PRINCIPLES OF AGRONOMY AND SOIL SCIENCE

STUDY MATERIAL

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PRINCIPLES OF AGRONOMY AND SOIL SCIENCE

Course Code:_____

UNIT-I:

Introduction and scope of agronomy- National and International Agricultural Research Institutes in India, Classification of crops, Classification of field crops, According to Origin, Botanical Commercial, Economical, seasonal, Ontogeny, Agronomic, Leaf Morphology and Special Purpose crops. Definition of climate and weather, Definition of meteorology, Climatology, Agri-meteorology, composition and structure of atmosphere, Influence of weather on crop growth development, Biotic and Abiotic factors.-Agro climatic zones of A.P. and India.

UNIT-II:

Tillage-Objective of tillage, characteristic of good seed bed, effect of tillage on soil properties (Pore space, texture, structure, bulk density, colour of the soil), Types of Tillage. Sowing-Methods of sowing, time and depth of sowing of major agricultural crops, Methods and time of application of manure and fertilizers. Critical growth stages, duration, season and water requirements of various field crops. Weeds-Influence of weeds on crop production, list out principles and practices of weed management. Problems of crop production in dry farming, Agronomic measure in reducing evapo-transpiration losses, Organic farming-Sustainable Agriculture.

UNIT-III:

Soil: Definition -branches of Soil science difference between surface and sub-surface soil, Rocks: Definition – classification-igneous, sedimentary and metamorphic rocks, Minerals-Definition, classification, primary, secondary, essential, accessory, silicate, non-silicate minerals, light and heavy minerals primary silicate minerals; quartz, feldspars micas pyroxenes

amphiboles secondary silicate; secondary minerals, Ca, Mg, S and Micronutrient containing minerals-chemical formulate.

Weathering: Definition-types of weathering physical weathering of rocks, agents of physical weathering, temperature, water, wind and glaciers, Chemical weathering, solution, hydration, hydrolysis carbonation-oxidation-reduction, biological weathering, role of plants and animals in weathering. Soil forming processes: Eluviations, illuviation, humification, calcification, laterization, podzolozation, salinization, alkalization and gleization.

UNIT-IV:

Soil Profile-Detailed description of theoretical soil profile. Soil structure-Definition-classification based on type, class and grade, factors influencing formation of aggregates-importance and management of soil structure. Soil air- Composition of soil air, management of soil air. Soil temperature- influence of soil temperature on plant growth-factors influencing soil temperature-management of soil temperature. Soil color determination and importance.

UNIT-V:

Ion exchange- Cation and anion exchange –factors influencing ion exchange capacity of soils importance of ion exchange calculation of base saturation and exchangeable acidity, Soil organic matter: importance of organic matter CN ratio of organic matter and its importance.

Soil biology- Soil flora and fauna their characteristics, role of beneficial organisms mineralization–immobilization, nitrogen fixation, nitrification, denitrification, solubilization of phosphorus and sulphur. Soil fertility- Concepts of soil fertility and soil productivity. Essential plant nutrients- N, P, K functions and deficiency symptoms in plants. Classification of problematic soils- acid, saline, saline-sodic characteristics and their reclamation.

Text Books:

1. A Text book of Agronomy. Chandrasekaran, B., Annadurai, K. and Somasundaram, E. New Age International Publishers. 2010.
2. Introduction to Soil Science. Mahendra Sharma. Agrotech Publishing Academy. 2018.
3. Principles of Agronomy, Yellamanda Reddy, T. and Shankar Reddy, Kalyani Publishers, 2010.
4. Nature and Properties of soils. Brady, N.C and Ray, R.W. Pearson Education Inc., New Delhi, 2005.
5. Fundamentals of Soil Science. Indian Society of Soil Science, IARI. Jain publications New Delhi, 1998.

Reference Books:

1. Meteorology. William, L.D. McGraw-Hill Book. Co. New York, 1965.
2. Crop Production in Dry Regions. Arnon, L. Leonard Hill Publishing Co., London, 1972.

3. Manures and Fertilizers, Yawalkar, K.S and Agarwal, J.P. Agricultural Horticultural Publishing House, Nagpur, 1977.
4. Introduction to Soil Physics, Hillel, D. Academic Press, London, 1982.

Web Links:

1. http://ecoursesonline.iasri.res.in/Courses/Introduction%20to%20Soil%20Science/SSAC121/Start%20to%20read%20the%20Course.html
2. http://ecoursesonline.iasri.res.in/Courses/Principles%20of%20Agronomy%20&%20agrcltrl%20Meteorology/AGRO101/Start%20to%20read%20the%20Course.html
3. http://www.hrsacademy.in/wp-content/uploads/2017/02/Principles-of-Agronomy-and-Agricultural-Meteorology.pdf
4. https://www.unaab.edu.ng/attachments/483_SOS%20211%20LECTURE%20NOTE.pdf

UNIT I

Introduction

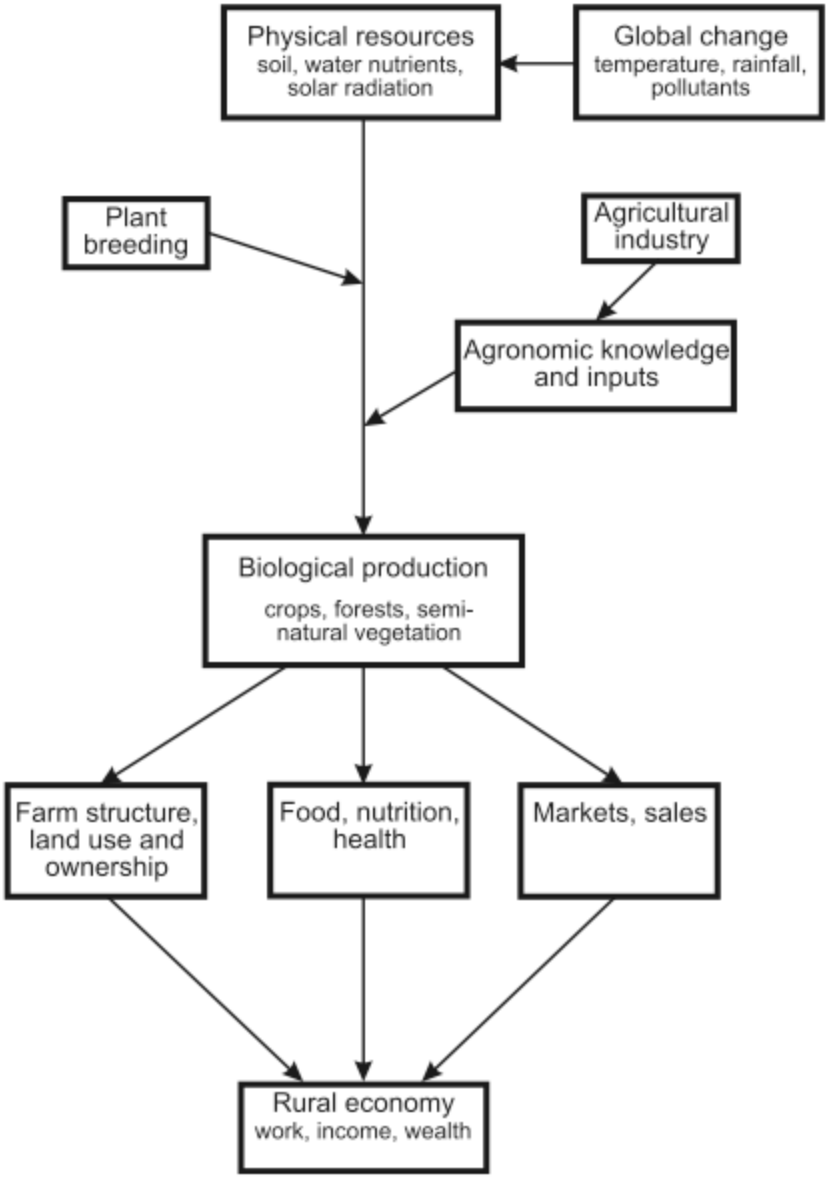
The term agriculture is derived from the Latin words “ager” or “agri” meaning “soil” and ‘cultra’ meaning ‘cultivation’. Agriculture is a very broad term encompassing all aspects of crop production, livestock farming, fisheries, forestry etc. Agriculture may be defined as the art, the science and the 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) which others are beyond the control (climate).

Definition of Agronomy

1. Agronomy is derived from a Greek word ‘agros’ meaning ‘field’ and ‘nomos’ meaning ‘management’. Principles of agronomy deal with scientific facts in relations to environment in which crop are produced.
2. Agronomy is branch of agricultural science, which deals with principles, & practices of soil, water & crop management.
3. It is branch of agricultural science that deals with methods which provide favorable environment to the crop for higher productively.

Boundaries and scale

Crop management, and its scientific study agronomy, are part of a system that comprises the physical elements of the climate, soil and land, the biological constituents of the vegetation and soil, the economic opportunities and constraints of markets, sales and profit, and the social circumstances and preferences of those who work the land.



Flow diagram of physical, biological, economic and social dimensions of agronomy

Scope of Agronomy

Agronomy is a dynamic discipline with the advancement of knowledge and better understanding of planet, environment and agriculture. Agronomy science becomes imperative in Agriculture in the following areas.

1. Identification of proper season for cultivation of wide range of crops is needed which could be made possible only by Agronomy science.
2. Proper methods of cultivation are needed to reduce the cost of cultivation and maximize the yield and economic returns.
3. Availability and application of chemical fertilizers has necessitated the generation of knowledge to reduce the ill-effects due to excess application and yield losses due to the unscientific manner of application.

4. Availability of herbicides for control of weeds has led to development for a vast knowledge about selectivity, time & method of its application.
5. Water management practices play greater role in present day crisis of water demand and Agronomy science answer to the questions 'how much to apply?' and 'when to apply?'.
6. Intensive cropping is the need of the day and proper time and space intensification not only increase the production but also reduces the environmental hazards.
7. New technology to overcome the effect of moisture stress under dry land condition is explored by Agronomy and future agriculture is depends on dry land agriculture.
8. Packages of practices to explore full potential of new varieties of crops are the most important aspects in crop production which could be made possible only by Agronomy science.
9. Keeping farm implements in good shape and utilizing efficient manner to nullify the present day labour crisis is further broadening the scope of agronomy.
10. Maintaining the ecological balance through efficient management of crops, livestock and their feedings in a rational manner is possible only by knowing agronomic principles.
11. Care and disposal of farm and animal products like milk and eggs and proper maintenance of accounts of all transactions concerning farm business is governing principles of agronomy.

NATIONAL AND INTERNATIONAL RESEARCH INSTITUTES IN INDIA

NATIONAL RESEARCH INSTITUTES:

1. CAZRI : Central Arid Zone Research Institute, Jodhpur, Rajasthan
2. CFTRI : Central Food Technological Research Institute, Mysore, Karnataka
3. CICR : Central Institute for Cotton Research, Nagpur, Maharashtra
4. CPRI : Central Potato Research Institute, Simla, H.P.
5. CRIJAF : Central Research Institute for Jute and Allied Fibres, Barrack Pore, W.B.
6. CIAE : Central Institute of Agriculture Engineering, Bhopal, M.P.
7. CPCRI : Central Plantation crops Research Institute, kasargod, Kerala
8. CRIDA : Central Research Institute for Dryland Agriculture, Hyderabad, A.P.
9. CRRI : Central Rice Research Institute, Cuttack, Orissa
10. CSWCRTI : Central Soil and Water Conservation Research and Training Institute, Dehradun, U.P.
11. CTCRI : Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala

12. CSSRI : Central Soil Salinity Research Institute, Karnal, Haryana
13. CTRI : Central Tobacco Research Institute, Rajahmundry, A.P.
14. DOR : Directorate of Oilseeds Research, Hyderabad, A.P.
15. DRR : Directorate of Rice Research, Hyderabad, A.P.
16. DWR : Directorate of Wheat Research, Karnal, Haryana
17. DWMR : Directorate of Water Management Research Institute, Jhansi, U.P.
18. FRI : Forest Research Institute, Dehradun, U.P.
19. IARI : Indian Agriculture Research Institute, Pusa, New Delhi
20. IGFARI : Indian Grassland Fooder and Agroforestry Research Institute, Jhansi, U. P.
21. IISR : Indian Institute of Sugarcane Research, Lucknow, U.P.
22. IISS : Indian Institute of Soil Science, Bhopal, M.P.
23. IIPR : Indian Institute of Pulse Research, Kanpur, U.P.
24. IIHR : Indian Institute of Horticultural Research, Bangalore, Karnataka.
25. ILRI : Indian Lac Research Institute, Ranchi, Bihar
26. JTRL : Jute Technological Research Laboratory, Kolkata, W.B.
27. NCMRT : National Centre for Mushroom Research and Training, Solan, H.P.
28. NRCG : National Research Centre for Groundnut, Junagadh, Gujarat
29. NRCS : National Research Centre for Sorghum, Hyderabad, A.P.
30. NRC for Soybean, Indore, M.P.
31. NRC for Spices, Calicut, Kerala
32. NRC for Cashew, Pattur, Karnataka
33. NRC for Citrus, Nagpur, Maharasthra
34. NRC for Rapeseed and Mustard, Bharatpur, Rajasthan
35. NRC for Oil Palm, Pedavegi, Andhra Pradesh.
36. NCWS : National Centre for Weed Science, Jabalpur, M.P.
37. NBPGR : National Bureau of Plant Genetic Resources, New Delhi
38. NAARM : National Academy of Agricultural Research Management, Hyderabad
39. NBSSLUP : National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharashtra
40. NPPTI : National Plant Protection Training Institute, Hyderabad, A.P.
41. PDCSR : Project Directorate for Cropping Systems Research, Meerut, U.P.
42. SBI : Sugarcane Breeding Institute, Coimbatore, Tamil Nadu

INTERNATIONAL INSTITUTES:

CGIAR : Consultative Group on International Agricultural Research, Washington, D.C.

CIFOR : Centre for International Forestry Research, Bogor, Indonesia

CIAT : Centre International de Agricultural Tropical, Cali, Columbia

CIMMYT : Centre International de la Mejoramientode Maizy Trigo, Mexico

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

FAO – Food and Agricultural Organization, Rome

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

ICARDA : International Center 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

IIMI : International Irrigation Management Institute, Colombo, Sri Lanka

ILRI : International Livestock Research Institute, Nairobi, Kenya

IRRI : International Rice Research Institute, Manila, Philippiness

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

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

WMO- World Meteorological Organization, Vienna

CROPS

In general, crop is an organism grown and / or harvested for obtaining yield. Agronomically, crop is a plant cultivated for economic purpose.

Classification of crops

Classification is done to generalize similar crop plants as a class for better understanding of them.

Classification types used in crops

1. Based on ontogeny (Life cycle)
2. Based on economic use (Agronomic)
3. Based on Botany (Scientific)
4. Based on seasons
5. Based on climate
6. Based on origin
7. Based on commercial
8. Based on leaf morphology
9. Based on special purpose

1. Based on Ontogeny (Life cycle)

a) Annual crops: Crop plants that complete life cycle within a season or year. They produce seed and die within the season. Ex. Wheat, rice, maize, mustard etc.

b) Biennial crops: Plants that have life span of two consecutive seasons or years. First years/ season, these plants have purely vegetative growth usually confined to rosette of leaves. During the second year / season, they produce flower stocks from the crown and after producing seeds the plants die. Ex. Sugar beet, beet root, etc.

c) Perennial crops: They live for three or more years. They may be seed bearing or non-seed bearing. Ex. Napier fodder grass, coconut, etc.

2. Based economic use (Agronomic)

a) Cereals: Cereal derived from word 'Ceres' which denotes as 'Goddess' who was believed as the giver of grains by Romans. Larger grains used as staple food – Rice, wheat, maize, barley, oats etc. Cereal grain contains 60 to 70% of starch and is excellent energy rich foods for humans. In almost every country and region, cereals provide the staple food. Cereals are an excellent source of fat soluble vitamin E, which is an essential antioxidant.

b) Millets: Millets are small grained cereals, staple food in drier regions of the developing countries are called 'millets'. These are also staple food for people of poor countries. In India, pearl millet is a staple food in Rajasthan. Millets are broadly classified in to two, 1) Major millets and 2) Minor millets.

Major millets: 1. Sorghum 2. Pearl millet 3. Finger millet

Minor millets: 1. Foxtail millet 2. Little millet 3. Common millet

c) Pulses: Seeds of leguminous plants used as food (*Dhal)* rich in protein. Pod containing grain is the economic portion. Pulses are preferred for protein rich value & also economic important in cropping system. The wastes or stalk is called the 'haulm' or 'stover'. Haulm is used as green manure and has high value cattle feed. Green pods used as vegetables, e.g. cowpea. Seed coat of pulses are nutritious cattle feed.

1. Red gram
2. Black gram
3. Green gram
4. Cowpea
5. Bengalgram
6. Horsegram

d) Oil seeds: Those crops which are rich in fatty acid are cultivated for the production of vegetable oil. They are used either for edible or industrial or medicinal purposes.

1. Groundnut or peanut
2. Sesame or gingelly
3. Sunflower
4. Castor
5. Linseed or flax
6. Niger
7. Safflower
8. Rapeseed & Mustard

Groundnut: Pod is economic portion in groundnut and contains 50% of oil content. Oil is edible or cooking oil and haulm is a used as cattle feed and also has manure value. The shell has fuel value. It is a bed material in the poultry forms. Oil cake is used as cattle feed and has manurial value. Oil is used for production of *Vanaspathi* and soap making.

Sesame: Sesame oil is cooking oil and economic parts are generally seeds (in the pod). Gingelly cake is used as a cattle feed, whereas capsule and stalk are used for composting / burning purpose.

Castor: Seed (kernal) of castor contains oil and used as medicinal and industrial oil. Mainly aviation industries use this for lubrication purpose. Castor cake is concentrated organic manure. The shell and stalk is used for fuel purpose.

Mustard: Mustard oil is edible oil and seeds are the economic portion. Oil cake is a good cattle feed.

Safflower and sunflower: Oil is used for cooking purpose. Mud Cake is used as cattle feed and also organic material and decorticated manure.

Linseed: Oil extracted from seeds is used in preparation of paints and varnishes.

e) Sugar crops : Crops cultivated for sugar. Juice is extracted from stem of sugarcane used for jaggery or sugar. Number of by products like molasses, bagasse, pressmud etc. is obtained from sugar industry. Molasses used for alcohol and yeast formation and bagasse for paper making and fuel. Pressmud used for soil amendment; whereas, trash (green leaf + dry foliage) is used for cattle feed. Sugar beet is another sugar crop where tubers are mainly used for extraction of sugar.

f) Fibre crops: Plants are grown for obtaining fibre. Different kinds of fibre are, i) seed fibre – cotton; ii) Stem/ bast fibre – Jute, mesta; iii) leaf fibre – *Agave*, pineapple.

Cotton: Important fibre crop of the world, used for garment purpose. Seed for cattle feed and oil is edible purpose. Epidermal hairs of seed coats is the economic portion. Lint (*Kapas*-seed) has industrial value (fibre) and stalk is of fuel nature.

Jute, *Sunhemp,* mesta:

The fibre obtained from stems is used for gunny bags, ropes. Stem itself is used as fuel. Sunhemp is used for both stem fibre and green manure crop.

g) Fodder / Forage: It refers to vegetative matter, fresh or preserved, utilized as feed for animals. It includes hay, silage, pasturage and fodder.

Ex. 1. Grasses - *Bajra napier* grass, guinea grass, fodder sorghum, fodder maize.

2. Legumes - Lucerne, *Desmanthus*, etc.

h) Spices and condiments: Crop plants or their products used for flavour, taste and add colour to the fresh or preserved food. Ex.– Ginger, garlic, fenugreek, cumin, turmeric, chillies, onion, coriander, anise and asafetida.

i) Medicinal plants: Crops used for preparation of medicines. Ex. Tobacco, mint. etc.

j) Beverages: Products of crops used for preparation of mild, agreeable and simulating drinking. Ex. Tea, coffee, cocoa (Plantation crops).

3. Scientific or botanical classification

Botanical or scientific names of plants which consist of genus and species and are universally accepted. Carolus Linnaeus, a Swedish botanist, was responsible for the binomial system of classification.

Group	**Grass (Wheat)**	**Legume (Alfaalfa)**
Kingdom	Plant	Plant
Division	Spermatophyta	Spermatophyta
Sub-division	Angiospermae	Angiospermae
Class	Monocotyledonae	Dicotyledonae
Order	Graminales	Rosales
Family	Gramineae	Leguminosae
Tribe	Hordeae	-
Genus	Triticum	Medicago
Species	Aestivum	Sativa

4. Based on seasons

Crops are grouped under the seasons in which their major field duration falls.

a) Kharif crops: Crops grown during June-July to September–October which require a warm wet weather during their major period of growth and shorter day length for flowering.

Ex. Rice, maize, castor, groundnut.

b) Rabi crops: Crops grown during October–November to January-February, which require cold dry weather for their major growth period and longer day length for flowering.

Ex. Wheat, mustard, barley, oats, potato, bengal gram, berseem, cabbage and cauliflower.

c) Summer crops: Crops grown during February–March to May–June which require warm dry weather for growth and longer day length for flowering. Ex. Black gram, greengram, seasome, cowpea etc.

This classification is not a universal one. It only indicates the period when a particular crop is raised. Ex. *Kharif* rice, *kharif* maize, *rabi* maize, summer pulse etc.

5. Based on climatic condition

1) Tropical crop : Coconut, sugarcane

2) Sub-tropical crop : Rice, cotton

3) Temperate crop : Wheat, barley

4) Polar crop : All pines, pasture grasses

6. Classification According to the Place of origin

A number of crops may be grown elsewhere but each crop has its nature place. Accordingly the crops are grouped into two groups:

a. Nature: which are grown with in the geographic limit of their origin. Crop of Indian origin are Rice, Barley, Black gram, Gram, Mustard, Castor, Sugarcane, Cotton.

b. Exotic or alien or Introduced: These crops are grown even beyond their site if origin. Some of the crops which are now grown in India but introduced from other countries are Tobacco, Potato, Jute, Maize, Sunflower.

7. Commercial Classification

The plant products which have commercial use go under popular groupings

a. Food crop: Rice, Wheat, Greengram, Soyabean, Groundnut

b. Feed Crop: Oats, Napier grass, Sorghum, Maize, Berseem, Lucerne

c. Industrial or Commercial Crops: Cotton, Sugarcane, Sugarbeet, Tobacco, Jute

d. Food Adjuvents: Turmeric, Cumin, Garlic.

8. Classification Based on Leaf Morphology

Morphology means external, well visible structural features of leaf. External leaf characteristics, such as shape, margin, hairs, the petiole, and the presence of stipules and glands, are frequently important for identifying plants to family.

9. Classification Based on Special Purpose

The crops are included in special purpose crops classification are as follows;

1.Green Manure Crops

These kinds of crops are grown to increase the fertility of soil. These crops are grown and then mix in the soil during ploughing. Sometime these are grown, cut and left in the ground for an prolonged period prior to applying tillage operations. Examples: Alfalfa.

2. Silage Crops: These are the crops grown for livestock and dairy consumption. The crops are grown, cut and preserved as silage. The advantage is continuous supply of fodder to animals during dry periods or when green fodder is not available.

Examples: Grasses, Maize, Oat.

3. Catch Crops: These are also called as critical crops as they are grown to fill in the space in case when main crop failed due to any reason or sowing of major crop is delayed for some reason. They are grown to cover economic less to some extent.

Examples: Sorghum and Maize for Fodder

4. Relay Crops

It is a crop that is planted as a second crop in the agriculture fields, however after the first crop has achieved its reproductive growth but is not ready to harvest.

Example: The sowing of Sugarcane in Sugar Beet is an example of relay cropping.

5.Companion Crops: Companion crops are those crops in agriculture that are grown together.

Examples: Maize – Red Beans (Lobia) and Barley-Oat

6.Cover Crops:

These crops are grown with the objective to keep the soil safe from erosion. These are planted to cover the ground so that water and wind erosion don't harm the soil plus it also safeguard nutrient loss by leaching.

Examples: Mash, Mong Bean, Grasses.

Weather and climate

Weather: It is defined as "A state or condition of the atmosphere at a given place and at a given instant of time".

1. The daily or short term variations of different conditions of lower air in terms of temperature, pressure, wind, rainfall, etc".
2. The aspects involved in weather include small areas and duration, expressed in numerical values etc. The different weather elements are solar radiation, temperature, pressure, wind, humidity, rainfall, evaporation etc. Weather is highly variable. It changes constantly sometimes from hour to hour and at other times from day to day.

   Example: The air temperature of Rajendranagar on 20-01-2000 at 2.30 p.m. is 32°C.

Climate

It is defined as

1. "The generalised weather or summation of weather conditions over a given region during comparatively longer period".
2. "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 is described by normals etc.

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

Difference between Weather and Climate

S. No.	Weather	Climate
1	A typical physical condition of the atmosphere	Generalised condition of the atmosphere which represents and describes the characteristics of a region
2	Changes from place to place even in a small locality	Different in different 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 contingent planning	Helps in long-term agricultural planning

Meteorology

Meteorology is defined as

1. "The science of atmosphere".
2. “A branch of physics of the earth dealing with physical processes in the atmosphere that produce weather”.

Climatology

It is defined as “The science dealing with the factors which determine and control the distribution of climate over the earth's surface”. Different factors affecting the climate of a region are:

1. Latitude.
2. Altitude.
3. Land and water.
4. Winds and air masses
5. Low and high pressure belts.
6. Mountain barriers.
7. Ocean currents.
8. Extent of forests, etc.

The above factors are also known as “climatic elements”.

Agricultural Meteorology

Agriculture is defined as “A branch of applied meteorology which investigates the responses of crops to the physical conditions of the environment”. The word `Agrometeorology’ is the abbreviated form of agricultural meteorology.

Practical Utility / Importance / Economic Benefits / Significance of Study of Agricultural Meteorology:

In a broad manner the study of agricultural meteorology helps in

1. Planning cropping systems / patterns.
2. Selection of sowing dates for optimum crop yields.
3. Judicious irrigation to crops.
4. Reducing or eliminating outbreak of pests and diseases.

5. Managing weather abnormalities like cyclones, heavy rainfall, floods, drought etc. This can be achieved by ;

a) Protection : When rain is forecast avoid irrigation. But, when frost is forecast apply irrigation.

b) Avoidance : Avoid fertilizer and chemical sprays when rain is forecast.

c) Mitigation : Use shelter belts against cold and heat waves.

6. Effective environmental protection.

Scope of agricultural meteorology

In addition to the points mentioned above, the influence of weather on agriculture can be on a wide range of scales in space and time. This is reflected in the scope of agricultural meteorology as detailed below:

1. At the smallest scale, the subject involves the study of micro scale processes taking place within the layers of air adjacent to leaves of crops, soil surfaces, etc.
2. On a broader scale, agrometeorologists have to use the standard weather records to analyze and predict responses of plants.
3. The agro meteorologist also be concerned with the study of glass houses and other protected environments designed for improving agricultural production.

Atmosphere: The atmosphere is defined as "The colourless, odourless and tasteless physical mixture of gases which surrounds the earth on all sides". It is mobile, compressible and expansible. The earth is elliptical in shape. It has three spheres. They are:

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

Uses of atmosphere for agriculture:

The uses of atmosphere are:

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 it is a source of water vapour, clouds etc.

Composition of the 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 3/4th of the atmosphere lies upto 7 miles (11 km).

The atmosphere is a mixture of many gases. In addition, it 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 percent by volume. Nitrogen and oxygen make up approximately to 99 percent and the remaining 1 per cent by other gases (Table 1.1). Innumerable dust particles are also present in the lower layers of the atmosphere.

Table 1.1 Principal gases comprising dry air in the lower atmosphere

S. No.	Constituent	Percent by volume	Percent 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

Physical structure of the atmosphere

On the basis of vertical temperature variation, the atmosphere is divided into different spheres or layers as detailed below:

I 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 14 kilometers above the mean sea level; at the equator it is 16 kilometers; and 7- 8 kilometers at the poles.
3. Various types of clouds, thunderstorms, cyclones and anti cyclones occur in this sphere because of the concentration of almost all the water vapour and aerosols in it. So, this layer is called as “Seat of weather phenomena”.
4. The wind velocities increase with height and attain the maximum at the top of this layer.

II Stratosphere

1. This layer exists above the tropopause (around 20 km onwards) and extends to altitudes of about 50-55 kilometers.
2. This layer is called as "Seat of photochemical reactions".
3. The upper boundary of the stratosphere is called stratopause and above this level there is a steep rise in temperature.

III Mesosphere / Ozonosphere

1. There is a maximum concentration of ozone between 30 and 60 km above the surface of the earth and this layer is known as ozonosphere.
2. A property of ozone is that it absorbs ultra violet rays. The temperature of the ozonosphere is high (warm) due to selective absorption of ultra violet radiation by ozone.
3. Because of the preponderance of chemical process this sphere is called as "Chemosphere".

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 ionised. Enriched ion zones exist in the form of distinct ionised layers. So, this layer is called as ionosphere.
3. According to some climatologists, the layer between 80 and 140 kilometers is known as “Thermosphere”.

V 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. Hydrogen and Helium gases predominate in this outer most region.

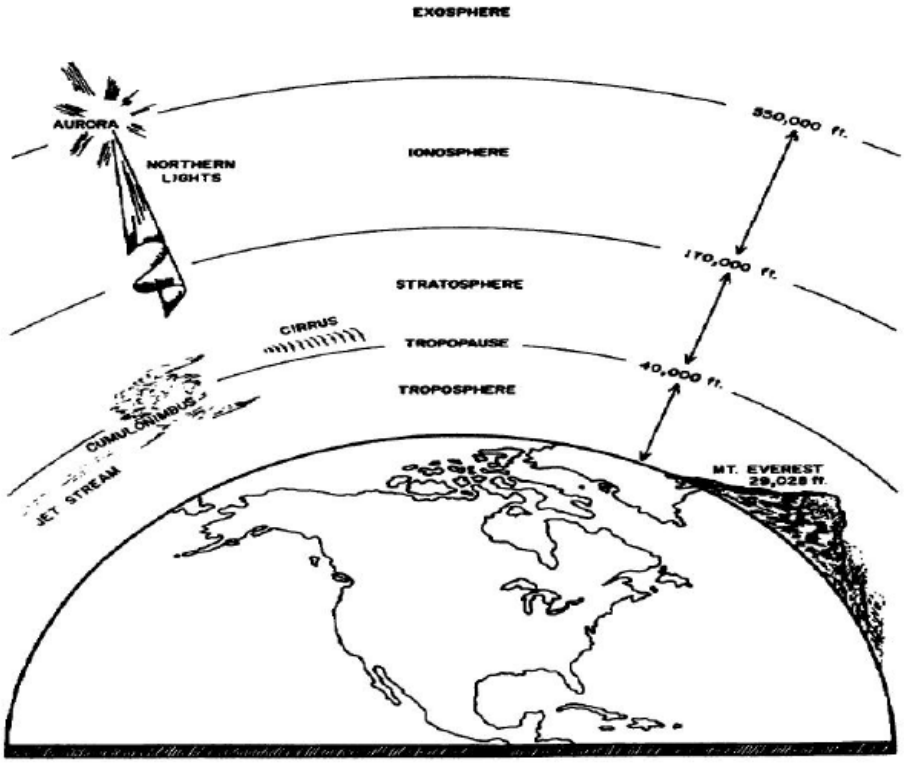
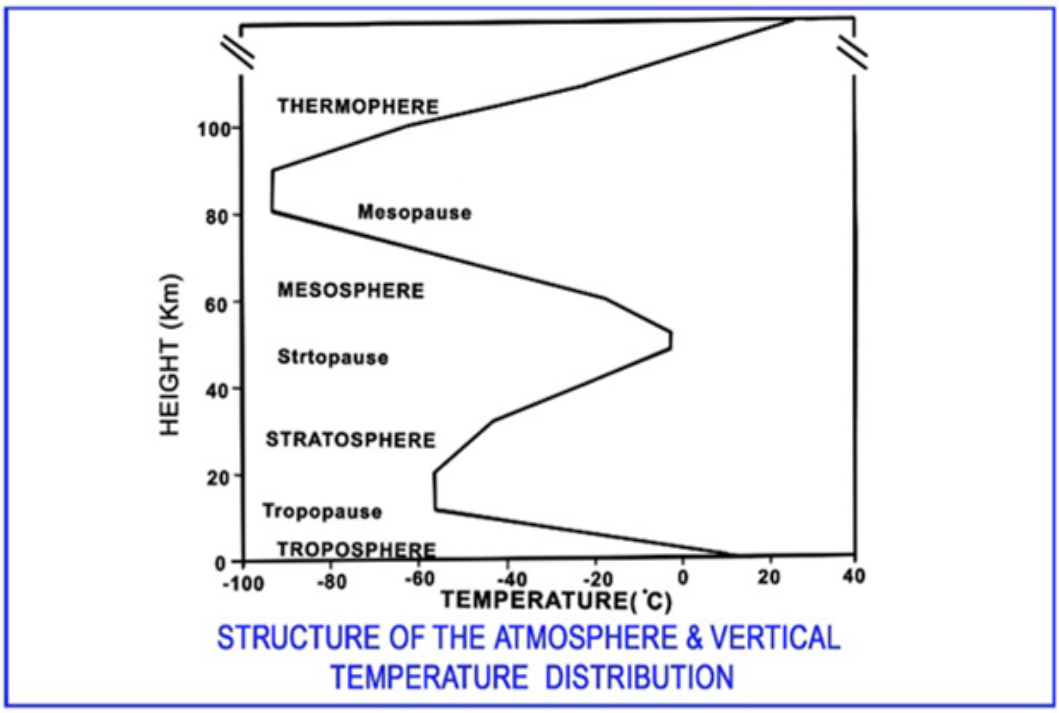
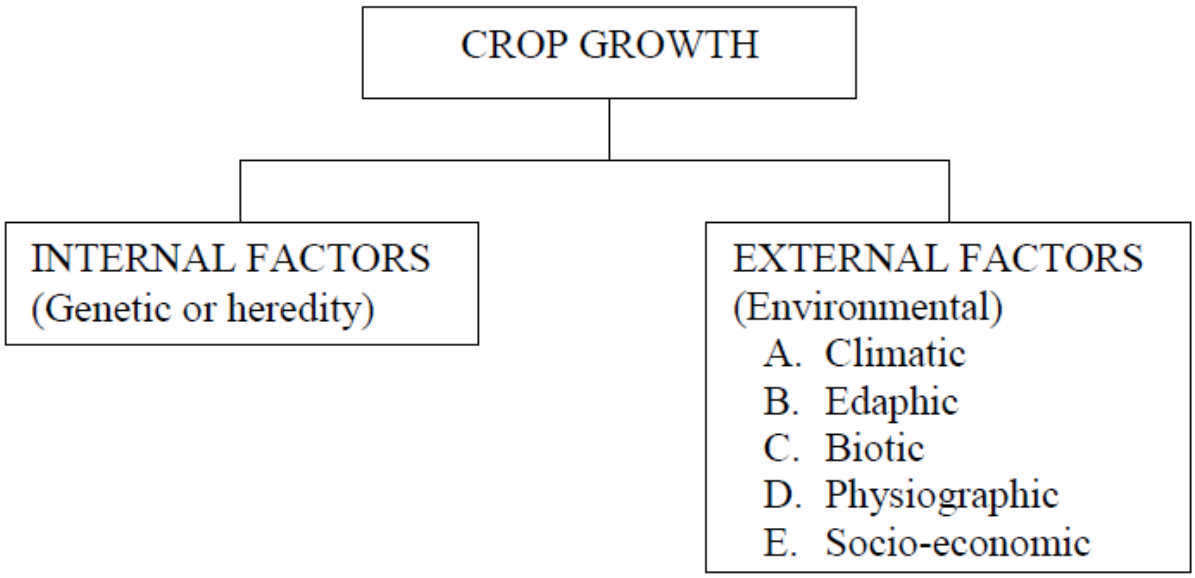


Fig. 1 Atmosphere-Structure



Factors affecting crop production – climatic – edaphic - biotic- physiographic and socio economic factors



I. Internal factors

Genetic factors

The increase in crop yields and other desirable characters are related to Genetic make-up of plants.

1. High yielding ability
2. Early maturity
3. Resistance to lodging
4. Drought flood and salinity tolerance
5. Tolerance to insect pests and diseases
6. Chemical composition of grains (oil content, protein content)
7. Quality of grains (fineness, coarseness)
8. Quality of straw (sweetness, juiciness)

The above characters are less influenced by environmental factors since they are governed by genetic make-up of crop.

2. External factors

A. Climatic
B. Edaphic(soil)
C. Biotic
D. Phsiographic
E. Socio-economic

The abiotic factors that affect plant growth and development include climate, soil, physiographic and socio-economic factors. They are the nonliving components of the

environment which, along with the biotic or living factors, determine the extent in which the genetically-dictated characters are expressed in the plant.

A. CLIMATIC FACTORS

Nearly 50 % of yield is attributed to the influence of climatic factors. The following are the atmospheric weather variables which influences the crop production.

1. Precipitation
2. Temperature
3. Atmospheric humidity
4. Solar radiation
5. Wind velocity
6. Atmospheric gases

1. Precipitation

1. Precipitation includes all water which falls from atmosphere such as rainfall, snow, hail, fog and dew. Rainfall one of the most important factor influences the vegetation of a place.
2. Low and uneven distribution of rainfall is common in dryland farming where drought resistance crops like pearl millet, sorghum and minor millets are grown.
3. In desert areas grasses and shrubs are common where hot desert climate exists

2. Temperature

1. Temperature is a measure of intensity of heat energy. The range of temperature for maximum growth of most of the agricultural plants is between 15 and 40ºC.
2. Germination, growth and development of crops are highly influenced by temperature.
3. Physical and chemical processes within the plants are governed by air temperature.
4. Diffusion rates of gases and liquids changes with temperature.
5. Solubility of different substances in plant is dependent on temperature.
6. The minimum, maximum (above which crop growth ceases) and optimum temperature of individual's plant is called as cardinal temperature.

Crops	Minimum temperature ºC	Optimum temperature ºC	Maximum temperature ºC
Rice	10	32	36-38
wheat	4.5	20	30-32
Maize	8-10	20	40-43
Sorghum	12-13	25	40
Tobacco	12-14	29	35

3. Atmospheric Humidity (Relative Humidity - RH)

1. Water is present in the atmosphere in the form of invisible water vapour, normally known as humidity. Relative humidity is ratio between the amount of moisture present in the air to the saturation capacity of the air at a particular temperature.
2. Relative humidity of 40-60% is suitable for most of the crop plants.

4. Solar radiation (without which life will not exist)

1. From germination to harvest and even post harvest crops are affected by solar radiation. All physical process taking place in the soil, plant and environment are dependent on light
2. Photoperiodism is a response of plant to day length
3. Short day – Day length is <12 hours (Rice, Sunflower and cotton), long day – Day length is > 12 hours (Barley, oat, carrot and cabbage), day neutral – There is no or less influence on day length (Tomato and maize).

5. Wind velocity

1. The basic function of wind is to carry moisture (precipitation) and heat.
2. The moving wind not only supplies moisture and heat, also supplies fresh CO_2 for the photosynthesis.
3. Wind movement for 4 – 6 km/hour is suitable for more crops.
4. Causes soil erosion.
5. Spread of pest and diseases.

6. Atmospheric gases on plant growth

1. CO_2 – 0.03%, O_2 - 20.95%, N_2 - 78.09%, Argon - 0.93%, Others - 0.02%.
2. CO_2 is important for Photosynthesis, CO_2 taken by the plants by diffusion process from leaves through stomata
3. O_2 is important for respiration of both plants and animals while it is released by plants during Photosynthesis
4. Nitrogen is one of the important major plant nutrient.

B. EDAPHIC FACTORS (soil)

Plants grown in land completely depend on soil on which they grow. The soil factors that affect crop growth are

1. Soil moisture
2. Soil air
3. Soil temperature

4. Soil mineral matter
5. Soil organic matter
6. Soil organisms
7. Soil reactions

1. Soil moisture

a) Water is a principal constituent of growing plant which it extracts from soil
b) Water is essential for photosynthesis
c) The moisture range between field capacity and permanent wilting point is available to plants.

2. Soil air

a) Aeration of soil is absolutely essential for the absorption of water by roots
b) Germination is inhibited in the absence of oxygen
c) O_2 is required for respiration of roots and micro organisms.
d) Potato, tobacco, cotton linseed, tea and legumes need higher O_2 in soil air
e) Rice requires low level of O_2 and can tolerate water logged (absence of O_2) condition.

3. Soil temperature

a) It affects the physical and chemical processes going on in the soil.
b) It influences the rate of absorption of water and solutes (nutrients)
c) Soil temperature controls the microbial activity and processes involved in the nutrient availability

4. Soil mineral matter

a) The mineral content of soil is derived from the weathering of rocks and minerals as particles of different sizes.
b) These are the sources of plant nutrients. eg; Ca, Mg, S, Mn, Fe, K etc

5. Soil Organic matter

a) It supplies all the major, minor and micro nutrients to crops
b) It improves the texture of the soil
c) It increases the water holding capacity of the soil,
d) It is a source of food for most microorganisms

6. Soil organisms

a) The raw organic matter in the soil is decomposed by different micro organisms which in turn releases the plant nutrients

b) Atmospheric nitrogen is fixed by microbes in the soil and is available to crop plants through symbiotic (Rhizobium) or non-symbiotic (Azospirillum) association

7. Soil reaction (pH)

a) Soil reaction is the pH (hydrogen ion concentration) of the soil.
b) Soil pH affects crop growth and neutral soils with pH 7.0 are best for growth of most of the crops
c) Soils may be acidic (<7.0), neutral (=7.0), saline and alkaline (>7.0)

C. BIOTIC FACTORS

Beneficial and harmful effects caused by other biological organism (plants and animals) on the crop plants

1. Plants

a) Competitive and complimentary nature among field crops when grown together
b) Competition between plants occurs when there is demand for nutrients, moisture and sunlight particularly when they are in short supply or when plants are closely spaced

2. Animals

a) Soil fauna like protozoa, nematode, snails, and insects help in organic matter decomposition.
b) Insects and nematodes cause damage to crop yield and considered as harmful organisms.
c) Honey bees and wasps help in cross pollination and increases yield and considered as beneficial organisms
d) Burrowing earthworm facilitates aeration and drainage of the soil.

D. Physiographic factors

a) Topography is the nature of surface earth (leveled or sloppy) is known as topography. Topographic factors affect the crop growth indirectly.
b) Altitude – increase in altitude cause a decrease in temperature and increase in precipitation and wind velocity (hills and plains)
c) Exposure to light and wind: a mountain slope exposed to low intensity of light and strong dry winds may results in poor crop yields (coastal areas and interior pockets)

E. Socio-economic factors

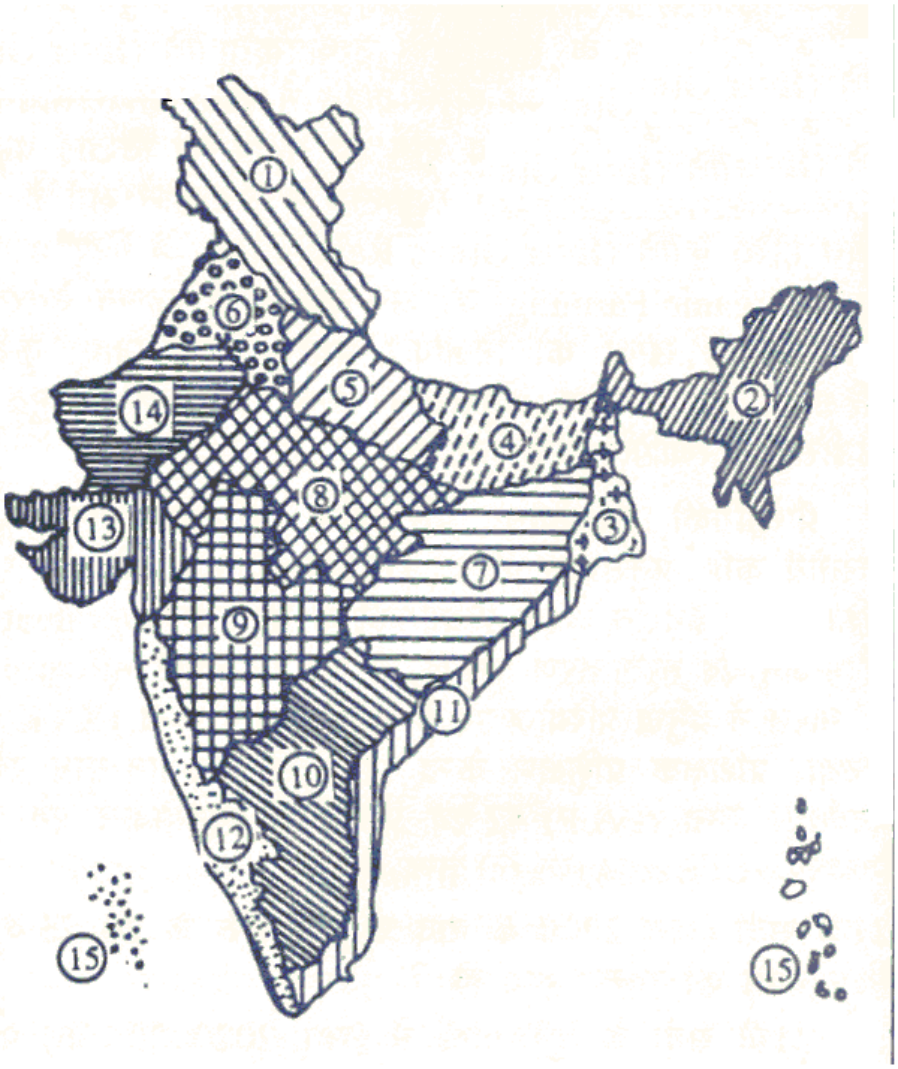
a) The economic condition of the farmers greatly decides the input/ resource mobilizing ability (marginal, small, medium and large farmers)

AGRO-CLIMATIC ZONES OF INDIA AND ANDHRA PRADESH

Planning Commission has demarcated the geographical area of India into 15 agro-climatic regions. These are:

1. **Western Himalayan Region:** Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Uttaranchal. The region consists of skeletal soils of cold region, podsolic soil, mountainous soil, hilly brown soil. Lands have steep slopes in undulating terrain.
2. **Eastern Himalayan Region:** Assam Sikkim, West Bengal and all North-Eastern states. These region falls under high rainfall and high forest cover. Shifting cultivation is practiced in nearly one third of the cultivated area and this causes degradation of the soil, with heavy runoff, soil erosion and flood.
3. **Lower Gangetic Plains Region:** West Bengal, soils are mostly alluvial and are prone to floods.
4. **Middle Gangetic Plains Region:** Uttar Pradesh, Bihar. About 39 percent of the gross cropped area of this region is irrigated.
5. **Upper Gangetic Plains Region:** Uttar Pradesh. Irrigation is trough canals and tube wells. A good potential for exploitation of ground water.
6. **Trans-Gangetic Plains Region:** Punjab, Haryana, Delhi and Rajasthan. These regions have the highest sown areas, highest irrigated area, high cropping intensity and high ground water utilization.
7. **Eastern Plateau and Hills Region:** Maharashtra, Uttar Pradesh, Orissa and West Bengal. Irrigation is through canals and tanks. The soils are shallow and medium in depth.
8. **Central Plateau and Hills Region:** Madhya Pradesh, Rajasthan, Uttar Pradesh.
9. **Western Plateau and Hills Region**: Maharashtra, Madhya Pradesh and Rajasthan. The average rainfall of this zone is 904 mm.
10. **Southern Plateau and Hills Region:** Andhra Pradesh, Karnataka, Tamil Nadu. Dry farming is adopted and the cropping intensity is 111 percent.
11. **East Coast Plains and Hills Region:** Orissa, Andhra Pradesh, Tamil Nadu and Pondicherry. Irrigation is through canals and tanks.
12. **West Coast Plains and Ghats Region:** Tamil Nadu, Kerala, Goa, Karnataka, Maharashtra. Variety of cropping pattern, rainfall and soil types.

13. **Gujarat Plains and Hills Region:** Gujarat. This zone is arid with low rainfall in most parts. Irrigated through tube wells and wells.
14. **Western Dry Region:** Rajasthan. Hot sandy desert, erratic rainfall, high evaporation, scanty vegetation. The ground water is often deep and often brackish. Famine and drought are common features of this region.
15. **The Islands Region:** Andaman and Nicobar Islands, Lakshadweep. These regions are typical equatorial with rainfall of 3000 mm spread over eight to nine months. Largely forest zone with undulated land.



Agro climatic Zones of Andhra Pradesh

The cropped area in Andhra Pradesh is divided into seven zones based on the agro-climatic conditions. The classification mainly concentrates on the range of rainfall received, type and topography of the soils.

1. **Krishna – Godavari Zone:** It covers East Godavari Part, West Godavari, Krishna, Guntur, and contiguous areas of Khammam, Nalgonda and Prakasam. Rainfall of this zone is 800-1100mm. Soil type is deltaic alluvium, red soils with clay, red loams, coastal sands and saline soils. Paddy, Groundnut, Jowar, Bajra, Tobacco, cotton, chillies, Sugarcane and Horticultural Crops are the important crops grown.
2. **North Coastal Zones:** Covers Srikakulam, Vizianagaram, Visakhapatnam and uplands of East Godavari districts. This zone receives a rainfall of 1000-1100 mm mainly from south west monsoon. Soil type is red soils with clay base, pockets of acidic soils, laterite soils, Soils with PH 4-5. Main crops grown in these zones are Paddy, Groundnut, Jowar, Bajra, Mesta, Jute, Sun hemp, Sesame, Black gram and Horticultural Crops.
3. **Southern Zone:** Districts in this zone are Nellore, Chittoor, Southern parts of Prakasam and Cuddapah and Eastern parts of Anantapur. Rainfall received is about 700-1100 mm. Soil type is Red loamy soils, Shallow to moderately deep. Crops like Paddy, Groundnut,cotton Sugarcane. Millets and Horticultural Crops are mainly grown.
4. **North Telangana Zone:** Adilabad, Karimnagar, Nizamabad, Medak (Northern part), Warangal (Except N.W.Part), Eastern tips of Nalgonda and Khammam are the districts in this zone. Rainfall received is about 900-1500 mm. Soil type is Chalkas, Red sandy soils, Dubbas, Deep Red loamy soils, Very deep black cotton soils. Paddy,Sugarcane,Castor,Jowar, Maize, Sunflower, Tuemeric, Pulses and Chillies are the important crops.
5. **Southern Telangana Zone:** Hyderabad, Rangareddy, Mahabubnagar (except southern border), Nalgonda (except North eastern border), Medak (Southern parts), Warangal (North Western Part) are the districts covered. This zone receives a rainfall of about 700-900 mm. Soil type is red earth with loamy sub soil (Chalkas). Paddy, Sunflower, Safflower, Grapevine, Sorghum, Millets, Pulses and Orchard crops are the important crops.
6. **Scarce rainfall zone:** the districts covered are Kurnool, Anantapur, Prakasam (western parts), Cuddapah (Northern part), Mahabubnagar (Southern border). Receives a rainfall of 500-750 mm. Soil type is red earths with loamy soils (Chalkas), red sandy soils and black cotton soils in pockets. Cotton, Korra, Sorghum, Millets, Groundnut, Pulses, Paddy are the important crops.

7. **High altitude and Tribal areas:** Northern borders of Srikakulam, Vizianagaram and Visakhapatnam, East Godavari and Khammam are the districts covered. This zone receives a rainfall more than 1400 mm. Horticultural Crops, Millets, Pulses Chillies, Turmeric and Pepper are the important crops grown.