect of these decisions is long lasting. These decisions cannot be controlled and reversal of these decisions incur high cost. The decisions are also known as Basic decisions.
      a) Size of the farm
      b) MAchnery and labour programme
      c) Construction of farm buildings
      d) Irrigation, conservation and reclamation programmes

2. Administrative management decisions
   (i) Financing the farm business
   (ii) Supervision
   (iii) Accounting
   (iv) Adjusting the farm production programme

3. Marketing management decisions
(i) Buying
(ii) Selling

Summary

Farm management is that branch of agricultural Economics, which deals with the business principles and practices of farming with an object of obtaining the maximum possible returns from the farm as a unit under a sound farming programme.

- Land, labour, capital and organisation are called factors of production.
- Land is the natural resource-the place where production takes place land gets rent.
- Labour, the human power involved in production-labour gets wages.
- Capital, wealth which is used in producing further wealth or which yields an income-capital earns interest.
- Organisation combines all these factors – invests money – takes risk – organisation is rewarded with profits.

Short Answer Type Questions

1. Define the following terms:

a) Land b) Labour c) Capital d) Organization e) Farm management d) Factors of Production

2. List out forms of capital.

3. What are the characteristics of land?

4. What are the characteristics of organizer?

5. Write about the payment to factors of Production.

Long Answer Type Questions

6. How do manage a farm?

7. Explain the role of factors of production in an economic activity.

8. Briefly explain the nature and scope of farm management?

References

1. Johl, S.S and Kapur J.R 2006. Fundamentals of Farm Business management. Kalyani Publishers, New Delhi.
2. Raju, V.T and Rao, D.V.S 2006.Economics of Farm producyion and Management, Oxford & IBH Publishining Co Pvt. Ltd, New Delhi.

Unit 2

FARM RECORDS

STRUCTURE

2.1 The need to maintain farm records
2.2 The important use of farm records
2.3 Important Farm records and their maintenance (Dairy, Cashbook, labour wage register, live stock register and inventory)

2.1 Need to Maintain The Farm Record

The modern farmer has to run his farm activities on commercial lines by considering all possibilities of keeping the costs to the minimum and striving for production to the maximum. It requires making rational decision based on correct information about various activities taken up on the farm in the past and the results obtained. This past information is preserved in the Farm records. The main objectives of farm records are to control the farm business, guide future decisions and provide data required for sound farm planning.

2.2 Important Uses of Farm Records

1. Help in Evaluation of Farm Performance

Find out strong and weak points in his enterprise. He is able to locate the factors responsible for losses and try to rectify the same

2. Helps in Decision Making

Farm records will provide necessary information for sound decision making. The farmer can alter his cropping pattern, or spare his resources for better enterprise, or replace an enterprise by the other. Farm records will enable the farmer to measure the progress during certain period.

3. Helps in Farm Planning

The records provide information regarding the available land, labour, seeds, machinery, fertilizer and how much more can be procured from external sources. They will guide him regarding the technical and economical efficiency of different enterprises.

4. Farm records are essential in settling the arrangement on sharing; leasing and making new contacts.

5. They prevent misunderstandings among the partners.

6. Records form an important basis for farm credit and financing. The money lending agencies rely upon these farm records, based on which the repaying capacity of the farmer is assessed by the money lender or bank.

Limitations in the maintenance of Farm Records

1. Illiteracy
2. Small size holdings
3. Fear of taxation
4. Complicated nature
5. Nature of farming

2.3 Farm Records maintained on an average farm

1. Land use records
2. Permanent dead stock register
3. Farm livestock register
4. Farm labour records
5. Input records
6. Feed records
7. Crop production and disposal records
8. Livestock production and disposal records

The formats of different types of records and their use are given under.

1. Land use records

Particulars	Area (ha)
Cultivated area	
Irrigated	
Irrigated dry	
Dry	
Permanent fallows	
Land under buildings	
Problematic soils	

The different types of land, i.e., irrigated dry and unirrigated operated by the farmer, including the land lying idle or area under problematic soils, etc. can be understood by using the Land use records. This information helps in preparing the cropping pattern in the farms.

2. Permanent dead stock register

Particular	Year of construction / Purchase	Construction value / Purchase value (Rs.)	Amount spent on repairs per annum (Rs)
Farm buildings			
Cattle shed			
Wells /Tube wells			
Pump house			
Tractors			
Oil engines			
Electric motors			
Threshers			
Sprayers			
Bullock carts			
Wooden ploughs			
Iron ploughs			
Cultivators			
Harrows			
Crowbars			
Spades			
Sickles			
Hand hoes			
Others (if any)			

The particulars on year of purchase, purchase value amount spent on repairs, et., of different dead stock available in the Permanent dead stock register helps the farmer to make a decision on incurring an amount on certain repairs or to replace the item or to go for custom hiring, etc.

3. Farm Livestock Register

Type	Number		Breed	Age	Purchase value (Rs.)
	Homebred	Purchased			
Milch animals					
Cows					
She-buffaloes					
Draft animals					
Bullocks					
He-buffaloes					
Young stock					
Heifers					
Calves					
Others					
Sheep / Goat					
Poultry birds					
Others					

The information available from the Farm livestock records helps in planning for purchase / disposal and maintenance of the animals.

4. Farm Labour Records

Season: Crop: Variety: Area:

Date	Operations	Owned labour				Hired labour				Wages (Rs.)			
		TP	CP	M	W	TP	CP	M	W	TP	CP	M	W

TP = Tractor power CP: Cattle pair days M= Man labour W = Woman labour

The information on total labour requirement for different operations, enterprises and the seasons help the farmer to plan the area under different crops to adjust with the demand and supply of labour.

5. Input Records

Date / Month	Input	Quantity	Rate (Rs.)	Value (Rs.)

The information from the Input records gives a picture of the extent of different inputs utilized crop-wise and variety – wise. The actual use indicates whether a particular input was over – used or under – used and the imbalances if any can be corrected accordingly.

6. Feed Records

Date/ Month	Type of feed	Milch animals		Draft animals		Young stock		Poultry	
		Quantity (kg/Q)	Value (Rs.)	Quantity (kg/Q)	Value (Rs.)	Quantity (kg/Q)	Value (Rs.)	Quantity (kg/Q)	Value (Rs.)

The information on feed particulars indicates whether the livestock was given required ration or not, so that feed efficiency can be worked out.

7. Crop production and Disposal records

Season	Date / Month	Crop	Area	Main product (Q)	By product(Q)	House hold consumption	
						Quantity(Kg)	Value (Rs.)
1	2	3	4	5	6	7	8

Used as seed		Kind payments		Sold		Balance	
Quantity(Kg)	Value (Rs.)	Quantity(Kg)	Value (Rs.)	Quantity(Kg)	Value (Rs.)	Quantity (Kg)	Value (Rs.)
9	10	11	12	13	14	15	16

The details of Crop production and Disposal records help to estimate the profitability or otherwise of the farm business.

8. Livestock production and disposal records

Date / Month	Particulars	Milk		Eggs		Farm Yard Manure	
		Quantity(l)	Value (Rs.)	Quantity(No.)	Value (Rs.)	Quantity(t)	Value (Rs.)
1	2	3	4	5	6	7	8

Poultry litter		Household consumption				Particulars of conversion		
		Milk		Eggs		Quantity of milk (l)	Ghee obtained (l)	Value (Rs.)
Quantity(l)	Value (Rs.)	Quantity(l)	Value (Rs.)	Quantity(l)	Value (Rs.)			
9	10	11	12	13	14	15	16	17

Production levels and household consumption or value addition of different enterprises are reported in the Livestock production and disposal records.

9. Input and Feed stock Register

Date / Month	Particulars of inputs / feed			Opening balance (kg)			Receipts (kg)			Quantity issued (kg)			Balance (kg)			Source of purchase			Cost (Rs.)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

The Input and Feedstock Register is maintained to assess the stock position of farm inputs and feed at a particular point of time.

10. Log Book

Season: Crop: Variety: Area:

Date / Month	Name of the machinery	Operation done	Time (No. of hrs.)	Power consumed		Fuel consumed		Lubricants		Repairs (Rs.)
				(Units)	Cost (Rs.)	Quantity (l / Kg.)	Value(Rs.)	Quantity (l / Kg.)	Value(Rs.)	
1	2	3	4	5	6	7	8	9	10	11

The relevant expenditure on machinery and equipment can be known by maintain the log book.

Apart from these, there are other records maintained on the corporate farms and the state farms and are listed hereunder.

1. Forecast register
2. Daily memorandum sheet (DMS)
3. Muster sheets
4. Permanent dead stock register
5. Temporary dead stock register
6. Fertilizers and chemicals register
7. Seed stock register
8. FYM Register
9. Cattle feed register
10. Tractor expenditure record
11. Livestock register
12. Farm produce stock register
13. Produce stock register
14. Indent register
15. Sales price register
16. Sanction register
17. Auction register and
18. Cash book

SUMMARY

- Farm records helps the farmer to evaluate his progress, help in decision making and plan for betterment.
- They are essential for sharing, partnership or contracts.
- Important farm records are Diary, Cash book – wage – Register, Stock-Register and Inventory.
- Inventory helps to assess the real worth of the farmer – profits or assets made in a year / losses incurred.

Short Answer Type Questions

1. Write importance of keeping the Farm Records.
2. Write about **or Table Head of** Cash Book / Diary/Labour Wage Register /Stock Register / Farm Inventory.
3. Name the important farm records, maintained on a established agricultural farm.
4. What is the main function of Inventory?
5. Describe the importance of Stock Register.
6. How is a Wage Register useful to farmers? What are its details?
7. Explain the columns and uses of a Cash Book.

Long Answer Type Questions

1. Name the important farm records, maintained on an established agricultural farm. Explain them with neat Table Heads.
2. Which farm record helps to assess the real worth of a farm? Give details of the columns of that record.

References

1. Johl, S.S and Kapur, J.R 2006.Fundamentals of Farm Business management. Kalyani Publishers, New Delhi.

2. Raju, V.T and Rao D.V.S.2006.Economics of Farm producyion and agement, Oxford & IBH Publishining Co Pvt. ltd, New Delhi.

UNIT 3

AGRICULTURAL MARKETING

STRUCTURE

India is an agricultural country and one third of population depends on the agricultural sector directly or indirectly. Agriculture remains as the main stray of the Indian economy since times immemorial. Indian agriculture contribution to the national gross domestic product (GDP) is about 18 per cent. With food being the crowning need of mankind, much emphasis has been on commercialising agricultural production. For this reason, adequate production and even distribution of food has of late become a high priority global concern.

Agricultural marketing is mainly the buying and selling of agricultural products. In earlier days when the village economy was more or less self-sufficient the marketing of agricultural products presented no difficulty as the farmer sold his produce to the consumer on a cash or barter basis.

Today's agricultural marketing has to undergo a series of exchanges or transfers from one person to another before it reaches the consumer. There are three marketing functions involved in this, i.e., assembling, preparation for consumption and distribution. Selling on any agricultural produce depends on some of factors like the demand of the product at that time, availability of storage, etc. The products may be sold directly in the market or it may be stored locally for the time being. Moreover, it may be sold as it is gathered from the field or it may be cleaned, graded and processed by the farmer or the merchant of the village.

The task of distribution system is to match the supply with the existing demand by whole selling and retailing in various points of different markets like primary, secondary or terminal markets. 0

Most of the agricultural products in India are sold by farmers in the private sector to moneylenders (to whom the farmer may be indebted) or to village traders. Products are sold in various ways. For example, it might be sold at a weekly village market in the farmer's village or in a neighboring village. If these outlets are not available, then the produce might be sold at irregularly held markets in a nearby village or town, or in the *mandi*.

In India, there are several central government organisations, who are involved in agricultural marketing like, Commission of Agricultural Costs and Prices, Food Corporation of India, Cotton Corporation of India, Jute Corporation of India, etc. There are also specialised marketing bodies for rubber, tea, coffee, tobacco, spices and vegetables. Under the Agricultural Produce (grading and marketing) Act of 1937, more than forty primary commodities are compulsorily graded for export and voluntarily graded for internal consumption. Although the regulation of commodity markets is a function of State government, the Directorate of Marketing and Inspection provides marketing and inspection services and financial aid down to the village level to help set up commodity grading centers in selected markets.

With the changing agricultural scenario and global competition, there is a need of exploiting the available resources at maximum level. The value added services will give the existing agricultural engine a new dimension. The next logical step could be food-processing which not only could be another revenue generating area but also can provide lots of full-time employment to the youth.

3.1 Meaning of Agricultural Marketing

The term agricultural marketing is composed of two words-agriculture and marketing. Agriculture, in the broadest sense, means activities aimed at the use of natural resources for human welfare, i.e., it includes all the primary activities of production. But generally, it is used to mean growing and/or raising crops and livestock. Marketing connotes a series of activities involved in moving the goods from the point of production to the point of consumption. It includes all the activities involved in the creation of time, place, form and possession utility.

3.2 Definitions of Agricultural Marketing

1. The study of agricultural marketing comprises all the operations, and the agencies involved in the movement of farm produced foods and raw materials and their derivatives, such as textiles, from the farms to the final consumer and effects of such operations on farmers, middlemen and consumers (By Thomsen).

2. Agricultural marketing is the study of all activities, agencies and policies involved in the procurement of farm inputs by the farmers and the movement of agricultural products from the farmers to the consumers (By Acharya and Agarwal).

3.3 Importance of Agricultural Marketing

Agricultural marketing plays an important role not only in stimulating production and consumption, but also in accelerating the pace of economic development. Its dynamic functions are of primary importance in promoting economic development. The technological break through has led to a substantial increase in production on the farms and to the larger marketable and marketed surplus. To maintain this tempo and pace of increased production through technological development, an assurance of remunerative prices to the farmer is a prerequisite, and this assurance can be given to the farmer by developing an efficient marketing system.

The agricultural marketing plays a dual role in economic development in countries whose resources are primarily agricultural.

The importance of agricultural marketing in economic development has been indicated as:

1. Optimization of Resource use and Output Management

An efficient agricultural marketing system leads to optimization of resource use and output management. An efficient marketing system can also contribute to an increase in the marketable surplus by scaling down the losses arising out of inefficient processing, storage and transportation. A well-designed system of marketing can effectively distribute the available stock of modern inputs, and there by sustain a faster of growth in agricultural sector.

2. Increase in Farm Income

An efficient marketing system ensures higher levels of income for the farmers by reducing the number of middlemen or by restricting the commission on marketing services and the malpractices adopted by them in the marketing of farm products. An efficient system guarantees the farmers better prices for farm products and induces to invent surpluses in the purchase of modern inputs so that productivity and production may increase. The need for providing adequate incentives for increased production is therefore very important, and this can be made possible only by streamlining the marketing system.

3. Widening of Markets

A well-knit marketing system widens the market for the products by taking them to remote corners of the country i.e., to areas far away from the production points. The widening of the market helps in increasing the demand on a continuous basis, and there by guarantees as a higher income to the producer.

4. Growth of Agro-based Industries

An improved and efficient system of agricultural marketing helps in the growing of agro-based industries and stimulates the overall development process of the economy. Many industries depend on agriculture for the supply of raw materials.

5. Price Signals

An efficient marketing system helps the farmers in planning their production in accordance with the needs of the economy. This work is carried out through price signals.

6. Adoption and spread of New Technology

The marketing system helps the farmers in the adoption of new scientific and technical knowledge

7. Employment

The marketing system provides employment to millions of persons engaged in various activities, such as packaging, transportation and processing. Persons like commission agents, brokers, traders, retailers, weigh men, hamalis and regulating staff are employed in the marketing system.

8. Addition to National Income

Marketing activities add to the nation's gross national product and net national product.

9.Better Living

The marketing system is essential for the success of the development programmes, which are designed to uplift the population as a whole. Any plan of economic development that aims at diminishing the poverty of the agricultural population, reducing consumer food prices, earning more foreign exchange or eliminating economic waste has, therefore, to pay special attention to the development of an efficient marketing for food and agricultural products.

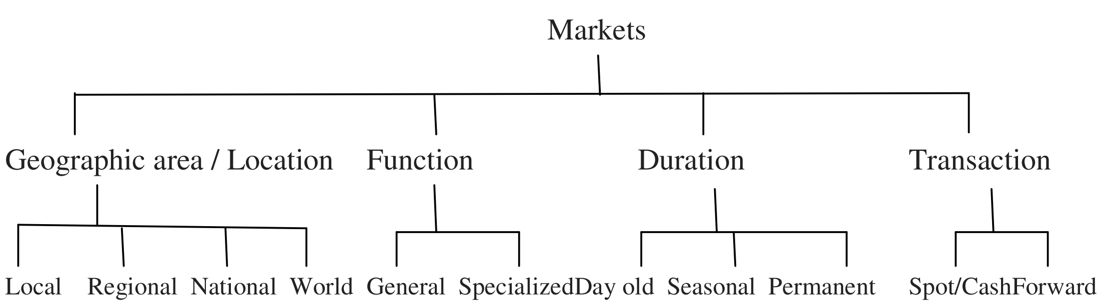
10. Creation of Utility

Marketing is productive, and is as necessary as the farm production. It is, in fact, a part of production itself, for production is complete only when the product reaches a place in the form and at the time required by the consumers. Marketing ads cost to the product; but, at the same time, it adds utilities to the product. The following four types of utilities of the product are created by marketing.

a. Form Utility, b. Place Utility, c. Time Utility and d. Possession utility

3.4 Classification of Markets

Markets are classified differently by taking different criteria into consideration.



3.4.1Based on Geographic area / Location

This classification has been based on the area that the market serves. Under this category there are 4 types of markets.

(a) Local or village markets: A market in which the buying and selling activities are confined among the buyers and sellers drawn from the same village or nearby villages. The village markets exist mostly for perishable commodities in small lots, e.g. local milk market or vegetablemarket.

(b) Regional markets: A market in which buyers and sellers for a commodity are drawn from a larger area than the local markets. Regional markets in India usually exist for food grains.

(c) National markets: A market in which buyers and sellers are at the national level. National markets are found for durable goods like jute and tea.

(d) World market: A market in which the buyers and sellers are drawn from the whole world. These markets exist in the commodities which have a world-wide demand and/or supply, such as coffee, machinery, gold, silver, cotton, sugar, rice etc.

3.4.2 Based on Function

This classification has been done based on the nature of function that the market discharges.

(a) General markets: A market in which all types of commodities, such as food grains, oil seeds, fiber crops, etc., are bought and sold is known as general market.

(b) Specialized market: A market in which transactions take place only in one or two commodities is known as a specialized market. The examples are food grain markets, vegetable markets, cotton market etc.

3.4.3 Based on Duration

In this system markets are classified depending upon the period of its existence or the duration for which it lasts. There are 3 types under this.

(a) Day-old markets: Markets which will exist only for a day periodically e.g. highly perishable products like fish vegetables etc.

(b) Seasonal markets: Commodities traded in these markets are less perishable and can be stored for some time. e.g. Food grains, oil seeds etc.

(c) Permanent markets: The commodities traded in these markets are durable in nature and can be stored for many years. e.g. Machinery and manufactured goods.

3.4.5 Based on Transaction

The markets which are based on the type of transactions in which people are engaged are of two types.

a. Spot or Cash Markets: A market in which goods are exchanged for money immediately after the sale is called the spot or cash market.

b. Forward or Speculative Markets: A market in which the purchase and sale of a commodity takes place at time ‘t’ but the exchange of commodity takes place on some specified date in future i.e. time t+1.

3.5 Functions of Marketing

The essential functions of a goods marketing system are (1)Assemb1ing, (2) Distribution (3) Grading and standardization (4) Processing (5) Storage (6) Transportation (7) Marketing finance and (8) Market intelligence.

(1) Assembling: It is the process of bringing the commodity from the producer or seller to a common place. Village merchants, retail merchants, commission agents etc., do this work at village level.

(2) Distribution: The produce assembled from the producers is distributed to the consumer through different channels.

(3) Grading and Standardization: Graded and standardized produce always fetches higher price than the raw produce. Normally grading is done at trader’s level. Well defined grades as per the norms fixed up by the Agricultural Market department will be accepted in the export market also.

(4) Processing: The produce collected and graded has to be converted into consumable shape, viz polishing of rice, polishing turmeric etc., The processing cannot be taken up by individual farmers. So the traders, whole sellers, cooperatives etc., can be engaged in processing.

(5) Storage: Agriculture is highly seasonal. There is a glut in the market during harvest season. Naturally the prices go down when the supply is more. The commodities which are produced only once in a year need to be stored properly for making them available through out the year. It is also necessary to store the produce for such a time till the prices are satisfactory. Normally there are no facilities to store the produce by individual farmers. They are compelled to sell the produce soon after the harvest. Therefore storing the produce in godowns built and maintained on scientific lines is essential.

(6) Transportation: Physical movement of the produce from the producing centres to the consuming areas is called transporting. In our country most of the villages are ill connected. Roads are not good. Transport costs are high. As much as 30% of the consumers price is due to transport cost. The transport facilities have to be improved to considerable extent in our country. For perishable products like vegetables and fruits quick transport is essential. Necessary refrigerated vans should be used for their transport.

(7) Marketing Finance: Finance is required for the cultivator to retain his produce for a reasonable period to get a better market price. There are a number of organizations that provide crop loans to the farmers. But there is none for providing market finance. As a result farmer is forced to sell the produce immediately to clear off his crop loans etc., Therefore steps are to be taken to provide financial assistance to the farmers, so that he can wait and sell the produce when the price is high.

(8) Market Intelligence: Market information plays an important role in modern marketing. Information regarding Prices of commodities at various markets, Availability of commodity and the Demand for the commodity are to be provided to the farmer / producer from time to time. Market information is given through news papers or broadcast through Radios etc.

3.6 Defects in the present Marketing System

At present there are many problems in the Agricultural marketing systems in India.

I. If marketable surplus is very low with individual famers, he prefers to sell his produce at low price in the village itself.

2. The small farmers and marginal farmers borrow money required for crop production during the season from village money lenders or village traders. He is bound to dispose off his produce right in the threshing floor, to clear off such debts. He is not able to wait till the prices rise.

3. The farmer has no proper storage facilities to keep the produce for some months. There is the fear of pests, fire and theft. To avoid risk, the cultivator sells his produce at whichever rate offered by the village traders.

4. There are no transport facilities to take the produce to the nearby markets where the farmers can get better price. The small quantity of the produce intended for sale become uneconomical.

5. The village traders take large quantities of samples of the produce which are not accounted for sale and thus become uneconomical to the farmers.

6. Use of defective weights and measures always put the farmers at a loss.

7. Lack of knowledge about prevailing market prices is another handicap for the farmers.

8. There are a number of middlemen in the present marketing system. There is a lot of difference between consumer’s price and producer’s price. A major share of income is taken away by middlemen.

3.7 Steps taken for improving agricultural marketing to safeguard farmers

The following steps are taken by Government to improve marketing practices.

1. Organising Producers and Consumers Societies

The Government encourage formation of producers’ societies and consumers’ societies in cooperative or other sectors. Such organizations help to avoid unnecessary middlemen. The advantages of large scale organisation can be enjoyed by small producers.

2. Improving transport facilities

Top priority is given to laying of roads connecting villages with towns. Motor vehicles are operated to connect villages. The railways transport the seed meant for sowing at concessional rates. Refrigerated vans are provided to transport perishables like fruits, vegetables, fish etc.

3. Standardization of weights and measures

Metric weight act has come into force from 1956. Under this act only metric system has to be used in all transactions of market. All weighing and measuring units need to be certified by the Controller of weights and measurement.

4. Grading, processing and standardization

The Government has developed guidelines to prepare the produce into different grades according to which the prices can be fixed. I.S.I. Mark is given for individual products for those items which are being manufactured as per specifications. In case of notified commodities 'AGMARK' seal is necessary. The consumer feels confident about the quality of the product and at the same time producer gets maximum possible price for supplying specified quality product.

5. Market intelligence

Information regarding the prevailing prices of different commodities is given through Radios, News papers, etc, so that the farmer can be aware of the market trends and is not deceived by the middlemen. The Government also conducts market surveys and publish its reports. This information is useful to the producers, traders and also to the consumers in regularisation of supply of the produce.

6. Providing market finance

Provision of finance to the farmer after the harvest of the produce, to meet his immediate expenses without disposing his produce. With this assistance, he can store his produce and wait till such time the prices are acceptable to him.

3.8 Regulated Markets

With the objective of safe guarding the interests of farmers and to eliminate the defects of present marketing system, Regulated markets were started under an act called A.P. Agricultural Produce and Live stock Markets Act 1966. Market committees are constituted with representatives from growers, traders, local Panchayat leaders etc.

All important commodities of an area are covered under this Act. All sales and purchases of those commodities should be done through the regulated market yards.

Functions

The following are the functions of a regulated market

(1) Assemble the produce from growers.
(2) Conduct open quotation of the produce so that competitive price is realised by the producers.
(3) Godown facilities are provided.
(4) Facilities for processing and standardization are provided.
(5)The persons involved in trading as middlemen (Commission agents) have to necessarily register their names in the market committee. They should obtain license from concerned authority as commission agents.
(6) Licensed weigh men are arranged to handle the produce.
(7) Only standard weights and measures are used.
(8) Market information is provided to the growers and traders.
(9) Promote good relation between and buyers, by settling any disputes that may arise.
(10) Ensure good price for the producer and satisfactory quality and rates to the consumer.

Advantages

The following are the advantages of regulated markets:

(1) The active participation of middlemen is avoided. The producer and the buyer come face to face and come to a mutually agreeable price.
(2) Only standard weights and measures are used.
(3) Licensed weighmen are employed to handle the produce.
(4) The producer is allowed to keep his produce for a few days, so that he can wait for better price.
(5) They buyer is at liberty to choose the produce of good quality,
(6) All transactions are made in ready-cash basis so that the seller need not worry about payments.

Marketing Institutions

Marketing institutions are big business organizations which have come up to operate the marketing machinery. In addition to individual, corporate, cooperative and government institutions are operating in the field of agricultural marketing.

They perform one or more of the marketing functions. They assume the role of one or more marketing agencies, described earlier in this section. Some important institutions in the field of agricultural marketing are:

(i) The State Trading Corporation (STC),
(ii) The Food Corporation of India (FCI)
(iii) The Agricultural Cooperative Marketing Federation (NAF ED).
(iv) The Directorate of Marketing and Inspection, Government of India
(v) State Level Agricultural Marketing Departments and Agricultural Marketing Boards
(vi) State and lower level co-operative marketing societies
(vii) Fair price shops, Consumers co-operative stores, Milk unions.

Marketing Agencies

There are different marketing agencies dealing in agricultural produce, starting from village level. All the marketing functions may not be performed by any single agency. Collection and grading is done at small towns, where processing units like rice mills, oil expellers, sugar factories are established. The produce is now in the form usable by consumers. This is distributed to the wholesalers from where it reaches to consumer through retail merchants. As seen above, the produce passes through many agencies, which are the links in the system. There are many Channels through which the produce reaches from the producer to consumer.

3.9 Marketing Channels

Marketing channels are the routes through which agricultural products move from producers to consumers.

Explanation of Marketing Channel

A marketing channel may be defined in different ways. The chain of intermediaries through whom the various food grains pass from producers to consumers constitutes the marketing channels.

Marketing Channels of Food grains

Marketing channels for various cereals in India are more or less similar, except the channel for paddy (or rice), where rice millers come into the picture. For pulse crops, dal mills appear prominently in the channel.

Some common marketing channels for food grains have been identified as follows:

(i) Farmer to consumer;
(ii) Farmer to retailer or village trader to consumer,
(iii) Farmer to wholesaler to retailerto consumer,
(iv) Farmer to village trader to wholesaler to retailer to consumer,
(v) Farmer to co-operative marketing society to retailer to consumer,
(vi) Farmer to Government agency (FCI, etc.) to fair price shop owner to consumer,
(vii) Farmer to wholesaler to flour miller to retailer to consumer.

The channels for paddy-rice and pulses are broadly the same, except that rice millers or dal millers come into the picture before the produce reaches retailers or consumers.

Marketing Channels for Oilseeds

Marketing channels for oilseeds are different from those for food grains, mainly because the extraction of oil from oilseeds is an important marketing function of oilseeds.
The most common marketing channels for oilseeds in Indiaare

(i) Producer to consumer (who either directly consumes the oilseeds or gets it processed on custom basis).
(ii) Producer to village trader to oil retailer to consumer.
(iii) Producer to oilseeds wholesalers to processor to oil wholesaler to oil retailer to oil consumer.
(iv) Producer to village trader to processor to oil consumer.
(v) Producer to Government agency to processor to oil wholesaler to oil retailer to oil consumer.

3.10*RythuBazars*

Government of Andhra Pradesh under the leadership of Honourable Ex and Now Chief Minister Sri N. Chandrababu Naidu decided to establish permanent marketing to counter the hike in prices of essential agricultural commodities and provide reasonable prices to farmers. As a result of that *Rythu bazars* were started in Andhra Pradesh in year 1999 on the lines of 'ApniMandi' being operated by the 'PubjabMandi Board'.

Concept

Andhra Pradesh is the second largest producer of fruits, vegetables and flowers in the country. The predominately grown fruit crops are mango, banana, cashewnut, sapota, guava and pomegranate. Brinja1, lady's finger, onion, tomato, beans and gourds are the major vegetables produced in the state. Regulated market yards for fruits and vegetables are functioning only at few centers in the state. The marketing system for fruits and vegetables is in the hands of middlemen. Middlemen exist at various levels between the farmer and the consumer and exploit through malpractices in weighments, handling and payments.

The farmer's share in the consumer's rupee is estimated to be just 40 paise. In addition the estimated losses in handling of vegetables in the traditional channel of marketing is about 30-3 5%.

Large number of small farmers are unable to effectively bargain for a better price in the wholesaler markets. Inefficiencies in wholesale market result in a long chain of intermediaries, multiple handling, lossin quality and increase the gap between producer and consumer prices. Intermediaries and system inefficiencies consume a disproportionate share of consumer prices. Large number of small retailers each handling small quantity create high overheads leading to high margins on produce.

It was therefore felt necessary to evolve an alternative marketing strategy where both growers and consumers are benefited. Rytu bazars are thus planned for direct interface between the farmers and the consumers eliminating middlemen. *Rytu bazars*, if function effectively, can act as price stabilization centers. *Rythubazars* will operate outside the purview of Agricultural market committees to be managed by estate officers and under the control of Joint Collectors of the District.

Summary

- Agricultural marketing consists of all the functions and services used in moving the commodities from the producer to the final consumer.
- Agricultural marketing plays an important role not onlu in stimulating production and consumption, but in accelerating the pace of economic development.
- Markets are classified on the basis of various dimensions of market.
- Good marketing system has functions like assembling, distributionetc.
- Government has taken steps to improve the agricultural marketing.
- Regulated markets are started with the main objective of eliminating unnecessary middlemen and to sageguard the interests of farmers.
- The main objective of rytu bazars is to ensure remunerative prices to the farmers and provide fresh vegetables to consumers at reasonable rate fixed every day.

Short Answer Questions

1. Define Agricultural Marketing.
2. Name the Functions of a good marketing system.
3. What is Day Old Market/Santa?
4. s Spot Market?
5. What is Market intelligence?
6. What is Marketing Channel? Write about Marketing Channels for Food Grains/Oil Seeds
7. Explain the concept of Rytu Bazar
8. Write two functions and two advantages of Regulated Market
9. What is Grading /Processing / Standardisation?
10. What is Marketing Finance?

Long Answer Type Questions

1. What is Market? Write classification of Markets.
2. Write the Importance of agricultural marketing in the economic development
3. Explain Functions of Marketing./a good marketing system.
4. Write Deffects in the present marketing system. Explain Steps taken by the Government to improve the present Agricultural Marketing to Safeguard of the Farmers.
5. What are Regulated Markets? Write advantages of them/ Regulated Markets.

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UNIT 4

Farm Credit

STRUCTURE

4.1 Meaning, Definition and Need of Farm Credit

Credit is defined as ‘THE TEMPORARY TRANSFER of assets or wealth from one who has to the one who has not. This technique of transfer helps the farmer to equip himself with the required capital to be invested in agricultural production. The basis for credit transaction is trust or confidence on the part of agency extending credit.

Credit forms part of capital investment in agriculture. Generally farmers in India are poor and they need credit for investment in agriculture. Credit is required not only for meeting production expenses during the crop growth period, but also for consumption requirements. It is also required for the purpose of marketing to meet expenditure on processing, storage, transportation etc., so that the farmers are able to keep the produce till the prices become satisfactory.

4.2 Classification of Farm Credit

Based on the duration over which the loan is enjoyed by the borrower, loans are classified into three types.

1. Short Term Loans

These are meant for meeting the expenditure during crop growth period on items like wages to labour, payment of inputs viz., seeds, manures, fertilizers, plant protection material etc., and the repayment is done at the end of crop period, usually one year.

2. Medium Term Loans

Credit required for the purchase of bullocks, bullock carts, milch cattle, implements, electric motors and pump sets etc., may be classified under this category. Repayment is done usually over 2 to 5 annual installments.

3. Long Term Loans

These loans are required for long term investments. Purchase of land, costly machinery like tractors, digging wells, making permanent improvement to the land, raising orchards etc., require large amounts. The repayment schedule is planned over 5 to 1 5 annual installments depending on the nature of investment.

4.3 Sources of Credit

The sources of Agricultural Credit can be broadly classified into two categories viz., institutional agencies and non-institutional agencies.

4.3.1 Institutional Credit Agencies

1. Government
2. Cooperative institutions
3. Grameena Bank
4. Commercial Banks

4.3.1.1 Government

Keeping in view of quantum of rural indebtedness, the Government have taken steps to provide financial assistance for farmers. The credit given by Government is known as Taccavi loans. They are granted to the farmers to clear off old debts and also for short term needs. Government from time to time gives the directions to commercial banks for providing financial assistance to the agricultural sector.

4.3.1.2Cooperative Institutions

Cooperative institutions form major source of agricultural credit. Cooperative societies Act 1904 provided the formation of cooperative credit societies and cooperative banks. These institutions function as the source of credit at village level to meet the short, medium and long term credit needs of farmers.

(a) **Primary Agricultural Credit Societies (P.A.C.S)** They function at the village level. They provide loan to cultivators directly. Short term crop loan are given to farmers. The recovery of loan will be usually in one installment at the end of crop season. Besides these societies can purchase commonly farm implements, sprayers, dusters, etc. which an individual small farmer cannot afford to purchase. These equipments are given to farmers on nominal rent for a day or two. These societies also run the stores to supply fertilizers, insecticides, besides supplying important items of domestic needs and cloth store. The service-oriented activities are intended to make necessary items available in the villages at reasonable rate. It inculcates the habit of mutual cooperation and involvement of many members in cooperativemovement.

(b) Central Cooperative Banks

These banks are the sanctioning bodies of short-term and medium-term loans. The applications received from primary societies are sanctioned and amounts are released to the societies. These cooperative banks are in turn financed by the State cooperative bank, which is the Apex Bank at the state level.

4,3.1.3 Commercial Banks

Consequent to the nationalization of banks in the year 1969, the credit operation of commercial banks was brought under the control of Reserve Bank of India As a result, a number of branch offices of these banks were opened in rural areas to meet the credit needs of farmers. Some banks have set up branches exclusively for agricultural development activities.

These Commercial banks advance money to

(l) Cultivators directly

(2) Fertilizer firms

(3)Pesticide firms

(4) Agro-based processing units

(5) Cooperative and

(6)Farmers Services Societies

Short term, medium term and long term loans are granted against the security of land or property.

4.3.1.4Village Money Lenders

Till early years of 20th century agriculturists were only dependent on private money lenders for their capital requirements in agriculture. The transaction with money lenders is simple and instantaneous. The quantity of loan and the rate or interest depend on the relation between the lender and the borrower and also on the trust of the creditor on the repaying capacity of the borrower. The village money lender is easily accessible to the farmer. He does not require a number of forms to be filled in as in the case of banks. He believes on the personal security of the property, owned by the farmer. He is ready to lend money without asking whether the loan amount is used for productive purpose or otherwise. He will also extend money even though the previous loan is not repaid completely. It all depends on the mutual understanding between the credit and the borrower. In spite of the simplicity in the process, there are some disadvantage with money lenders; The rate of interest is very high The profits from farming are hardly sufficient to pay the interest. In case of failure of crops, it is impossible to pay either principal or interest. In due course the farmer is compelled to sell out a portion of his land or property to repay the debt. Generally the cultivators are illiterate. They can be easily deceived by the money lenders. They do not know for how much amount they are executing bond. They do not keep record of amounts repaid. As such they fall a victim to the various tactics of the village money lenders.

Other Higher Financing Agencies to Agriculture

4.4 NABARD

NATIONAL BANK FOR AGRICULTURAL AND RURAL DEVELOPMENT

Agricultural Refinance and Development Corporation (ARDC) has not made an expected dent in the field of direct financing and delivery of rural credit against the massive credit demand for rural development. As a result many committees and commissions were constituted.

Banking commissions like,

* National Commission on Agriculture (NCA) in 1976

* Committee to Review Arrangements for Institutional Credit in Agricultural and Rural

Development (CRAFICARD) in 1979. This CRAFICARD, under the chairmanship of Sri. B. Sivaraman, a former member of planning commission recommended the setting up of a national level institution called NABARD for providing all types of production and investment credit for agriculture and rural development. As a result of CRAFICARD's recommendations NABARD came into existence on July 12th, 1982. The then existing national level institutions such as Agricultural Refinance and Development Corporation (ARDC), Agricultural Credit Department (ACD) and Rural Planning and Credit Cell (RPCC) of RBI were merged with NABARD with a share capital of Rs. 500 crore equally contributed by Government of India and RBI. NABARD operates through its head office at Mumbai and 17 regional offices-one each in major states, 10 sub-offices in smaller states / U.Ts and 213 district offices.

Board of Management

Central Government in consultation with RBI appoints all the directors in the "Board of Management along with the chairman and the managing director (MD). The MD.is the chief executive officer (CEO) of NABARD and he is primarily responsible for the various operations of bank. Apart from MD and chairman, the Board of Management consists of 13 other directors and these directors will act as "Advisory council" of NBARD. Out of the 13 directors of "Advisory council"

-2 Are experts in rural economics and rural development.

-3 Are representative of co-operatives.

-3 Are representative of commercial banks.

-3 Are officials of Government of India.

-2 Officials belong to State Governments.

Sources of Funds

Authorized share capital of NABARD is Rs. 500 crore equally contributed by Government of India and RBI issued and paid up capital of Rs. 100 crore. Other sources are:

Borrowings from Government of India (GoI) and any institution approved by GOI.
Borrowings from RBI.
Deposits from State government and local authorities
Gifts and grants received.

Objectives

- As an apex refinancing institution, NABARD surveys and estimates all types of credit needed for the farm sector and rural development
- Taking responsibility of promoting and integrating rural development activities through refinance.
- With the approval of Government of India, NABARD also provides direct credit to any institution or organization or an individual.
- Maintaining close links with RBI for guidance and assistance in financial matters.
- Acting as an effective catalytic agent for rural development i.e., in formulating appropriate rural development plans and policies.

Functions

The functions of NABARD are broadly categorized as:

(a) Credit activities

(b) Development activities, and

(c) Regulatory activities

(a) Credit activities

- NABARD prepares for each distinct a potential linked credit plan annually and this forms the basis for district credit plan.
- It frames the terms and conditions to be followed by credit institutions in financing rural farm and non farm sectors.
- It participates in finalization of annual action plan at block, district and state level
- It monitors the implementation of credit plans.
- It frames policies for farm sector.
- It provides refinance facilities.

Refinance is of two types: 1.Short-term refinance is extended for agricultural production operations and marketing of crops by farmers and farmers cooperatives and production and marketing activities of village and cottage industries. The eligible institutions for Short term refinance are state cooperative banks (SCBs), regional rural banks, commercial banks and other banks approved by RBI. The time period is 12 months.

2. Medium term and long term refinance is extended for investments in agriculture and allied activities such as minor irrigation, farm mechanization, dairy, horticulture and for investment activities of rural artisans, small scale industries (SSI) etc. The period is up to a maximum of 15 years. The eligible institutions are land development banks (LDBs). The extent of refinance under various schemes is

Pilot rainfed farming projects (100%

Wasteland development scheme of individuals (100%).

Non - farm sector scheme (outside the purview of IRDP) 100%.

Ago-processing units (75%).

Bio-gas scheme (75%).

All other schemes including IRDP (70%).

Farm mechanization (50%)

Rural Electrification Corporation (50%).

Apart from refinance, NABARD also provides direct finance to state governments and state sponsored corporations.

NABARD will monitor its assisted projects in order to ensure their proper implementation. It also undertakes consultancy work for projects even though they are not refinanced by NABARD.

(b) Development Activities

For the productive use of credit, the following developmental activities are under taken by NABARD.

Institutional development: Providing financial assistance for establishment and development of institutional financial agencies.

Research and Development Fund: Providing funds for research and development efforts of institutional financial agencies.

Agricultural and Rural Enterprises Incubation Fund (AREIF): For providing assistance while inception of new enterprises.

Rural Promotion Corpus Fund (RPCF): It is meant to provide financial assistance for training cum production centers, rural entrepreneurship development programmes, and technical monitoring and evaluation centers.

Credit and Financial Services Fund (CFSF): It aims at providing the assistance for innovations in rural banking and credit system, supports institution for research activities, surveys, meets etc.

Linking SHGs to credit institutions: During the year 1992, NABARD started the pilot project of linking SHGs to credit institutions. Under this, it provides 100 percent refinance to banks for loans extended to SHGs.

(c) Regulatory Activities

As an apex development bank, NABARD shares with RBI, some of the regulatory and supervisory functions in respect of cooperative banks and regional rural banks (RRBS). They are:

Under Banking Regulation act 1949, NABARD undertakes the inspection of RRBs and cooperative banks (other than PACs).

Any RRB or cooperative bank seeking permission of RBI, for opening branches needs recommendation of NABARD.

The state and district central cooperative banks also need an authorization from NABARD for extending assistance to units outside the cooperative sector and non credit cooperatives for certain purposes beyond the cut-off limit.

4.5 Regional Rural Banks

All India Rural Credit Review Committee (AIRCRC) under chairmanship of Sri. B. Venkatappaiah during the year 1969 was of the opinion that over large parts of the country the marginal and small farmers were deprived of having access to the cooperative credit both for production and investment purposes. This stressed the establishment of institutional financial agencies under public sector. Consequently the first spell of nationalization of banks was done in 1968 with greater expectations, but the situation had not changed as per the expectations.

Hence, the Government of India appointed a working committee under the chairmanship of Sri. M. Narasimham to study the financial assistance rendered to the weaker sections in the rural areas. This working committee recommended the setting up of rural based institutional agencies called "Regional Rural Banks" after identifying short coming in the functioning of commercial banks and cooperatives.

The Government of India accepted the recommendations of Sri. Narsimham committee and regional rural banks came in to existence through regional rural banks ordinance on 26th September, 1975. Initially only 5 RRBs were set up on pilot bases with sponsorship of commercial banks on October 2nd, 1975.This ordinance of 1975 was replaced by the Regional Rural Banks Act, 1976.

The main features of the RRBs are:
State sponsored
Regionally based
Rural oriented
Commercial type their main objective is developing rural economy by providing loans for the purpose of development of agriculture, trade, commerce, industry and other productive activities in rural areas. They are particularly helpful to small and marginal farmers, agricultural labourers, village artisans and other small entrepreneurs. Each RRB has jurisdiction of l to 5 districts with a network of branch offices. Each branch is expected to serve one to three blocks.

Each RRB is sponsored by a Scheduled Commercial Bank, in consultation with state and central governments. The sponsored bank will provide the required share capital, staff assistance and financial assistance to the RRB will be sponsored by the central government, sponsored bank and state government in the ratio of 50: 35:15. A nine member board of directors will be constituted by the central Government for running Grammena bank smoothly.
The list of five RRBs opened in the country is presented below.

S. No. Sponsoring Bank Name of RRB Head Quarters

1. Syndicate Bank Pratham Bank, Moradabad (UP).

2. State Bank of India (SBI), Gorakhpur (UP).

3. United Bank of India Gaur Grameena Bank, Malda (WB).

4. Punjab National Bank Haryana Kshetn'ya Bhiwaniddaxyana) Grameena Bank.

5 .United Commercial Bank, Jaipur Nagalur Anchalik Grameena Bank, Jaipur, Rajasthan.

The Objectives of RRBs are

To develop rural economy.

To provide credit for agriculture and allied activities.

To encourage small scale industries, artisans in the villages.

To reduce the dependence of weaker sections (Marginal farmers, small farmers and rural artisans) on private money lenders.

To fill the gap created by the moratorium on borrowings from private money lenders.

To make backward and tribal areas economically better by opening new bank branches.

To help the financially poor people in their consumption needs.

The main functions of RRBs are:
(l) Mobilise deposits
(2) Grant production loans and term loans to small and marginal farmers.
(3) Grant loans to village artisans, small entrepreneurs andto persons engaged in any productive activity.
(4) Give financial assistance to cooperative societies and farmers service societies in their area of operation.

Functioning of RRBs

Each RRB is being sponsored by a scheduled commercial bank. The operational area of each RRB is one or two districts. Each branch of RRB can serve a population of roughly 20,000 people.

Authorized share capital of each RRB is Rs. one crore, contributed by central government, state government and sponsoring commercial bank in the ratio of 50 : 15 : 35. Issued Capital for each RRB is Rs. 25 lakhs.

The rate of interest charged by RRB on the loans is same as that of Primary Agricultural Credit Societies (PACS), but they are allowed to offer 0.5 per cent interest more than that of commercial banks on its deposits.

RRBs have simplified procedural formalities in giving agricultural finance on recommendations of Sri. Baldev Singh's working group. RRBs use local languages in their transactions. The cost of operation i.e., user charges are low as compared to that of commercial banks.

Regional Rural Banks in AP

1. Andhra Bank

- ChaitanyaGrameena Bank
- Godavari Grameena Bank .

2. Indian Bank.

- Saptagiri Grameena Bank
- Kanakadurga Grameena Bank
- Shri Venkateswara Grameena Bank

3. State Bank of Hyderabad.

- Deccan Grameena Bank
- Golconda Grameena Bank
- Sri Ram Grameena Bank
- Sri Satavahana Grameena Bank

4. State Bank of India.

- Andhra Pradesh GrameenaVikas Bank (APGVB)
- Kakatiya Grameena Bank

- Manjeera GrameenaBank .
- Nagarjuna Grameena Bank
- Sangameswara Grameena Bank
- Sri Visakha Grameena Bank

5. Syndicate Bank

- Andhra Pragathi Grameena Bank
- Pinakini Grameena Bank
- Rayalseema Grameena Bank
- Sree Anantha Grameena Bank

4.6 Kisan Credit Card (KCC)

The Government of India introduced Kisan Credit Card scheme by banks during 1998-99. The scheme was designed by NABARD. KCC aims at adequate and timely support from the banking system to the farmers for their short-term production credit needs in cultivation of crops, purchase of inputs etc in a flexible and cost effective manner.

Under this scheme, the farmers would be issued a credit card-cum pass book incorporating the name, address, particulars of land holding, borrowing limit, validity period etc and it will serve both as an identity card as well as facilitates the financial transactions.

Credit limit on the card may be fixed on the basis of operational holding, cropping pattern and scale of finance as recommended by the District Level Technical committee (DLTC) / State Level Technical Committee (SLTC).

4.7 Crop Insurance

The Crop insurance scheme was introduced in 1985. Crop insurance is an important means of protecting farmers against elements of risk and uncertainty in crop production and stabilizing farm income. Crop insurance provides benefits to the farmers, such as security against of failure of crops, credit worthiness and confidence to take risks.

Crop insurance against risk involves the substitution of a small known cost for the possibility of a large but uncertain loss. The insurance companies are able to accept risk of loss from natural hazards on individual farms, because they are able to spread this risk over a large number of farms. They are able to predict what percentage of farms in the aggregate will suffer damages as a result of weather and other conditions beyond farmer's control. As a result of spreading risk over a large number of farms, insurance companies are able to absorb the risk of loss on individual farms.

Benefits of Crop Insurance to the Farmers

1. There is a big protection to farmers against the failure of crops and stabilize their incomes.

2. Crop insurance improves their credit worthiness for securing loans from Credit agency.

3. Farmers and trade centers improve their income stability as a result of the stabilization of farm income.

4. It reduces the Government's obligation against disaster to provide itself in case of crop failures.

5. Crop insurance provides greater confidence to farmers to venture upon the adoption of modem technology involving large expenditure on modern inputs and greater risk due to natural hazards.

In India, there are limited numbers of trained persons who prepare forecasts for different aspects of crop production on the basis of economic and statistical data. At the farm management level, the farmer cannot make decision on the basis of projections. The national agricultural outlook can give limited local application. The farmer should make his predictions and stay with it after consulting the local extension worker and farm economist. The Government price support programme playing a part in determining agricultural prices and the farm income supplemented through payments of subsidies, the opportunities for the Indian farmer to prepare this outlook programme are enlarged**.**

Hurdles to Implementation

Certain problems arise in carrying out the crop insurance scheme to the desired extent.

(a) It is administratively difficult to inspect crops and determine the extent of loss.

(b) It is expensive to determine the rate of premium for individual farmers.

(c) Chances of corruption among the lower strata of the revenue and insurance agents cannot be ruled out.

SUMMARY

- Credit is the temporary transfer of assets or wealth from one who has it to the other who has not.
- Farm credit is classified as short term, medium term and long term depending on the time for which the amount is enjoyed by the borrower.
- The sources of credit can be divided as institutional and non-institutional.
- Money lenders are non-institutional credit agency.
- Institutional credit agencies are 1) Government 2) Cooperative 3) Grameena Bank and 4) Commercial Banks.

Short Answer Type Questions

1. Define credit.

2. Why do farmers need credit?

3. How do you classify farm credit based on the duration?

4. What is the purpose of short-term loan?

5. Name sources of credit to farmers. How are they classified?

6. What are the advantages and disadvantages of taking loan from village money lenders?

7. How does Government help farmers in providing Credit?

8. Explain the role of commercial banks as a source of farm credit.

9. What is crop insurance?

10. What are Taccavi loans?

11. What are the apex banks?

12. Abbrevate the Word NABARD. Names its Functions

13. Write about Kisan Credit Card (KCC)

Long Answer Questions

1. Explain the role of cooperative institutions in providing credit to farmers?

2. Describe the objectives, structure and role/functions of Regional Rural Banks (Grameena Banks)?

3. Explain the functions of NABARD and its role in agricultural and rural finance
4. Write about NABARD

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UNIT 5

Agricultural Cooperation

STRUCTURE

5.1 Meaning and Definition of cooperation

In one sense, cooperation is probably as old as civilization. Early people had to learn to work together to meet their common needs or perish. Cooperation means working together. It implies an association of individuals for attaining a common economic objective. This is voluntary effort by the members. Cooperation is defined as SELF HELP made effective by organization.

According to Calvert, "Co-operation is a specialized form of economic organization in which people voluntarily associate together on the basis of equality for the promotion of their common economic interests". Each for all and all for each is the motive of cooperation.

5.2 Aims of Cooperation

1. Mutual help and co-existence.

2. Protection of weak persons.

3. Ensuring equal distribution of income and justice in proportion to their share.

4. Eliminating the middle men

5. Ultimately leading to moral advancement for the society

5.3 Principles of Cooperation

The following are the important principles of cooperation.

i) Association of Individuals/ Open Membership /Universality

The membership of a Co-operative Society is open to all those who have a common interest, those who are convinced of its benefits and those who are prepared to share the benefits and responsibilities involved in such a membership. A minimum of ten members are required to form a cooperative society. The Co–operative Societies Act does not specify the maximum number of members for any co-operative society. However, after the formation of the society, the member may specify the maximum number of members. Members join the cooperative organisation when it is not possible to take up the work individually. One man-one vote is the principle.

ii) Principle of Unity or Political and Religious Neutrality

Unity is the fundamental force behind all co-operative organizations. It is above all beliefs, faiths and convicts.

iii)Principle of Voluntary Association

Members join the co-operative society voluntarily, that is, by choice. A member can join the society as and when he likes, continue for as long as he likes, and leave the society at any time.

iv) Principle of Equality

Equal opportunities are given for all the members for their economic development. The membership is open to all irrespective of any consideration.

v) Principle of Equal Justice

The benefits of the organisation will be distributed among all the members in proportion to their effort on the society for its advancement. There is a binding force of common interest and living together.

vi) Principle of Democracy

The organisation is managed by the board of directors elected from out of the general body.

vii) Principle of Thrift

Encouraging small savings inculcating the habit of thrift which leads to the economic development.

viii) Principle of Neutrality

The fundamental aspect of cooperative organisation is its non-alignment to any political body and observes neutrality.

ix) Principle of Honorary Service

Individuals associated in the cooperative organisations should be prepared to work for the interests of the society on honorary basis.

5.4 Cooperative Societies Act-Features

The first Indian Cooperative societies act was passed in 1904. The act was intended to encourage cooperative credit societies with an objective of providing credit for the small agriculturists.

Important Features

1. The societies functioning hither to were recognised.

2. Only credit societies were recognized.
3. No dividends were allowed on the share capital but the entire profits are to be carried over to the reserve fund.
4. 4/5th of the members should be from agriculturists, and

5. Unlimited liability is the principle

5.5 Credit Structure of Cooperative Societies

The cooperative credit structure in India consists of two parts, one engaged in short and medium-term credit and the other in long-term credit. The former, in each state, is a three-tier structure. The primary agricultural credit societies at the village form the base. They federate into Central banks, usually at the district level, which in turn federate into an apex bank serving an entire state.

Apex Bank

Central Cooperative Bank

Primary Cooperative Societies

Primary Agricultural Credit Societies Primary Agricultural Non-Credit societies

The apex or state cooperative bank in each state is closely linked with the Reserve Bank of India which provides considerable financial assistance to cooperative credit structure.

The cooperative banking system is integrated one and because of its three-tier structure, has been enabled to extend credit to agriculturists, artisans and small men in general. The structure of cooperative credit organization can be well understood by the above figure.

5.5.1 Primary Agricultural Credit Societies (PACS)

Primary cooperative societies exist at operational level to extend credit to the farmers. The fundamental functions of PACS are to provide short and medium term credit to its members. It may supply agricultural and other production inputs and undertake marketing of agricultural produce. Besides, the cooperative may help in formulating and implementing a plan for agricultural production for the village and undertake such educative, advisory and welfare functions as the members might be willing to take up.

Functions

1 .To associate itself with programme of production.
2. To lend adequate amount to members for consumption purpose limited to their paying capacity.
3. To attract local savings for share capital and fixed deposits.
4. To borrow adequate funds from the central financial agencies for helping the members adequately for the above purpose.
5. To distribute fertilizer, seeds, insecticides, agricultural implements, etc., either on its own behalf, or agent.
6. To supervise use of loans and to see that they are paid punctually and regularly.
7. To supply certain consumer goods which are in common demand such as kerosene, sugar, etc.
8. To store the produce of the members till it is sold.
9. To collect or purchase produce, where necessary, on behalf of a consumer's society, marketing society or government and
10. To associate itself with programmes of economic and social welfare for the village as a whole.

5.6 Non-Credit Cooperative Organizations

A part from providing credit to the farmers, cooperative Societies will also take up different activities which will help the rural population to get the economic, social and cultural advancement.

Non Credit Organisations are

1. Producer's Societies

2. Weavers Societies

3. Consumer's Societies

4. Cooperative farming Societies.

5.7 Multi Purpose Cooperative Society

The main objective of multi-purpose cooperative societies is to help the individual small farmers to achieve the benefits of rich farmers by uniting.

A limited area/one village is taken as a unit. Low share capital. Unlimited liabilities, honorary management are the main features.

Functions
1. Providing short-term and medium-term loans.

2. Purchasing and hiring of machinery like tractors, implements, power Sprayers etc.

3 Arranging for the supply of seeds, fertilizers, pesticides etc.

4. Making arrangements for storing of produce by construction of godowns etc.

5. Marketing of produce at profitable rates.

6. Cooperative farming wherever possible.

7. Running consumer cooperatives to supply cloth and groceries at reasonable rates.

5.8 Farmer's Service Cooperative Society (FSCS)

The National Commission on agriculture during 1973 -74 had recommended the setting up farmers service cooperative societies (FSCS) with a view to provide the rural public a package of services such as supply of inputs, marketing, storage facilities and to run the custom service units and rendering other types of assistance at a single contact point. They provide all short-term, medium-term and long-term goals

SUMMARY

- Cooperative is a association of individuals for attaining a common economic objective.
- Each for all – All for each is the motive of cooperation.
- There are certain principles of cooperation such as equality, justice democracy, thrift, neutrality etc.
- Cooperative Societies act was passed on 1904.
- Primary Cooperative Societies – Multipurpose Cooperative Society – Non credit Cooperative Societies, Farming Societies are different forms of cooperatives.
- The functions of cooperative societies are
  1) Storage-Marketing
  2) Seed processing
  3) Hiring of agricultural Machinery
  4) Social Service Activities

Short Answer Type Questions

1 Define Cooperation

2. What is the motive of Cooperation?

3. What are the salient features of Cooperative Societies Act 1904?

4. What is a multipurpose Cooperative Society? What are its functions?

5. Explain the functions of farmers service cooperative societies.

6. Write any four functions of primary agricultural credit societies.

7. What are the aims of cooperation?

Long Answer Type Questions

1. Explain the principles of cooperation.

2. What are PACS/PRIMARY AGRICULTURAL SOCIETIES? Write their Functions.

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Unit 6

Agricultural Extension

STRUCTURE

6.1 Meaning of Extension Education

The word 'Extension' is derived from the Latin roots, 'tensio' meaning 'stretching' and'ex' meaning 'out'. Thus the term 'Extension Education' means that type of education which is 'stretched out' into the villages and fields beyond the limits of the schools and colleges to which the formal type of education is normally confined.

Extension education is an applied behavioral science, the knowledge which is applied to bring about desirable changes in the human behavior through various methods and by applying the latest scientific and technologicalinnovations.

Definition of Agricultural Extension

Agricultural extension may be defined as a special branch of Extension Education which deals with the economic and social aspects of people engaged in or associatedwith agriculture.

6.2 Objectives of Agricultural Extension Education

The following are the objectives of agricultural extension education

1. The dissemination of useful and practical information relating to agriculture
2. The practical application of useful knowledge to farm and home.
3. Ultimately improve all aspects of life of the rural people, within the framework of the national, economic and social policies involving the population as a whole.

The main aim of extension worker is to bring about a change in the behavior of the people with the help of skillful manipulation of elements of the learning situation.All the teaching should be carried out according to the needs and resources of the local community or group

6.3 Differences between Formal Education an Extension Education

Extension Education is different from formal education in many aspects.

Formal Education	Extension Education
1. The Teacher starts with theory and works up to practicals.	1. The Teacher (Extension worker) starts with practical theory and may take up theory later on.
2. Student study subjects.	2. Farmers study subjects.
3. Fixed curriculum is followed.	3. Fixed curriculum is not followed.
4. Class attendance is compulsory.	4. Participation is voluntary.
5. The teacher has more or less homogeneous audience.	5. The teacher has large and heterogeneous audience
6. It is more theoretical.	6. It is more practical.

6.4 Extension Teaching Methods

A method is a procedure or process for attaining an objective. The choice of a channel or method of communication, also known as extension teaching method, generally depends on the number and location of the target audience; and the time available for communication. They are categorized as individual method, group method and mass method. Each of the methods has both advantages and limitations. The extension agent has to choose a particular method or combination of methods according to the needs of the situation.

1. Individual Method

In this method, the extension agent communicates with the people individually, maintaining separate identity of each person. This methodis followed close to the communicator, and sufficient time is available for communication. Example: farm and home visit, farmer's call etc.

2. Group Method

A group may be defined as an aggregate of small number of people in reciprocal communication and interaction around some common interest. In this method, the extension agent communicates with the people in groups and not as individual persons. This method is adopted when it is necessary to communicate with a number of people simultaneously; who are located not far off from the communicator and reasonably good time is available for communication. Here group participation and formation of group opinion are important.

3. Mass Method

In this method, the extension agent communicates with a vast and heterogeneous mass of people, without taking into consideration their individual or group identity. The normal group boundary gets obliterated.

This method is followed where a large and widely dispersed audience is to be communicated within a short time. There may be a few communicators such as the extension agent and some subject matters specialists. The size of the audience may be a few hundreds in mass meeting, few thousands in campaign and exhibition and millions in news paper, radio and television.

Classification of Extension Teaching Methods

The communication methods adopted in extension may be classified as follows:

I. Individual Method	II. Group Methods	III. Mass Methods
1. Farm and home visit 2. Farmer's call 3. Personal letter 4. Adaptive or minikit trial 5. Farm Clinic	1. Result demonstration 2. Method demonstration 3. Group meeting 4. Small group training 5. Field day or farmers day 6. Study tour	1. Farm publication 2. Mass Meeting 3. Exhibition 4. Newspaper 5. Radio 6. Television

I. Individual Methods

1. Farm and Home Visit

Farm and Home visit is a direct, face-to-face contact by the extension agent with the farmer or homemaker at their farm or home for extension word.

2. Farmer's Call

Farmer's call is a call made by a farmer or homemaker at the working place of the extension agent for obtaining information and assistance.

3. Personal Letter

Personal Letter is written by the extension agent to particular farmer or homemaker in connection with extension work. This should not be regarded as a substitute for personal contact.

4. Adaptive or Minikit Trial

Adaptive or Minikit Trial is a method of determining the suitability or otherwise of a new practice in farmer's situation. This may be regarded as an on-farm participatory technology development process in which farmer's choice and farmer's opinion about the practice are most important. This is the first stage a new and improved practice passes through, before it is taken up for result or method demonstration, or recommended for large-scale adoption. Mini kits are, however, distributed in some States for assisting the poor farmers or in times of distress, to maintain farm productivity.

5. Farm Clinic

Farm clinic is a facility developed and extended to the farmers for diagnosis and treatment of farm problems and to provide some specialist advice to individual farmers. The extension agency may set up farm clinics in the village and/or in the organization's headquarters and sub-centers, where the relevant subject matter specialists, in collaboration with the extension agents, discuss, diagnose and prescribe treatment to farmers problems, meeting those present individually, on fixed place, day and time. The specialists may visit the local area, if needed for an on-the-spot diagnosis and guidance or follow-up. This method is suitable for treatment and preventionof health problems relating to plants, animals and soils.

II Group Methods

1. Result Demonstration

Result Demonstration is a method of motivating the people for adoption of a new practice by showing its distinctly superior result. The demonstrations are conducted in the farm or home or selected individuals and are utilized to educate and motivate groups of people in their neighborhood. This is a very effective method for the transfer of technology in a community.

Demonstrations may stimulate farmers to try out innovations themselves, or may even replace a test of the innovation by the farmer. They can show the causes of problems and their possible solutions without complicated technical details. A great advantage of demonstration is seeing how an innovation works in practice.

Conducting demonstrations with own hands shall encourage the farmers to act on a scientific basis, rather than something which is magical. Demonstrations, to be effective, should be integrated with the total extension programme.

2. Method Demonstration

A Method Demonstration is given before a group of people to Show how to carry out an entirely new practice or an old practice in a better way. It is essentially a skill training, where the emphasis is one effectively carrying out a job, which shall improve upon the result. It involves seeing, hearing, participating and practicing in a group which shall stimulate interest and action. Method demonstration is sometimes used as complementary to result demonstration.

3. Group Meeting

Group Meeting is a method of democratically arriving at certain decisions by a group of people, by taking into consideration the member's points of view. Group meetings and discussions aim at collective decision making and at improving individual decision making by using the knowledge and experience of colleagues. The group process enhance people's and facilities programme implementation. It also develops capability of the people for disaster management.

4. Small Group Training

Small Group Training is a technique of imparting specific skills to a group of people who need them by creating an appropriate learning situation. This is an effective method for transfer of technology.

5. Field Day or Farmers' Day

Field Day or Farmers' Day is a method of motivating the people to adopt a new practice showing what has actually been achieved by applying the practice under field conditions. A field day or farmers' day may be held in a research farm or in a farmer's field or home. If the number of participants is large, they should be divided into small groups of about 20 to 25 persons each, who shall visit the spots in rotation.

6. Study Tour

In Study Tour, a group of interested persons and guided by one or more extension agents moves out of their neighborhoods or study and learn significant improvements in farm and home elsewhere. The main purpose is to motivate the visitors by showing what others have been able to achieve. The programme may include visit to farmer's place as well as research stations, and may be held within the district, outside the district or even outside the State. Study tours may be synchronized with programmes of national importance like National Fair, World Fair etc. Visit so some places of interest may be included in the programme. A group of 30 to 50 persons may be convenient for study tour; However, a maximum number of 80 to 100 persons may be accommodated in one batch.

III. Mass Methods

1. Farm Publication

Farm Publication is a class of publication prepared by the extension agency 111 printed form, containing information relating to the improvement of farm and home. Farm publicatios are of a various types such as leaflet, folder, bulletin, newsletters, journal and magazine. Farm publications may be used singly or in combination with other extension methods.

2. Mass Meeting

Mass Meeting is held to communicate interesting and useful informations to a large audience at a time. The size of the audience for mass meeting may be a few hundreds, but at the time of fairs or festivals it may be few thousands. The majority of the audience have a purpose in attending the meeting, though some outsiders may attend it out of curiosity. Mass meeting may be held in a covered or in an open place. Public address system is essential for conducting mass meeting. Slide or film show may enhance effectiveness of the meeting.

3. Exhibition

An exhibition is a systematic display of models, specimens, charts, photographs, pictures, posters, information etc. in a sequence around a theme to create awareness and interest in the community. This is method is suitable for reaching all types of people. Exhibitions may be held at the village, block subdivision, district,state, national and international levels. Though an exhibition is organized around a major theme, other related themes and some unrelated items like entertainment may also be included. Farmers' fairs and Kisanmelas held by the agricultural universities, institutes and various other organizations in which field visit, training programmesetc are combined with exhibition are effective and taking advantage of popular.Exhibitions may also be organized by taking advantage of local fairs and festivals. In fixing dates for exhibition, the weather condition and the schedule of farm operations may be kept in view.

4. Newspaper

Newspaper is a bunch of loose printed properly folded, which contains, news, views, advertisements etcand is offered for sale at regular intervals, particularly daily or weekly. Newspapers are usually printed on a special type paper, known as newsprint. There are been considerable progress in printing technology and with modern methods it has been possible to achieve high seed and excellence in printing.

Daily newspapers are resource-strong and are published from national/state capitals or big cities. Their approach is cosmopolite and the circulation may range from about lakh to several lakhs, some of the daily newspapers are quite big and are published simultaneously from a number of cities

5. Radio

Radio is an electric audio-medium for broadcasting programmes to the audience. This medium is cosmopolite in approach and is suitable for communication to millions of people widely dispersed and situated in remote areas. Availability of low cost transistor sets has helped radio to penetrate deep into the rural life.
Radio is suitable for creating general awareness amongst the people, help change their attitude and reinforce learning. The medium is extremely convenient for communication in times of crises and urgent situations. People with no education or very little education and those who are not in a position to attend extension programmes personally, can take advantage of this medium and build up adequate knowledge and skill. It listened to while one is engaged 1n farming or household work.

6. Television

Television is an electronic audio-visual medium, which provides pictures with synchronized sound. This medium is cosmopolite in approach and can be used to create instant mass awareness. Television combines the immediacy of radio with the mobility of cinema and can carry messages over long distance at a relatively low unit cost. Television is a multi-media equipment as it can include motion picture, recording, slide, photograph, drawing, poster etc. Television can show taped as well as live programmes. Both recording and playback equipments are transportable, allowing flexibility of use. Television can be viewed in an ordinary room.

6.5 Audio-Visual aids

Audio-Visual aids are instructional devices which are used to communicate message more effectively through sound and visuals. The aids help in stimulating the sensory organs like ears and eyes and facilities quick comprehension of the audience. These may be used for literate as well as for illiterate people. The use of audio-visual aids has the following advantages.

1. Capture audience attention and arouse their interest.
2. Highlight main points of the message clearly.
3. The possibility of misinterpreting concepts is reduced.
4. Structure the learning process more effectively.
5. Messages perceived with several senses are understood and retained better.
6. Provide experience otherwise difficult to get.
7. Help reach more people irrespective of their level of literacy and language.
8. Speed up the process of learning.
9. Can adapt the speed of presentation to the reactions of the audience.
10. Save time of teacher and learner.

The instructional devices through which the message can only be heard are known as AUDIO AIDS. The instructional devices through which the message can only be seen are known as VISUAL AIDS. The instructional device through which the message can be heard and seen simultaneously are known as AUDIO VISUAL AIDS.

Classification of Audio-Visual Aids

The audio-visual aids may be classified into three categories as follows

I. Audio Aids	**II. Visual Aids**	**III. Audio-visual aids**
1. Tape recorder 2. Public address system 3. Telephone	A. Non projected 1. Chalk board 2. Bulletin board 3. Picture and photograph 4. Flannel graph, flash card, flip chart 5. Poster 6. Diagram, map, chart and graph 7. Specimen, model B. Projected 1. Slides 2. Film strip 3. Opaque projection 4. Overhead projection	1. Drama, puppet showing talking doll B. Projected 1. Motion picture (Cinema) 2. Video

I Audio Aids

1. Tape Recorder

A Tape recorder is equipment for recording sound on magnetic tape by electro-magnetic process, which may be played back when needed. The tape may be of celluloid, plastic or high tensile polyester film. These have an ultra thin coating of iron oxide on one side. The tape is magnetized as it passes through a recording head. To play back, the tape is passed again through the magnetic head. The recording and play back processes are accomplished by the same read, Tape recorder is suitable for use in meeting, training programme, campaign, recording radio programme etc.

2. Public Address System

Public Address System is a set of equipment to amplify the sound so that it is audible to a large audience over a distance. It is essential for extension programmes involving a large number or people such as mass meeting, training programmes, field day or farmers' day, campaign, exhibition etc.

The public address system has three components microphone, amplifier and loudspeaker. The microphone is connected to the input terminal of the amplifier and the loudspeaker to the producing terminal. The distance should be maintained to get a good clear sound.

3. Telephone

Telephone is a system of equipments through which people can communicate both ways to distance places. It provides for instant interpersonal communication, in which the communicator and the communicate change their roles while giving and getting information. Through only two persons can communicate at a time through a telephone, the systemservice many people in a given area. By using telephone people can keep contact with the outside world, without physically moving out. This speed of communication and involves considerable saving of time, money and labour.
With the establishment of telephone in each Gram Panchayat office at the Village level, rural telephone has become a reality in India. Subsequently telephones are installed in other villages also. In areas where electricity is not available, telephones are operated by setting up solar panels.

II Visual Aids

A. Non-Projected Visual Aids

1. Chalk Board

Chalk Board is a board for writing with chalk. Chalk Board is probably the simplest, cheapest, most convenient and widely use visual aid. Wooden board, coloured in black is mostly used, hence it is also known as blackboard. However, ground glass, roll-up materials, coloured in black, olive green or blue many be used. Roll-up materials are made of heavy cloth canvas coated with chalk board paint slating. At indoors, chalk board is generally fixed on a heavy flame or wall. It may be useful to have a longer board, one side of which may be

painted square with red lines, to facilitate drawing of graphs, illustrations etc. For field use, inward folding wooden board or roll-up material is convenient. Chalk board is suitable for use in lecture, training, programme, group meeting etc. -Clumsy hand writing of the speaker may confuse the audience.
- Writing is temporary.

2.Bulletin Board

Bulletin Board is a board for display of message. Bulletin board may be made of soft insulation board or perforated masonate board and may or may not be covered with glass. Paper containing the message may be fixed by board-pin on the. Soft insulation board. On commercially available perforated boards, the message is displayed by pressing plastic letters and symbols on the perforations. Fixing, dismantling and re-fixing message is very convenient on both types of board; The message on the bulletin board may be in the form of words, graphs, charts, photographs, publications etc. and may be used in the communication centre arid various types of extension programmes.

3. Picture and Photograph

Picture is a representation made by drawing, painting or photography which gives accurate idea of an object. A good picture may tell a story without using a single word. Pictures may be in black and white or in colour. Colour pictures and blowup photographs have more appeal.

4. Flannel Graph, Flash Card, Flip Chart

Flannel Graph, Flash Card and Flip Chart are visual aids in which the messages are written or drawn on thick paper and presented to the audience to synchronize with the talk. This produces a dramatic effect on the audience.

5. Poster

Poster is placard displayed in a public place with the purpose of creating awareness amongst the people. A poster is generally seen from a distance and the person glancing at it seldom has the time or inclination to stop and read. The job of the poster is to stop hurriedly passing persons, thrust the message upon them quickly and lead them to action immediately or eventually.

6. Diagram, Map, Chart and Graph

Diagram, Map, Chart and Graph are visuals where information is summarized and presented in a more or less abstract form. For example, a Diagram is line drawing of an object or an idea, a Map is an informative diagram of an area, a chart contains information in tabular from and a Graph is an diagrammatic representation of the relationship between variables.

7. Specimen, Model

Specimen is sample which represents the whole and MODEL is miniature replica of an object. Specimen and model are used in method demonstration, group meeting, training programme, exhibition etc. Diorama is generally used in exhibition and communication centres.

B. Projected Visual Aids

1. Slides

Slide is a transparent mounted picture which is projected by focussing light through it. The projected may be made on roll-back screen or on white wall. Slides of 35 mm films mounted on individual cardboard frames are more common and are extremely used in extension programme. Glass slides are generally used in cinema halls.

Because of the availability of electricity in the rural areas, it is possible to use slide projectors fitted electric bulb for extension work. There are two types of slides projectors. One is manually operated and cheap, in which every time the projected slide is taken out and a new slide is inserted in the slot and pushed by hand in position. The other one is automatic slide projector in which a large number of slides are serially inserted in the magazine slots before hand and are changed one by one at the time of projection by a remoted control device. Automatic slide projector is costly, but produces good quality images and is extremely convenient for a slide show.

2. Film Strip

Film Strip is a continuous strip of film consisting of a small number of individual frames or pictures arranged in a sequence. Each strip may contain about 30 to 60 frames of photographs, diagrams, drawings or lettering. The pictures may have explanatory titles. The entire length of the strip has perforations on both sides, which facilities forward or backward movement of the pictures.

Some of the slide projectors have facility for projecting film strip also. Film Strips on some fixed topics may be available from commercial firms or scientific Organizations. These may also be made according to one s own requirement with the help of a good photographic studio. Film strips are generally used in training programme.

3. Opaque Projection

In Opaque Projection a large-a pictured projector is used to project opaque materials. Opaque projector is also known as opeidoscope. Pictures, drawing, diagrams directly from books; magazines etc. or drawn on sheets of paper can be projected. The size of the project able material should be around 25 cm x 25 cm. Materials for projection is inserted into the projector by lowering the platen. This lowering of the platen results in a light flash, which may disturb the audience. To eliminate this problem, series of pictures may be prepared on paper rolls. The projector may have a built-in pointer. Opaque projection may be used in training programmes, group meeting etc. Pictures relevant to the talk should be selected in advance and arranged in proper showing order.

4. Overhead Projection

In Overhead Projection, the picture is projected on the screen. This is accomplished by overhead projector. Drawing, diagram, lettering etc are made on transparent sheets and are put on the glass platform of the overhead projector, through which strong light is passed. .They rays of light are converged by a lens and reflected by a mirror held at an angle, on the creen at the back.The instructional items may be written or drawn by hand on transparent, sheets, transparent cell phone or polythene rolls with a special pen or wax crayon. These may be wiped clean with a dry cloth. Printing on transparencies may be made through photographic, Xerox or electronic process. The transparencies may be in colour or in black and white, and may be repeatedly used.Overhead projection enables the speaker to simultaneously deliver the talk and project the instructional materials, while facing the audience. The speaker can also write, make sketch and erase while projection them. Important psychological techniques like covering a portion of the transparency with a sheet of paper and making progressive disclosure and super imposing diagrams may be achieved in overhead projection at case and in an effective way. A thin object may be placed on the transparency and used as pointer by the speaker. Overhead projection is used in training programme, group meeting, seminar, symposium, workshop etc.

III. Audio Visual Aids

A. Non-Projected Audio-Visual Aids

1.Drama, Puppet Show, Talking Doll

Drama is a theatrical performance around a theme by some people who have rehearsed for it. In puppet Show the dolls are made to perform by controlled movement of the puppeteer from outside. Both the media require adequate preparation and rehearsing. Puppets may be of different types such as glove or hand puppets, string puppets, rod puppets and shadow puppets. Glove or hand puppets are simple to handle. This is like a three-fingered glove which fits on the hand. The first finger is inserted inside the head and the middle finger and thumb fit in the hands. These are moved when the story is told. For drama and puppet show, proper dress and lighting are essential. While puppet show may be held in daylight or at night, drama is generally performed at night. Talking doll is an innovation may be used to create general awareness of a group of people about an extension prograrmne. Its use is, however, restricted to the available of en expert ventriloquist, who can not only project own voice,but is also able to manipulate the movement of the doll is to synchronize with the voice.

Drama, puppet show and talking doll provide dramatic experience to the audience and may be used to communicate messages on broad social themes pertaining to rural life, rather than transfer of technology programmes.

B. Projected Audio-Visual Aids

1. Motion Picture (Cinema)

Motion picture is the projected image of positive print of a sound film taken by a movie camera, which produces synchronized movement of picture with Sound. The film consists of series of still pictures, each of which shows the Objects in slightly different position, which when projected on a screen in rapid succession, produces the Optical illusion of a continuous picture in which the Objects appear to move. The films have optical sound tracks which produce Sound, synchronized with the movement of picture.
Motion picture involves two distinct but interrelated functions production of the film and

projection of the film. Production of the movie film is a costly and highly technical job, which an extension agent is not likely to perform. In brief, production of movie film involves selection of a topic, making script, selecting locations and actors, arranging movie camera and raw film, making arrangements for lighting and sound recording, exposing the raw film shot by shot by expert technicians, processing, editing, printing positive copies, safe storage and distribution of films.

2. Video

The term video is derived from the Latin word 'Video' meaning to see VIDEO is an electronic audio-visual system for preparing video tapes of programmes and events, which could be projected through a receiving get with moving images and synchronized sound

The complementarily of video, motion picture and television and their differences shall help in understanding the special features and potential of video for use in extension.

Film can be transferred to video tape and videotape, to film, television can transmit live, filmed or video and taped material indiscriminately; film can be used to record the output of a television studio. While film and video are systems or recording which result in concrete, tangible worked, television is in essence a channel of transmission to whose principles of operation recording as such is secondary.

In motion picture, the raw film is coated with photo-sensitive material, which, after exposure requires dark-room processing and printing. In video, the tape is coated with magnetically sensitive material, which is magnetized after exposure and do not require such operations. In motion picture, editing of the film is a scissors-and-paste job, whereas in video the editing is done electronically by assembling image sequences from different sources in the desired order on the tape of a second machine.In motion picture, the images area projected on the screen from outside which requires a darkened place for viewing. In video and television, the images are projected from within the receiving set and can be viewed 1n an ordinary room preferably with some lights on.

6.6 Communication process and problems

Communication is the process of transferring an idea, skill or attitude from one person to another accurately and satisfactorily, In other words, it is the sharing if ideas, attitudes or skills between two or more persons. The main purpose of communication is to influence the behavior of people exposed to the communication.

Components of Communication Process

1.The **Communicator** - One who provides initiative to the process of communication.(The giver of the message) e.g., V.D.O.

2.The **Objective** - The purpose of communication e. g., to increase wheat production. (There should be a clear-cut and specific objectives; e.g. wheat growing farmers of village 'x' to know that improved varieties give increased yield)

3. The **Audience** - The receivers of the message the persons who are to change; e.g., wheat-

growing cultivators ‘x’ village.

4. The **Message** -Content of the communication, the specific changes you want to bring about; e.g., improved varieties give higher yields.

5. The **Channel -** The method or means used to get the message to audience; e. g., an informal meeting.

6. The **Treatment** - The way you put your message across, Within a channel, i.e., What the audience actually sees, hears or does; e. g., showing of actual specimens of local and improved wheats, to dramatize the difference between the two.

7**. Feedback** - Knowing the reaction of the audience to the message, e.g., farmers who attended the meeting were convinced about the superiority of the improved wheat over local variety.

8**. Evaluation** Measuring the effectiveness of the message, i.e., to what extent the objectives has been achieved, e. g., 50% of the farmers in village ‘x’ have adopted the cultivation of improved wheat in the first year.

Needless to say, a good extension worked should be a good communicator. To be a good communicator, one should thoroughly understand the nature of the above mentioned elements of the communication process and manipulate them effectively to achieve his objectives.

Problems of Communication

The problems of communication system from any of the elements enumerated above. They are as follows:

1. Uneffective environment.

2. Standards of communication.

3. Individual motivation.

4. Improper handling of message

5. Wrong selection and combination of channels.

6. Ineffective listening.

7. Perception.

8. Clarity of message.

9. Emotional blocks.

10. Stereotyped message.

11. Attitudes

12. Distortion

13.Empathy.

14. Problems of orientation.

6.7Mass Communication Media

Printed Media is those communication techniques that rely principally on combinations of printed words and pictures. This is our oldest formal combination. To apply this method effectively the educational levels and literacy rate of the audience must be considered extension programmes can take a broad and creative approach to ways in which to use print method for conveying news to audience.Spoken words are forgotten rapidly. To often refresh the farmers memory there should be some method to remind them from time to time. About 35 % of farm information loss was found in between extension worker and farmers. For effective communication, written methods are useful. Thus, the written methods are used to extension teaching to provide facts in such a manner that their attention is attracted, to make them understand, remember and finally to help them to take favorable decisions. Further the written communication reduces the loss of information during transit and in addition it covers large number of people within the short time

1. Leaflet (Flyer)

Single sheet of paper used to present information on only one topic in a concise manner and simple language.

2.Folder

Folder is a single piece of paper folded ones or twice, when it is opened the material presented are in sequence.

3. Pamphlet

Pamphlet size varies from 2-12 pages. The first cover page should be named in two or three colours with some action pictures. Full information about the selected topic is presented at greater length. When compared to a folder pamphlet services to the needs of farmers at different stages.

4. Bulletin

A bulletin contains large amount of information. Its primary objective is to give information which the reader can apply to his own local situations. Its size varies from 2-20 pages.

5. Booklet

When the materials more and exceeds 20 pages and limited to 50 pages then it is called a booklet.

6. News Story/News Article

News stories appear in the Newspapers. The newspapers vary greatly in their readers and coverage from the huge urban daily newspaper to the small community paper. They are published by government, private, and other organizations and can provide valuable channels for extension news. All the information or stories received by the news offices cannot be accepted and used by newspapers. Whether the news story is going to be appeared or discarded up on the news worthiness of upon information. News is any timely information that interests a number of persons. Anything that makes people to talk about is known as news. If a dog bites a man, it is not news. If a man bites a dog, it is news. The best news is that which has greatest interest for the greater number of people

News story attracts attention because it reports interesting day-to-day events or something new, different or unusual. News story is useful to develop farmer's interest; inform the general public communicate new information, create favourable attitude, and report the other methods like demonstration, meeting etc.

7. Wall Newspapers

Wall news papers are similar in size and appearance to posters. Which have more detailed current information and an illustration. It is similar in size and appearance to a poster, but they are different from poster, usually attempts to communication more than one fact or idea. They have more illustration and written materials.

8.Circular Letter

Circular letter is a letter written by the extension worker sent to many farmers periodically or on special occasion.

9. News Letter

News letter can be an effective, lost cost way to reach readers. The content of or newsletter, can be more localized and specialized than is possible with a general newspaper. Like the wall newspaper, the newsletter is well adapted to using local language and dialects. And a newspaper can include hand-written , type written or type-set copy. Duplication method also can very greatly. **Electronic Media**

1. Radio

It is a medium for mass communication; a tool for giving information and entertainment.

Purposes

1. To reach large numbers of people quickly and inexpensively.

2. To reach people not reached by other means.

3. To stimulate participation in extension through all other media.

4. To build enthusiasm and maintain interest.

Procedure or Technique

1. Determine its place in the teaching plan.
2. Be clear about the purpose of your broadcast.
3. Keep the interests and needs of the audience in view.
4. Select topics of current interest.
5. Time the broadcast synchronies with the farmer's leisure hours.
6. Decide what treatments to give straight talk, interview, panel, drama etc.
7. For writing the script, follow the principles given for writing news articles.
8. Encourage people to listen to rural programmes
9. Encourage them to write to the broadcastings stations about their likes, needs and opinions.
10. Encourage talented local people to participate in broadcasting.

Advantages

1. Can reach people more quickly than any other means of communication.
2. Specially suited to give emergency and timely information(e.g. weather, pest out-break etc)
3. Relatively cheap.
4. Reaches people who are unable to attend extensions meetings.
5. Reaches people who read little or none at all.
6. A means of informating non-form people(tax payers) about agricultural maters.
7. Build interest in other extension media.
8. Possible to do other things while listening.

Limitations

1. Limited number ofbroadcasting stations.
2. Not Within reach of all farmers.
3. Recommendations may not apply to individual needs.
4. No turning back if not understood

5. Frequently loses out in competition with entertainment.

6. Difficult to check on results.

2. Television (T.V.)

Television is one of the important mass media for dissemination information in the rural areas.

Television has unique and. advantages over other mass media, while is provides words with pictures and sound effects like the movies; 1t scores or; the latter by its high intimacy and reaches the largest number of people at the Shortest possible time. The visual in it has the advantage over the media. Televisioncan deal with typical problems, and depict known persons who can provide the solutions. People learn through the eye, and will remember things better if they see them. Television viewing does not demand the strain and discipline needed to read the printed medium. The messages on the TV screen are selected, sorted out and then presented in the simplest manner possible.Demonstrations, “the need” in farm extension, are brought to the farmer by television. This has great value in making converts to better farm practices. Apart from the evidence by their own eyes, farmers also respond readily to what is said, especially by other farmers and if the same point as extension people doubly effective. It is within the power of television or provide the dynamic the farmers home or community

6.8 Method and Result Demonstrations

6.8.1Result Demonstration

A result demonstration is a method of teaching designed to show by example the practical application of an established fact, or group of related facts. In other words, it is a way of showing people the value or worth of an improved practice whose success has already been established on the research station, followed by district or observation plots.

In this method the new practice is compared with the old one on ryots holding so that the villagers may see and huge the result for themselves. Such demonstration requires a substantial period of time and records need to be maintained. It is in no sense an experiment or a trial except perhaps in the method of the cooperator (demonstrator). The result demonstration may be varietal ii) Manorial iii) Cultural iv) Combination of two or more of the aforesaid three types, or v) Composite demonstration in which all the essential improved practices in respect of any crop are included as a package of improved practices.

There are two common same principles underlying this method.

(a) What a farmer himself does or sees, he will believe

(b) What is good for one person will have general application to others . (under similar conditions)

Objective or Purposes

1.Analyse situation and determine need

(Determine the place of the result demonstration in your teaching plan)

(a) Is it necessary to establish further confidence in local application or research findings and results of observation plots?

(b) What has been the experience of the extension worker in guiding the carrying out of the practice under similar conditions?

(c) Is it possible to locate good illustration of the practice locally, obviating the necessary of expensive result demonstrations?

(d) Is the need for result demonstration felt by the farmers?

2. Decided upon specific purpose

(a) Which particular audience should have the learning experience?

(b) What specifically do you want them to learn?

(c) Is it to give confidence to the extension worker and provide him with teaching material?

(d) Is it to establish confidence of farmer in the new practice?

(e) Is it do develop confidence in extension on the part of a community or of a minority group with whom extension worker is not known well and favourably?

3. Plan the result demonstration

(a) Consult subject matter specialist.

(b)Make is simple and clear-cut as possible. (The more complex the demonstration, the greater the difficulty in evaluating the results attribute to each of the practices involved.)

(c) Decide upon evidence needed and how local proof will be establish purpose.

(d) Determine number of demonstrations needed to accomplish purpose.

(f) Reduce plans to writing (calendar of operations etc.)

4.Select demonstration

(a) Consult with local leaders and select a demonstrator who commands the confidence and respect of his neighbours, and who is interested in improving his practices.

(b) Visit the prospective demonstrator to make sure that all conditions for successor demonstration are favourable.

(c) The demonstration should be conscious of the responsibility for the successful completion of the demonstration and its effect up on the community.

(d) The demonstrator should be willing for the demonstration to be used for teaching purposes such as publicity, pictures, meetings, tours and personal enquires.

(e) The demonstrator should be have to secure the necessary physical equipment, supplies and materials to carry the demonstration to a successful conclusion

(f) Explain and agree procedure with demonstrator and leave written instructions preferably.

5. Select the plot

(a) The plot should be located preferably in a roadside field for easy accessibility publicity.

(b) The field should be representative or typical of the soils in the village (neither too rich nor too poor).

6. Start the demonstration

(a) Give wide publicity before starting the demonstration.

(b) Get all the materials ready

(c) Start the demonstration in the presence of the villagers.

(d) Assist in getting the demonstration underway to made ceratin that the omission of some key point will not make later work fruitless.

(e) Arrange for a method demonstration meeting where a skill may be involved in the beginning stage of demonstration or later.

(f) Mark the demonstration plots with large, so that can all can see.

7. Supervise the demonstration

(a) Visit the demonstration plot with sufficient frequency to maintain demonstrators interest, check on progress, and see that succeeding steps are performed as outlined.

(b) Maintain records and assist the demonstrator also 1n keeping proper records.

(c) Give publicity to the demonstration and the farmer at suitable stages.

(d) Conduct tours to successful demonstrations at proper times.

(e) Let the demonstrator himself explain to visitors, as for as possible

(i) Mention in news stories, circular letters, radio talks etc. at critical stages.

8. Complete the demonstration

(a) See the final steps to complete the demonstration are taken.

(b) Take photographs

(c) Hold meetings at demonstration where visual evidences will contribute to confidence.

(d) Summaries records. Analysis and interest data

9. Follow-up

(a) Give wide publicity to results of demonstration.

(b) Encourage demonstrator to report at meetings.

(c) Prepare visual aids based on the result of demonstration.

(d) Get other farmers to agree to demonstrate during the next season.

Advantages

l. Gives the extension worker extra assurance that recommendation is practical and furnishes local proof of
its advantages.
2. Increases confidence of farmers in extension worker and his recommendations.
3. Useful in introducing a new practice.
4. Contributes to discovery of local leaders.
5. Provides teaching material for further use by extension.

Limitations

l. Requires lot of time and preparation on the part of extension worker

2. A costly teaching method

3. Difficult to find good demonstrators who will keep records.

4. Teaching value frequently destroyed byunfavourable weather and other factors.

5. Few people see the demonstration at the stage when it is most convincing.

6. Unsuccessful demonstrations may undermine the prestige of Extension, and entail loss of confidence.

6.8.2 Method Demonstration

It is relatively short-time demonstration given before a group to show how to carry out an entirely new practice or an old practice in a better way. It is not concerned with proving the worth of a practice but how to do something, e. g. pruning grapevine. It is definitely nor an experiment or trial but a teaching effort. In contrast to the result demonstration conducted by the farmer (demonstrator) under the supervision of the extension worker to prove that the recommended practice will word locally, the method demonstration is given by the extension worker himself or a trainer leader for the purpose of teaching a skill to a group.

In the role of a skilled technician the extension worker or leader shows the step-by step procedure in the operation, explaining each succeeding step as he proceeds. The learners watch the process, listen to the oral explanation, and ask questions during or at the close of the demonstration to clear up points about which there is uncertainty. Where practicable as many members of the group as possible repeat the demonstration in the presence of the others. This helps to fix the process in the minds of the audience and increase confidence in their ability to master the technique.

Objectives or Purposes

1. To enable the people to acquire new skills.

2. To enable people to improve upon their old skills.

3. To make the learners to things more efficiently, by getting rid of defective practices.

4. To save time, labour and annoyances and to increase satisfaction of learners.

5. To give confidence to the people that a particular recommended practice is a practicable preposition in
their own situation.

Procedures or steps to be followed

1. Analyse the situation and determine the need

(a) Determine that the subject-matter practice involves skills which need to be demonstrated to many people.

(b) Is the demonstration for new skills developed through research, or for old skills not being performed successfully?

(c) Is it suitable for visual presentation to a group?

(d) Can the demonstration be repeated satisfactorily by local leaders?

(e) Is the practice really important from the farmers View point?

(i) Can people afford to follow the practice?

(g) Are supplies and equipment available 1n sufficient quantities to permit wide-spread use of practice

2. Plan the demonstration in detail

(a) Gather all the information about the practice. Familiarise yourself with the subject matter. Check on research findings.

(b) Talk over the problem with a few village leaders. Let the villages help you plan the demonstration. Let them provide land and other requisites.

(c) Have a time table, depending on how much skill is required and how soon it is to be steps.

(d) Have a j ob break-down or a demonstration outline giving the operation in logical steps.

(e) Identify the key points to emphasised under each step.

(t) List out and select demonstration materials and equipment most likely to be available or readily obtainable.

(g) Arrange for diagrams, directions, and other teaching material to be distributed.

(h) Prepare kits of special material needed by local leaders of they are to repeat the demonstration.

(i) Make sure that the work place is properly arranged (lighting, no odours, no distracting noises)

3. Rehearse the demonstration

(a) Practice demonstration until you are through with all the steps and knows exactly what you should say or do at each step, so that the operation can be performed in a manner to inspires confidence.

(b)Make sure steps and points will be clear from audience's point of view.

(c) Check time required, to make sure there is opportunity for audience questions and other expected participation.

4. Give the demonstration

(a) Prior publicity should have been given about the place and time.

(b)But at the spot early to check up equipment and material.

(c) Make physical arrangements so that all participants can have good look at the demonstration and take part in the discussion.

(d)Explain purpose, and how it is applicable to local problems.

(e) Find out what they already know about the practice.

(f) Show each operation slowly step by step, repeat where necessary

(g) Use simple words to explain each step of the operation.

(e)Make sure audience can sees and hear clearly.

(i) Emphasis key points and tell why they are important

(i) Solicit questions at each step below going on to text step.

(k)Give opportunity to learners to practice the skill.

(l) Distribute supplemental teaching material (bulletins, leaflets etc) pertaining to the demonstration.

(m) Summarise steps covered in demonstration.

(n) Get the names of participants who propose to adopt the practice. This helps follow-up.

(0) If demonstration is given before local leaders who will repeat it; emphasise teaching points to be made. Explain contents of demonstration kit.

5. Follow-up

(a) Give publicity on the demonstration through press, radio, meeting etc.
(b) Arrange for reports on number of, and attendance at demonstrations given by local leaders.
(c) Make a sample check to assess the extent of use of the skill; and satisfaction derived bythose attending the method demonstration.

Advantages

1.Peculiarly suited in teaching skills is many people.

2. Seeing, hearing, discussing and participating in a group stimulates interest and action.

3. The costly ‘trial and error’ procedure is eliminated.

4. Acquirement of skills is speeded

5. Buildsconfidence of extension worker in himself, and also confidence of the people in the extension teacher, if the demonstration is performed skillfully.

6. Simple demonstration readily lend themselves to repeated used by local leaders

7. Introduce changes of practice at a low cost. Provides publicity material.

Limitations

1. Suitable only for practices involving skills.
2. Needs good deal of preparation, equipment and skill on the part of extension worker.
3. May require considerable equipment to be transported to the work place
4. Requires a certain amount of showmanship not possessed by some extension workers.

6.8.3 DifferentiationBetween Result Demonstration andMethod Demonstration

Particulars	Result Demonstration	Method Demonstration
Purpose	To show locally the worth or value of recommended practice	To teach how to do a job involving skill(to teach doing skills)
Conducted by	Farmer(Demonstrator) under the guidance of extension worker	Extension worker himself or local leader specially trained for purpose
For the benefit of	The demonstrator as well as other farmers	Persons present at the demonstration
Comparison	Essential (not necessary to have replications in the same field)	Not essential
Maintenance of records	Necessary	Not necessary
Time required	Substantial period	Relatively very little
Cost	Costly	Relatively cheap
Interrelationship	Usually follows observation plots, may involve one or more method demonstrations	Often paves the way for result demonstration

6.9 Exhibition

An exhibition is a systematic display of models, specimens, charts, information, posters etc. In a sequence so as to be significant to teaching or creating interest in the participating members. An exhibition covers three stages of extension education viz, arousing interest, creating desire to learn and providing a chance to take a decision.

Fairs and festivals are usually taken advantages of, for arranging exhibition. Exhibition and displays have storage of the common characteristics as posters. There is difference between exhibits and displays. The exhibits are more of 3dimensional materials, while displays more mostly 2-dimensional.

Importance of Exhibition

1 .To acquaint the people with better standards.

2. To influence the people to adopt better practices.

3. To create interest in a wide range of people.

4. To promote understanding and create good will towards extension.

Points of arranging exhibition

1. Planning is the first step in preparing exhibits and displays. Decide who the audience is, what the message is, what you want the audience to do answer these questions will help you plan the mom of the exhibit, the appeal to use and the content.

2. The most effective exhibits or built around a single idea with a minimum of supporting information. Make it simple, understandable, portable am impressive in size.

3. Let there be sequence and continuity.

4. Use a few rather than many objects.

5. Make it durable, attractive, and action exhibits. Keep written materials as minimum. Clutter is the worth enemy of an exhibit. The fewer elements in your exhibit or display the better. This might be a live object such as a goat in an exhibit about goat.

6. Label legibly and briefly.

7. Spacing and decoration should have an appeal to the eye and to tell the story without any interpreter.

8. Keep the exhibits at a height not less than' two feet, and not more than seven feet from the floor. Place the centre of interest near eye level. This is approximately five feet.

9. Give adequate publicity.

10. Evaluate the effectiveness by the attendance, enquires and requests.

11. Distribute relevant literature

Suggestions in laying out exhibitions

Use local materials as far as possible since specimens from locality will have greater significance.

Take advantage of the local festivals and fairs.

Exhibition can be used for a wide range of topics such as improved home living, model promotion and display villages, feeding practices, shed construction, product of best material in the community etc.

Advantages

1. Best method to teach illiterate
2. Most fit for festive occasions.
3. Promotes good will towards the extension.
4. It is also recreational purpose.
5. Can create market for certain product
6. It has an imaginative appeal
7. It caters to the ruined group
8. It can fit into festive occasions and serve recreational requirements.
9. It promotes creative abilities to some extent.
10. It can stimulate competitive spirit when used for that purpose.

Limitations

1. Requires much preparation and investment.
2. It cannot be used frequently or widely.
3. Cannot lend itself to all topics.
4. Normally extension exhibits are arranged in a routine manner, without specific teaching aim.
5. It cannot be used separately at the same place without making substantial changes.
6. It cannot represent all phases of work.

6.10 Leadership

A leader is a person who has the modern knowledge required at a particular point in the group development and who is put into a situation where he uses that knowledge to help the group to achieve its goal. A leader in one group will not necessarily be a leader in another group. A leader has to perform the leadership character.

Leadership is an organization of personality traits or activities performed by the persons designed by a leader. Leadership is what an individual does while a member of a group is not a person but he is an active part of the whole. He must be accepted by other members of the group.

6.10.1 Types of Leaders

It can be said on the basis of research studies conducted by social scientists, philosophers and extension experts over a period of time, that there are several types of leaders depending upon the nature of work,they perform and influence on the followers. Perhaps from the practical application of studies on leadership, one refers that there are five types of leaders.

1.Autocratic or authoritarian leader

This type of-leader cannot trust people. He assumes that his workers are idle, not doing what they should do. He thinks that an employee must work since he is paid for it. Example of this type of leaders areHittler, and Saddam Hussain.

2. Democratic Leaders

This types of leaders shares with the group members in the decision making ' process and planning of activities. Under his leadership people’s participation is encouraged. He develops and understanding of responsibility on the part of the team members. He perceives peoples positions and feelings. In general, a democratic leader criticizes or evaluates in terms of results expected on the basis of their work rather than on the basis of this or that kind of personalities traits and back grounds like race, caste, age, sex etc. of the employees. He is unprejudiced. He is judgment is objective and impartial.

3. Laissez-faire leader

Some socio-psychologists believe that if one leaves alone the assigned extension work will be completed in a better way. He lacks in confidence in himself and withdraws from his responsibility of the work group. He pretends himself to be a rationalizer. Hence in this type of leadership problems may arise in administration, supervision, and coordination of the assigned work.

4. Professional leaders

The professional leader is one who has received specialized training in the job by which he earns livelihood (e.g. village level worker, subject matter specialist etc).

5. Lay-leaders These leaders may or may not have any specific training. They are paid for their work, and generally Work only part-time with local group organizations e-g. youth club president, gram sahayak or gramsathi. In general, lay leaders are also called volunteer leaders or local leaders. And these local leaders may be formal or non-formal, and may have office bearers of organised groups or hot. In the village situation, lay leaders are available and such participation of leaders makes success of extension work.

6.10.2 Principles of Leadership

In general there are a few principles of leadership which should be understood by extension professionals.

1. Effective leadership in a group is not concentrated in one or a few persons but the whole group should share it.

2. Leadership behavior may be learned and improved by almost any one.

3. Leadership must be accepted by other members of the group to be not be a leader of the same group in a different situation.

6.10.3 Qualities or Traits of a Leader

1. Physical fitness.
2. Mental ability (intelligence)
3. Sense of purpose (having definite ideas regarding the aims of the group).
4. Social insight (sensitivity to other person's position, problems or points of view)
5. Communication (including good listening, and speaking acceptable in public)
6. Love for people (friendliness without favoritism or without giving scope for indiscipline).
7. Democracy (giving all members equal opportunities for participation etc). i
8. Initiative.
9. Enthusiasm.
10. Authority (based upon mastery of knowledge and skills in a particular field
11. Decisiveness (ability to make good and prompt decisions or judgement)
12. Integrity or character.
13. Teaching ability.
14. Convictions and faith.

6.11 Self Help Groups(SHGS)

Self Help Groups (SHGs) denote groups of people, who came together, bound by principles of self help, with common interest to improve their socioeconomic conditions.

A self help group is small autonomous non-political group of people livingin the same vicinity of near each other and sharing common concerns come together voluntarily to work for their mutual personal social and economic development.

A SHG may be registered or unregistered. It typically comprises a group ofmicro entrepreneurshaving homogeneous social and economic backgrounds, all voluntarily coming together to save regular small sums of money, mutually agreeing to contribute to a common fund and to meet their emergency needs on the basis of mutual help. They pool their resources to become financially stable, taking loans from the money collected by that group and by making everybody in that group self-employed. The group members use collective wisdom and peer pressure to ensure proper end-use of credit and timely repayment. This system eliminates the need for collateral and is closely related to that of solidarity lending, widely used by micro finance institutions.[1] To make the bookkeeping simple, flat interest rates are used for most loan calculations.

Forming a Group

The main reason for a group to form is physical interaction based upon a common need or problem. The greater the extent to which individual share activities the more they will interact and the higher theprobability that they will from a group.

Principles of SHGs

- Mutual help
- Common purpose/interest.
- Common understanding.
- Meet regularly and participate actively.
- Conscious membership (voluntarily).
- Group size-small group (10 to 20 persons of local men or women).
- Record -Book keeping.

Objectives of SHGs

- Suitable access to financial serving.
- Stronger livelihood support systems.
- Enhancement of collective bargaining power.
- Self reliance and sense of dignity.
- Improvement in standard go living and empowerment

6.12RytuMithraGroups(RMGs)

Introduction

The Government of India has been giving a major thrust to agriculture credit with more emphasis on credit flow to Small Farmers/Medium Farmers/ Tenant Farmers ,as a very large number of them are yet to access bank credit and continue to be in the clutches of money lenders and input suppliers to meet their financial requirements for various areas. They are not only in large number but also are vulnerable and therefore without their development it becomes difficult to sustain Indian agriculture and alleviate poverty. It is, therefore, necessary to make concerned efforts to innovate appropriate and cost effective credit deliver system for this particular class of rural clientele. It is in this context that channelising credit through RythuMithra Groups (RMGs) is of significant importance as it is felt that such a system caters to the needs of such farmers besides being convenient and cost effective to bankers.

Aims of RythuMithra Groups

1. Economic viability of Small Farmers/Medium Farmers/Tenant.
2. Collective decision making for Agricultural problems
3. Susceptibility Agriculture-Role.
4. Entrepreneurial ability and autonomy.
5. Solvation of social problems.
6. Intermediaries eliminations.
7. Transfer of Technology, Market-Information.
8. Arranging of soil-test camps, Animal health camps and Agricultural experts lectures, social reforms in the village.

Objectives of RMGs

The state Government has formed the RMGs with the following objectives:

1. To serve as a conduit for technology transfer, facilitate common access to market information and market.

2. Only one member per family will become a member of RGM and it will have Convener and Co-convener
to operate bank account and facilitate thrift and credit activities in RGM on the lines of SHGs.

3. The optimum number of number of members in each RGM will be 15.

4. RMG will mobilise a minimum monthly thrift of about Rs 15/per member. A progressive farmer from
each group will be identified as contact farmer, who will be trained by the department in best management
practices.

6.13Group Dynamics

It was social psychologistKurt Lewin (1890–1947) who coined the term *group dynamics* to describe the positive and negative forces within groups of people. In 1945, he established *The Group Dynamics Research Center* at the Massachusetts Institute of Technology, the first institute devoted explicitly to the study of group dynamics. Throughout his career, Lewin was focused on how the study of group dynamics could be applied to real-world, social issues.

The word dynamics comes from the Greek word meaning force. The phrase means a study of cohesive and disruptive forces operating with in a group. The importance of group dynamics to a manager learn in the fact that many people tend to behave differently as individuals and members of a group. The management must thus study them both as individual and as group as these are two interrelated elements of a motivational situation He can thus equip himself better to anticipate the actions and reactions of others, and can there by ensure smooth interpersonal relationships

Group dynamic will be structured around the following topics

1.Basic elements of group behavior
2. Group cohesiveness

1. Group structure

1. Basic elements of group behaviour

The three basic elements which are generally of use in understanding the behaviour of a group are activities, interactions and sentiments. '

2. Group cohesiveness

The cohesiveness of a group reflects to the degree to which its members are attracted to the group, are motivated to remain in the group, and mutually influence one another.

3. Group structure

By group structure is meant the nature and characteristics of the interrelationship among the assigned certain duties or activities; he is given a certain position or status, and he assume certain functions. These duties, positions and functions may be termed as his role in the group

The difference between team and group dynamics

Although team dynamics are very similar to group dynamics, and the terms are often used interchangeably, there is an essential difference. Groups are a social community, consisting of two or more people who have something in common. A team is a special instance of a group in which the commonality is a shared goal. This fact, itself, creates a dynamic between team members because they are dependent on each other for success. For example, a sports team wins or loses as a whole. The word "team" is sometimes used, incorrectly, to refer to a group. For example, many sales "teams" are groups - because the sales people are incentivised individually. A sales person wins commission based on his/her own sales, and is not affected by the performance of other sales people.

6.14 Farmers Training Centres

State Agriculture Departments have started Farmers Training Centres with an objective of giving training to farmers, children, school, drop-outs and rural Unemployed youth. Certain skills are imparted in the trainees in doing particular Operation or technique evolved in agricultural crop production.

The training may be for 3 to 4 days or a month or so. An amount equal to the wages would earn will be paid to the trainees, so that they are not put to financial losses. Seed treatment, transplanting, weed control, hybridization in seed production, pest control methods are some of the fields in which training is given. People who are actually engaged infield work including casual labour, contract labour, women are selected for training. There are 17 farmers training centers in the state.

6.15 KrishiVigyanKendras (KVKs)

KrishiVigyanKendras are grass root level institutions devoted for impacting skill oriented programmes to illiterate small, marginal landless farmers, farm women and rural youth by organizing short and long term vocational training courses and income generating activities in addition to demonstration of latest technological development on the station and Technology Assessment and Refinement in the farmers field conditions. ICAR has sanctioned seven KVKs under ANGRAU in Andhra Pradesh. They are established in the rural areas at

l.Reddipalli,Anantapur district.
2. Amadalavalasa, Srikakulam district.
3. Rastakuntabai, Vizianagaram district
4. Banvasi,Kurnool district
5. Darsi,Prakasam district
6. Undi, West Godavari district
7. Garikapadu, Krishna district
8. Ghantasala,Krishna district
9. Nellore,Nellore district
10. Utukur,Kadapa district
11.Kondempudi,Visakhapatnam district
12.Kalikiri,Chittoor district
13.Kalyanadurgam,Anantpur district

Objectives of the KVKs

1.To demonstrate the latest agricultural technologies at their instructional farm with a view to reduce the technology dissemination losses.

2. To test and verify the technologies on farmers fields through on farm research, adoptive research. Front line demonstration etc. to develop location specific technologies

3. Toimparttraining to illiterate farmers, farm women and rural youth by following the method of “teaching by doing” and “learning by doing”.

4. Vocational programmes and income generating activities for young farmers are school drop outs by imparting skills in rural crafts.

5. To organize skill and production oriented short and long term trainings both on and off campus.

6. To organize KisanMelas, Field days. Farmer-Scientist interaction meetings.

7. To bring out literature, Radio and T.V. programmes on modern technologies.

6.16District Agricultural Advisor and Transfer of Technology Centres (DAATTCs)

The research -extension -farmer linkages at district level, ANGRAU decentralized the extension services of EEUs during 1998 by establishing District Agricultural Advisory and Transfer of Technology Centres (DAATTCs) a novel transfer of technology centre functioning from the AMC's located at the district head quarters. Later in2017 shifted to operate from nearest KVK

The Agricultural University believes in the concept that every research scientist should also be an extension worker, when it is a question of serving the farmers and thus work in active association and close, cooperation with the farmers. This therefore, enabled the research scientists to carve a niche in the hearts of the farmers and cam their good will. The farmer scientist interaction which takes place frequently, has brought high degree of confidence among fanners. In order to reinforce and strengthen this mode of working, the university has reorganized its extension wing by location the scientists at the district headquarters and Operate in cooperation and collaboration with all the line departments. Accordingly, 13 DAATT centres were established at each district headquarter, presently located in premises of nearest KVK, with a multidisciplinary team of 4 scientists. The ultimate goal is to station a team of University scientists covering all the faculties i.e. agriculture, animal husbandry and home science, headed by a scientist of Professor cadre in the DAATTCs.

Objectives of DAATTCentres

l. To develop data base for developing action plans.
2. To assess and refine technologies generated by the research scientists for suitability to different farming situations.

3 To conduct diagnostic surveys, identify field problems and provide scientific solutions.
4 To organize Kisanmelas.
5 To extend scientific expertise to the line departments in training programmes andpreparation of information materials.
6.To establish liaison with all the state holders in the district.
7. To assist in implementation of RAWEP
8. To maintain an useful agricultural information Centre.
9. To coordinate with AIR, TV and print media for dissemination with the line departments.
10. To implement any other extension programme in coordination with the line departments.

6.17 Participatory Rural Appraisal (PRA)

History: Participatory rural appraisal evolved from rapid rural appraisal-a set of informal techniques used by development practitioners in rural areas to collect and analyze data. Rapid rural appraisal developed in the 1970s and 1980s in response to the perceived problems of outsiders missing or miscommunicating with local people in the context of development

work. In PRA, data collection and analysis are undertaken by local people, with outsiders facilitating rather than controlling.
PRA is a methodology for interacting with villages, understanding them and learning from them. It involves a set of principles a process of communication and a menu of methods for seeking villagers participation in putting forwards their points of view about any issue and enabling them to do their own analysis with a view to make use of such learning.

Participatory rural appraisal (PRA) is a set of participatory and largely visual techniques for assessing group and community resources, identifying and prioritizing problems and appraising strategies for solving them. It is a research/planning methodology in which a local community (with or without the assistance of outsiders) studies an issue that concerns the population, prioritizes problems, evaluates options for solving the problem(s) and comes up with a Community Action Plan to address the concerns that have been raised.

PRA is particularly concerned that the multiple perspectives that exist in any community are represented in the analysis and that the community itself takes the lead in evaluating its situation and finding solutions. Outsiders may participate as facilitators or in providing technical information but they should not 'take charge' of the process.

In PRA, a number of different tools are used to gather and analyse information. These tools encourage participation, make it easier for people to express their views and help to organize information in a way that makes it more useful and more accessible to the group that is trying to analyse a given situation. In this appendix, a number of tools are presented that might be useful in a PRA studying the institutional aspects of a community forestry activity. These are by no means the only tools that would be useful in such a study and those which are proposed here would have to be adapted to any particular situation. They are intended to give a sense of what information can be obtained by using different tools and how diverse issues can be looked at from multiple angles. In no case are these tools ends in themselves. Rather they will help to provoke discussion and bring up issues that can then be followed up in interviews (which will often take place around the diagram that has been produced) focusing on relevant institutional issues. The key, in other words, is not just to make a Venn (or some other) diagram but to use the diagram to probe further and ask questions about how decisions are made, -what happens in different conflictual situations, etc.

It is hoped that the presentation of these tools will help stimulate the facilitator's ideas about how to gather the kinds of information recommended by this manual and will help people who are already familiar with PRA to get an idea of how the participatory toolkit might be applied to these institutional issues. Readers who do not yet have experience with PRA but who are interested in applying it to an institutional analysis are encouraged to contact an experienced practitioner or consult the literature for more extensive information on the correct use of the methodology.
Some features of PRA which make it well-suited as a learning and problem-solving tool for the rural poor are

Main Objectives

- It encourages group participation and discussion
- The information to be processed is collected by group members themselves
- It is presented in highly visual form, usually out in the open and on the ground, using pictures, symbols and locally available materials
- Once displayed, the information is “transparent rather than hidden” - all members can comment on it, revise it and criticize it. This assists in cross-checking and verifying collected data.

Principles

1. Optional ignorance
2. Seeking for diversity and differences
3. Offsetting Biases
4. Triangulating(crosscheck by using different methods)
5. Listening and Learning
6. Be Gender sensitive at all times

When to use?

PRA supports the direct participation of communities, with rural people themselves becoming the main investigators and analysts. Rural people set the priorities; determine needs; select and train community workers; collect, document, and analyse data; and plan and implement solutions based on their findings. Actions stemming from this research tend to serve the local community. Outsiders are there to facilitate the process but do not direct it. PRA uses group animation and exercises to facilitate information sharing, analysis, and action among stakeholders.

PRA is an exercise in communication and transfer of knowledge. Regardless of whether it is carried out as part of project identification or appraisal or as part of country economic and sector work, the learning-by-doing and teamwork spirit of PRA requires transparent procedures. For that reason, a series of open meetings (an initial open meeting, final meeting, and followup meeting) generally frame the sequence of PRA activities. A typical PRA activity involves a team of people working for two to three weeks on workshop discussions, analyses, and fieldwork.

How to use?

Participatory mapping

- Create a wall or ground map with group participation. Members should do the marking, drawing and colouring with a minimum of interference and instruction by outsiders.

- Using pencils, pens or local materials (e.g. small rocks, different coloured sands or powders, plant material) members should draw maps that depict/illustrate certain things. Each group member is then asked “to hold the stick” to explain the map or to criticize it or revise it.
- Create resource maps showing the location of houses, resources, infrastructure and terrain features-useful for analysing certain community-level problems.
- Create social maps, showing who is related to whom and where they live - useful in conducting PPP baseline surveys, etc.

Seasonal calendars

These charts show monthly changes in climate (rainfall or temperature) or agricultural activities (agricultural hours worked, different activities undertaken, crop cycles). The calendars are useful in identifying planting and harvesting times, labour constraints and marketing opportunities.

Matrices

These are grid formats used to illustrate links between different activities or factors. They are useful in information gathering and analysis.

Practical Applications

(1)**Natural Resource management**

(a) Watersheds, soil and water conservation e. g. Participatory watershed p1 an11mg and management (including rapid catchment analysis)

(b) Forestry

E.g, Social and community forestry; degraded forest assessment protection, nurseries and planting; identification to tree uses; uses and marketing of minor forest products.

(c) Wild life reserve buffer zones.

(d) Rural energy assessment and fuel and fodder budgeting.

(e) Village plans: Preparing village resource management plans, PRA and planning

(**2) Agriculture**

(a) Crops and animal husbandry, including farmer participating research/ farming systems research by farmer.
(b) Irrigation, including rehabilitation of small-scale gravity flow irrigation systems.
(c) Markets; Investigating markets and small holder marketing channels.

(d) Programmes for equality
(e) Health and nutrition

Summary

- Extension education us an applied behavioral science. It is different from formal education.
- Extension teaching methods are classified as (1) Individual contact methods (2) Group contact methods (3) Mass contact methods.
- Audio visual extension methods are Films, Exhibitions, Radio and Television.
- News papers, Magazines, Bulletins etc., are printed matter.
- Farmers Training Centres and KrishiVigyanKendras impart practical training to rural youth, school drop outs and farmers children.

Short Answer Type Questions

1. What is extension education?
2. Write the objectives of extension education.
3. How are extensionteaching methods are classified?
4. Give an account of 'FILMS' as a teaching aid.
5. What is exhibitioner? How are they useful to disseminate knowledge to ruralpeople?
6.Give the advantages of Radio and Television to educate farmers.
7. Describe the role of printed-matter in passing the agricultural information.
8. Give an account of farmers training centers.
9. What is farming situation based extension?
10.Write any four Differences between Result Demonstration and Method Demonstration
11.What is Group Dynamics?

Long Answer TypeQuestions

1. How does extension education different from formal education
2. Write Classification of Audio-Visual Aids. Explain them in brief.
3. Classify Extension Teaching Methods according to CONTACT. Explain them.
4. What are the objectives and functions of KrishiVigyanKendras.
5. What is Communication? Explain components of Communication Process.
6. Write about Mass Communication Media
7. Write about Electronic Media.
8. What is Result Demonstration? How to conduct it?
9. What is Method Demonstration? How to conduct it?
10. Write about Exhibition. Write its advantages and limitations.
11. What is Leadership? What is Leader? Explain types of Leaders.
12. What is Leader? Write Qualities/Traits of a Leader.
13. What is SHGs? Write its Principles and Objectives.
14. What is RMGs? Write its Aims and Objectives.
15. Write about KRISHI VIGYAN KENDRAS(KVKs). Write its Objectives.
16. What are DAATTCs? Write their Objectives.
17. What is PRA?Write Objectives, principles and Practical applications of PRA.

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1) Adivi Reddy, A. 2006. Extension Education. Sree Lakshmi Press, Bapatla.
2) Jalihal, K.A. and Veerabhadraiah, V. 2007. Fundamentals of Extension Education and Management in Extension. Concept Publishing House, New Delhi.
3) Vasanth R and Kiran. 2012 Extension Education - New Horizons – Kalyani Publishers, New Delhi.

CROPPRODUCTON & MANAGEMENT

I YEAR

PAPER-I PRINCIPLES OF CROP PRODUCTION

PERIODS PER WEEK : 05 PERIODS PER YEAR : 135

BLUEPRINT

S. No	Name of the Unit	No. of periods	Weight age in marks	Short answer questions	Essay type questions
I	Agriculture	12	6	3	1
II	Agrometeorology	36	18	3	2
III	Tillage and Tilt	28	14	1	2
IV	Cropping Systems	18	10	2	1
V	Weed Management	25	12		2
VI	Sustainable Agriculture	16	8	1	1
	Total	135	68	10	8

CROPPRODUCTON & MANAGEMENT

I YEAR

PAPER-II SOIL AND WATER MANAGEMENT

PERIODS PER WEEK : 05 PERIODS PER YEAR : 110

BLUEPRINT

S. No	Name of the Unit	No. of periods	Weight age in marks	Short answer questions	Essay type questions
I	Soil in trlation to plant growth	25	12	3	1
II	Mineral Nutrition, Manure and Fertilizers	35	18	3	2
III	Irrigation water management	40	20	1	3
IV	Dry land Agriculture	35	18	3	2
	Total	135	68	10	8

CROPPRODUCTON & MANAGEMENT

I YEAR

PAPER-III FARM MANAGEMENT AND AGRICULTURAL EXTENSION

PERIODS PER WEEK : 05 PERIODS PER YEAR : 110

BLUEPRINT

S. No	Name of the Unit	No. of periods	Weight age in marks	Short answer questions	Essay type questions
I	Introduction to Farm Management	20	10	2	1
II	Farm Records	20	10	2	1
III	Agricultural Marketing	25	12	3	1
IV	Farm Credit	20	10	2	1
V	Agricultural Co-operation	25	12	10	2
VI	Agricultural Extention	25	14	1	2
VII	Total	135	68	10	8

CROP PRODUCTION

MODEL QUESTION PAPER

I YEAR THEORY

PAPER-I

PRINCIPLES OF CROP PRODUCTION

Time: 3 Hours **Max.marks:50**

SECTION - A

Note: i) Answer all Questions.
ii) Each question carries 2 marks **1 0 x02=20**

1. Define Agronomy.
2. What instrument is used for measuring wind velocity?
3. What is a synoptic chart?
4. What is mixed cropping?
5. Define Tilth.
6. What is stubble mulch farming?
7. Define Intercropping.
8. What is meant by Seed dormancy?
9. What is weedicide?
10. Define Sustainable Agriculture.

SECTION – B

Note: i) Answer any 5 Questions
ii) Each Question Carries 6 marks **5x6=30**

11. Explain the effects of drought on growth and yield of crops.
12. What is meant by Remote sensing? Give its applications in Agriculture.
13. Define tillage? Write about its objectives?
14. Define crop rotation and explain the principles & advantages of crop rotation.
15. How weeds are harmful to crops?. Explain about integrated weed management.
16. Explain country plough with neat diagram.
17. What is weather forecasting? Write its types and their uses?
18. Write short notes on any two of the following:
    a) Methods of sowing b) Agro climatic zone of AP c) Bio-pesticides

CROP PRODUCTION

MODEL QUESTION PAPER

I YEAR THEORY

PAPER-II

SOIL AND WATER MANAGEMENT

Time: 3 Hours **Max.marks:50**

SECTION - A

Note: i) Answer all Questions.
ii) Each question carries 2 marks **1 0 x02=20**

1. What is C: N ratio?
2. Write Criteria of Nutrients for plants?
3. What is meant by balanced fertilization?
4. Define green manuring.
5. Define Field capacity.
6. Give critical stage for irrigation in wheat and ground nut
7. Define sub-surface drainage.
8. What is soil erosion?
9. What is a watershed?
10. What is soil productivity?

SECTION – B

Note: i) Answer any 5 Questions
ii) Each Question Carries 6 marks **5x6=30**

11. What is irrigation ? Write about objectives of irrigation?
12. Define drip irrigation and enlist its advantages and limitations.
13. What are the different types of green manuring? Give its advantages.
14. Write briefly about different types of nitrogenous & potassic fertilizers?
15. Explain about problems faced by formers in dry land agriculture?
16. Explain briefly about the agronomic measures in soil & water conservation?
17. What is humus? Write efforts of organic matter on soil properties?
18. Write short notes on any two of the following:
    a) Cat ion exchange capacity
    b) Soil fertility
    c) Soil Texture

CROP PRODUCTION

MODEL QUESTION PAPER

I YEAR THEORY

PAPER-III

FARM MANAGEMENT & AGRICULTURAL EXTENSION

Time: 3 Hours **Max.marks:50**

SECTION - A

Note: i) Answer all Questions.
ii) Each question carries 2 marks **1 0 x02=20**

1. Define Farm management.
2. Write any two functions of PACS.
3. What is a result demonstration?
4. What is fixed capital?
5. Define agricultural co-operation.
6. What is diary?
7. Expand DAATTCs?
8. Define Agricultural market.
9. What is crop insurance?
10. Define Extension Education.

SECTION – B

Note: i) Answer any 5 Questions
ii) Each Question Carries 6 marks **5x6=30**

11. Differentiate between formal and extension education.
12. How to manage a farm with respect land, labour, capital and organization?
13. What is meant by farm credit? Explain the classification of credit on the basis of repayment schedule
14. Explain in brief about principles of cooperation.
15. Mention farm records and explain any two of them.
16. Write in detail about problems of present marketing system.
17. Explain functions of NABARD?
18. Answer any **two of the following questions:**
    a. Concept of Rytu Bazar
    b. Method demonstration
    c. Rytumitra