AGR 101. Introductory Agriculture, Principles of Agronomy and Soil Management (Cr. Hr. 2+1)

Lecture Notes

The term agriculture is derived from the latin words *ager* or *agri* meaning soils and *cultura* means cultivation. Agriculture is the art, science and business of crop production. It encompasses all aspects of crop production, livestock farming, fishery and forestry. Agriculture is the conversion of solar energy into the chemical energy. Crop production is the conversion of environmental inputs like solar energy, carbon dioxide, water and nutrients in soil to economic products in the form of human or animal food or industrial raw materials.

Agronomy is derived from the greek words *Agros* meaning field and nomos meaning manage. It is branch of agricultural science which deals with principles and practices of soil, water, and crop management.

Agronomy deals with methods which provide favourable environment to higher crop productivity.

According to Norman (1980) it is a science of manipulating the crop environment complex with dual aims of improving productivity and gaining a degree of understanding of the process involved.

The recent definition of agronomy is the successful, sustainable, profitable, nutritionally secured, efficient crop production with least or no environmental degradation.

Agriculture is a science of farming. Scientific principles are employed to find ways of making it as efficient possible. Through scientific principles plants and animals are transformed genetically and most favorable environment is provided to harvest higher yields of good quality with least expense of energy. The scientific principles of various branches viz. soil science, genetics and plant breeding, entomology, plant pathology, microbiology, agricultural engineering etc. were employed in agriculture. Agriculture like any other science is a body of truths synthesized and systematized and arranged in such a way as to show the operation of general laws and principles.

Agriculture is an art which embraces knowledge of the way to perform the operation of a farm in a skillful manner. The physical and mental skills are involved in agriculture. The skills may be acquired through years of experience viz. ploughing, stacking hay bundles, handling animals, sowing, transplanting, driving a tractor etc.

Mental skills are those involved in decision making for example when to plough the land, selection of appropriate crops, seed selection etc.

Agriculture is a business: agriculture is no longer a way of living or subsistence agriculture where production is intended to meet the home requirements. Agriculture is intended to earn more income. Land, labour, capital are judiciously used. Like in any industry the farming industry should forecast the demand, tailor the production with demand to earn more profits. It involves processing, value addition, transportation, packing, storage in scientific way. Knowledge of employee and employer relationship or human resource management, export and imports, taxation, customs, tariffs and trade are required. All these aspects demand business knowledge in addition to the production and managerial skills. Traditional agriculture is no longer relevant for success in agriculture. Commercial Agriculture or Corporate Farming, Agri-Business Development Corporations demand entrepreneurs in agriculture rather than technologists alone.

Origin and History of Agriculture
Ancient Agriculture:

Agriculture has no single or simple date of origin

Man started hunting and gathering food which is most insecure for food. Hunting and gathering food can support 1man per sq km. He started rearing animals (pastoral stage) which can support three men per sq km, then shifted to plant culture which could support 100 men per sq km.

The primitive form of agriculture was shifting cultivation, in which man used the crudest tools, cut down a part of the forest, burnt the forest and started growing crops. After a few years when these plots lost fertility, choked with grass or bushes or became heavily infested with soil borne pests cultivators would shift to new site.

Subsistence agriculture: Grow it and eat it. It is the advanced form primitive agriculture. Hunting and gathering were subsidiary occupations

Nomadic population followed their flocks and herds in the seasonal pursuit of water, forage and shelter. Commercial ranching blended with subsistence farming. When land became limited farmers started Shifting cultivation.When land became limited shifting cultivation was changed to fallow rotation or legume rotation.

Mixed farming: field crops and animals, field grass husbandry. The same field is used for both cropping and grazing.

During nomadic period man come in contact with useful plants and animals and started domestication

Right to use land: inheritance of land – land is the security for livelihood. Arable land was divided based on topography. Seasonal cultivation of crops was practiced. During the cropping period the cattle were allowed to graze on a common grazing land in the villages. The byproducts of crops were used as feed for cattle.

Self sufficient agriculture village was the least common denominator of a permanent society. Later other crafts developed around agriculture. Down trodden people, slaves and bonded labour were the source of human labour.

Man first domesticated sheep and goat (8700-7700BC). Between 7500 to 6500BC man shifted from hunting/gathering food to agriculture. He was using pointed sticks, stone shoes with wooden handles to sow the seeds. Some of the land marks in the history of agriculture are

7500 BC – cultivation of wheat and barley. Seeds of wheat and barley were found at Jurmlo in Iraq which dates back to 6750BC

4400 BC – cultivation maize

3500 BC – cultivation of potato

3000BC to 1750 BC – Indus valley and Harappan civilization on the banks of river Indus. Huge granaries were excavated in these areas. Evidences of cultivation of barley, wheat, sesame, peas, date palm, cotton, lentil was found. Wooden plough and two wheeled cart were found.

2900 BC – plough was invented

2700 BC – silk month was domesticated in China.

2300 BC – chickpea, pear, sarson, and cotton were cultivated. Domestication of buffaloes and foul

2200 BC – Rice cultivation

1800 BC – Ragi cultivation

1725 BC – sorghum cultivation

1700 BC – Taming of horses

1500 BC – cultivation of sugarcane

Ancient literature Vedas have a mention of cultivation of cereals, vegetables, fruits, use of iron implements, ploughing, sowing seeds- broadcasting, fallowing, sequence cropping, use of dung as manure and irrigation.

Civilization flourished on the banks of rivers Nile, Tigris, Euphrates, Indus, Yellow river (in China). Dams were constructed across the rivers. Aswan dam across the river Nile dates back to 5000 years. Evidences of irrigation dates to 3300 BC

During 15th and 16th century AD many crop were introduced to India by Portuguese eg.

Potato, sweet potato, tomato, chillies, pumpkin, papaya, pineapple, guava, custard apple, groundnut, cashew nut, tobacco, American cotton, rubber, sweet and sour oranges, pomegranate, wild brinjal *etc.* Recently groundnut, sunflower and soybean were introduced to India.

Knowledge of agriculture acquired through experience transcended from generation to generation through intimate contacts and co-working with elderly people in the villages. Skills were inherited from generation to generation. Vedas, Vachanas, proverbs, quotes, and poems were the sources of information.

Early scientific thoughts of agriculture

Van Helmont (1577-1644 AD) – principle of vegetation is water.

John wood ward (1665 – 1728 AD) grew spring of mint in distilled and Hydepark conduit shaken with earth. The growth was more in the later. He concluded that the plants absorb terrestrial matter. Earth constitutes vegetation.

Jethro Tull (1674 – 1740 AD) –

Plants absorb soil particles through their roots

He realized the losses caused by the weeds. Invented horse hoe

Published new horse hoeing husbandry or an essay on the principles of tillage and vegetation,

Arthur Young (1741 – 1820 AD) conducted the pot culture experiments to increase the yield of crops by applying several materials like poultry dung, niter, gunpowder etc. He published all his findings in 40 volumes as Annals of Agriculture.

Lord Townshend popular as Turnip Townshend known for Norfolk rotation which comprises clover – wheat – turnip – barley

1809 – Humus theory which is the beginning of soil science

Sir Humphry Davy (1813 AD) published elements of agriculture chemeistry

Justus Von Liebig (1803 – 1873 AD)

Mineral theory of plant nutrition – simple analysis of plants and soil will provide reliable index fertilizer needs of the plant

Law of minimum – the growth of crop is determined by the quantity of what ever the factor which is least in supply in relation to the needs of the plant.

John Bennet Lawes (1814 – 1900 AD) developed superphosphate by treating rockphosphate with sulphuric acid in 1843. he stated that the phosphorus in bones could be made available by treating with sulphuric acid. J. H. Gilbert (1817 – 1901 AD) conducted the field experiments in the ancestral field of J. B. Lawes at Rothemstead near Herpenden in Heartfordshire. It is later known as Rothemstead Agriculture Experiment Station established in 1843 by Lawes and Gilbert.

The first state funded agricultural experiment station was established near Leipzig in Germany

J.B. Boussingault (1802 – 1882 AD) is known as father of field plot experimentation. He established a farm at Alsace in France during 1834 AD for conduct of field experiments. He stated plants obtain mineral nutrients from soil. He also maintained a balance sheet of nutrients taken from soil, rain water and air. He stated that the best crop rotation is one which produces more vegetative matter.

Laws of heredity and ways to cause mutation by G. J. Mendel (1866 AD) and heredity and inheritance proposed by Charles Darwin (1876 AD) caused major break through in the plant improvement.

Robert Ransome patented a cast iron share in 1785 AD and self sharpening share in 1803 AD.

Efficient seed drill was designed in 1830AD.

Tractor was successfully designed in 1892 AD which made tillage easier. Application of electricity in agriculture during 1920 AD.

Large scale manufacture of agriculture implements and machinery during 1930AD

Discovery of Bordeaux mixture by P M A Millerdet (1880 AD) and DDT by Paul Muller (1874 AD) were significant in the field of plant protection.

Development of agricultural in India

There were series of famines beginning from 1860 to 1900AD. The famine of 1896-97 AD is the greatest famine adversely affected the life of 69.5 million people in 3, 07,000 sq miles. On account of the famines there was acute shortage of food for human, fodder for cattle and raw material for the industry. In 1870 AD a joint department of agriculture, revenue and commerce was established. The famine commission was constituted by the British government upon the recommendation of which in the year 1880 AD a separate department of agriculture was established with the objective of increasing the production of food and raw materials for industries. Imperial Agricultural Research Institute was started at PUSA in Bihar during the year 1903 AD. Due to earthquake at Pusa the institute was shifted to New Delhi in 1936 AD. Later it was changed Indian Agricultural Research Institute (IARI). Upon the recommendation of Royal Commission on Agriculture, Indian Council of Agriculture Research (ICAR) was established in 1920 AD with its head quarter at New Delhi with the following objectives

- To promote research and education in agriculture, animal husbandry, fisheries and home science.
- To promote extension of knowledge in the field of agriculture, fisheries, animal husbandry *etc*.
- To undertake consultancy services in the field of research, education and dissemination of knowledge in the field of agriculture, animal husbandry, fisheries to government and other agencies
- To cooperate rural development activities concerning agriculture with other organizations *viz.* Indian Council of Social Science Research (ICSSR), Council of Scientific and Industrial Research (CSIR), Baba Atomic Research Centre (BARC) and other Universities.

ICAR is the apex body responsible for the organization and management of research and education in the fields of agriculture, animal sciences and fisheries in India. The minister of agriculture is the president of the ICAR. Its principal executive officer is director general. He is also secretary to the government of India in the Department of Agricultural Research and Education (DARE)

Research

ICAR has a net work of 45 central research institutes, 4 national bureaus, 9 project directorates, 30 national research centres, a national academy of agricultural research and management and 77 all India coordinated research projects in the country.

Education:

ICAR promotes and coordinates agricultural education in the country through technical and financial assistance to the state agricultural universities, postgraduate educational programmes in central institutes and schemes on manpower development and quality improvement.

With the assistance of ICAR 55 state agricultural universities and central agricultural university for NEH Region have been established in the country. These are responsible for promoting agricultural education, research and extension education at the state level.

Four ICAR institutes viz. IARI New Delhi, IVRI Izatnagar, NDRI Karnal and Central Institute for fisheries education Bombay have been conferred the status of deemed to be universities. These institutes besides research impart education at post graduate level in agriculture and animal sciences and also training in the specialized fields.

Agriculture development in Karnataka

Agriculture research and development in Karnataka was initiated by Leslie Coleman. There are 3 agricultural universities, one veterinary and animal and fisheries sciences university and a Horticultural Sciences university. Each university has colleges in different parts of the state which impart agricultural education. The zonal agricultural research stations under each university will carryout research to resolve location specific problems. The EEU, KVK, FTI, STU will extend the front line technologies developed in various fields of agriculture to the farmers.

Factors affecting crop production

Crop growth is influenced by internal factors and external factors. Internal factors are controlled by the genes and hereditary. External factors are climate, edaphic, biotic, physiographic and anthropic

Climatic factors:

Precipitation occurs in the form of rainfall, snow, hail and fog

Fog consists of water droplets so small that their fall velocity are negligible. Fog particles contact vegetation may adhere, coalesce with other droplets and eventually form a drop which is large enough to fall to ground.

Dew: during night there is loss of heat by radiation. Condensation of water vapour present in the air results in dew. Winter crops are efficient collectors and users of dew

Rainfall is the most important factor affecting the vegetation of place. Most of the crops receive their water supply from rain. The yearly precipitation i.e quantity, intensity and distribution largely influence crop growth.

Low and illdistributed rainfall is most common in dry lands wherein drought tolerant crops are grown.

Heavy and regular rainfall is the common feature in western ghats. High water requiring crops are grown eg coffee, cardmom, pepper, banana etc.

Desert : it is the least rainfall receiving area. Desert grasses and shrubs are common vegetation.

Drought: is condition of continuous lack of moisture so serious that crops fail to develop and mature properly

Adaptation to moisture situations:

Plants assimilate 0.1-0.3 per cent of the water absorbed from the soil.

Hydryphytes: aquatic plants which are grown in water. Swamp and bog plants.

They have spongy tissue. Stomata are numerous and located on the upper side of the leaves eg. Waterhyacinth, rice, eelgrass

Mesophytes: most common land plants. Stomata are more confined to or more numerous on the under side of the leaves. Root hairs are abundant. Root length and volume often equal or exceed top growth. True mesophytes wilt after loosing 25 per cent of their total water content. Xerophytic-mesophytes wilt after loosing 25 -50 per cent of their total water content.

Xerophytes: these are capable of enduring prolonged drought without injury. They will grow in a substrate which is depleted of water for growthto a depth of 20 to 25cm. They have modifications viz. reduced stomata, respiration, transpiration. In cati the carbon dioxide released during respiration stays in chlorenchyma tissue. It is reassimilated. Hydrophyllic cholloids in certain wheat varieties induce drought resistance. Due to bound water. During drought the expend not more than 2-10 per cent of the water absorbed.

Effects of excessive moisture:

- Limit oxygen supply
- Formation of toxic substances
- Leaching of nutrients eg nitrates
- Detrimental to germination, flowering, pollination and fruiting
- Continued turgidity, low transpiration,
- Disease incidence viz. rust, mildews,
- Curing and storing of produce hindered

Temperature

Temperature influences the following plant processes

Biochemical reactions

Uptake of carbon dioxide

Production of chloroplasts

Production of growth substances

Photosynthesis

Dry matter production

Germination

Leaf initiation

Leaf emergence

Leaf expansion

Flowering

Spikelet development

Grain development

Yield

Various biochemical process are associated with photosynthesis are controlled by temperature. Under high temperature photosynthesis become heat inactivated. Retardation of growth, adverse effects on fertilization at temperature below leathel limit.

Temperature is the measure of heat energy. The range of maximum growth for most agricultural plants I between 15-40^{o} C. Temperature of a place is largely determined by the distance from the equator (latitude) and altitude. Vegetation is classified into four classes based on the temperature requirement.

Megatherms: Equatorial and tropical, high temperature requiring eg rice, rubber, banana

Mesotherms: Tropical and subtropical, high temperature alternated with low temperature, eg maize, sorghum

Microtherms: Temperate and high altitude plants, low temperature requiring, wheat, oats, potato

Hekistotherms: Very low temperature requiring eg. Pines, spruce

Every plant community has its own minimum, optimum and maximum temperature known as cardinal points

Cordinal temperature of certain plants

Crops	Minimum	Optimum	Maximum
Wheat	3.8-4.4	24.9	29.9-32.2
Barley	3.8-4.4	19.9	27.7-29.9
Oats	3.8-5.0	24.9	29.9
Maize	7.7-9.9	31.6	39.9 -43.8
Sorghum	7.7-9.9	31.6	39.9
Rice	9.9-11.6	32.2	36.1-38.3
Tobacco	12.7-13.8	27.7	34.9

The minimum daily mean temperature at planting time for potato 7^{o}C , corn 14 ^{o}C, Cotton 17 ^{o}C. minimum temperature for germination of maize 4 ^{o}C, sorghum 9 ^{o}C, rice 9 ^{o}C,

Minimum temperature for growth initiation for sorghum 15-18 ^{o}C, optimum temperature for most temperate crops is 24-29 ^{o}C, maximum temperature 35-41 ^{o}C

Cool season crops fail to grow at an average temperature of 30-38 ^{o}C,

Wheat, potato, barley, oats require max temp of 30-38 ^{o}C, min 0-5 ^{o}C, optimum temp 20-30 ^{o}C

Warm season crops viz sorghum, maize, sugarcane, groundnut, redgram, cowpea, pearlmillet require maximum temp of 40-50 ^{o}C, minmum 15-20 ^{o}C, optimum temp. 30-38 ^{o}C.

Temperature effects on plants

Chilling injury: some plants growing in hot climate if exposed to low temperature (above freezing point) express chlorotic condition or bands on the leaves. eg sorghum, sugarcane, maize when exposed for 60hrs at 2-4 ^oC on the other hand cold loving plants viz. potato suflower tomato are unaffected.

Freezing injury: this is generally caused in plants growing in temperate regions. Water is frozen into ice crystals in the intercellular spaces. Frost damage in potato, tea are common

Suffocation: during winter ice or snow forma thick cover over the ground and the crop suffers for want of oxygen.

Heaving: injury to plants caused by a lifting upward of the plant along with the soil from its normal position in temperate regions where snow fall is common

Heat injury: very high temperature often stops growth. The plant faces incipient starvation due to high respiration rates. The plant is stunted. If such condition persists for a long period the plant is killed. Sterility of plants, young seedlings are killed, defoliation premature dropping of fruits are the adverse effects of high temperature

Vernalization: some plants require cold stimulus before they come for flowering. The cold treatment given to the sprouting seeds to effect the flowering is known as vernalization. Lysenko a Russian scientist proposed the incubation of sprouted seeds at temperature just above 0 ^oC for 2-3 weeks before sowing.

Thermoperiodism

The response of plants to rhythmic fluctuations in temperature is known as thermoperiodism. A number of physiological process *viz* germination, stem elongation, fruiting, floral development and increase in frost hardiness may proceed at most satisfactory rate under rhythem of alternating temperature.

Humidity: refers the the invisible water vapour present in the atmosphere. The air is said to be saturated when it holds maximum amount of water vapour at a particular temperature. The humidity in atmosphere is termed as relative humidity (RH)

Importance of RH

It is related to water relations in plant. Directly related to evapotranspiration

Indirectly related to leaf growth

Photosynthesis: when RH is low transpiration increases causing water deficits in the plant. Water deficit causes partial closer of the stomata and increases the mesophyll resistance thereby blocking the entry of carbon dioxide.

Pollination: when RH is high pollen dispersal from the anthers. Seed set is more at moderate RH than at high RH.

Pests: incidence of pests and diseases is high under high humidity. Under high RH fungal spores will germinate easily. Spread of blight disease of potato and tea is more rapid uner high RH. Aphid and jassid incidence is more under high RH.

Wind: the turbulence in the atmosphere is termed as wind. Moderate winds are essential for pollination, exchange of carbon dioxide in the canopy, winds also cause rains.

Adverse effects of wind:

High wind velocity increases transpiration, accelerates the desiccation of crop, reduce plant height, normal form and position of the shoot is permanently deformed when developing shoot is continuously exposed to wind from particular direction. Lodging of field crop, tearing of leaves, dropping of fruits, grain shedding, soil erosion, root exposure in deserts, spread of insect pests, spores of fungi. Wind also alters the balance fo hormones in plants wind increases ethylene production in barley and rice. Wind increases gibberilic acid content of roots and shoots in rice. Nitrogen concentration in both barley and rice increases with increase in wind speed.

Atmospheric gases:

Nitrogen of the atmosphere is directly used by symbiotic and asymbiotic nitrogen fixers. Carbon dioxide used by the plants during photosynthesis. Oxygen for respiration. The concentration of nitrogen, carbon dioxide and oxygen in air is 78.19, 0.03 and 20.95 per cent respectively. Sulphur dioxide and nitric oxide in atmosphere reach soil during rains improve soil fertility. Carbon dioxide enrichment of canopy improves crop productivity. On the other hand increase in concentratin of carbon dioxide, methane, nitrous oxide and fluorochlorocarbons in the atmosphere deplete ozone layer causing ultraviolet rays to reach earth and causes global warming.

Light:

Light is one of the most important factors influencing many vital plant processes.

Light is required for synthesis of chlorophyll pigment. Chlorophyll pigment is capable of absorbing radiant energy and converting it into potential chemical energy viz. carbohydrates through the process called photosynthesis. The photosynthesis is directly proportional to the amount of light. Other processes like seed germination, leaf expansion, growth of stem and shoot, production of tillers, branches, flowering, fruiting, root development, growth movements in plants.

Under low light intensity plants grow tall with weak stem which may cause lodging.

Plants obtain light from solar radiation which is the source for light and heat. Light efficiency in plants is less than 2 per cent.

The quality (wavelength and colour) the quantity (the intensity and duration of exposure to light) greatly influence the plant growth.

Quality refers to the wave length and colour. Of the total range of electromagnetic wavelengths in the solar spectrum, light or the luminous energy includes wavelengths between 400-750mμ (milli microns) or nm (nanometers). Quantity of light measured in g cal/m^2 /year. Lux: the light intensity from a standard candle at one m distance I a metre candle or lux.

Colour	Wave length	Effect on plants
Ultraviolet	<390 mμ	X rays and gamma rays. Very detrimental for growth accounts 0-4 %
Violet	400-435 mμ	Favorable for plant growth, Phototropism
Blue	435-490 mμ	Favorable for plant growth. Photosynthesis, blue is more efficient than red.
Green	490-574 mμ	Carbon dioxide assimilation
Yellow	574-595 mμ	Carbon dioxide assimilation
Orange	595-626 mμ	Carbon dioxide assimilation
Red	626-750 mμ	Carbon dioxide assimilation More favorable for plant growth
Infrared	>750mμ	Temperature will increase

Ecology, crop distribution and factors affecting crop distribution, adaptation of cultivated plants

Numerous investigations on soil, plant breeding, choice of species, introduction of new crops, tailoring agronomic requirements for crop production *etc.* are related to ecology.

Ecology: the term ecology is derived form the Greek word *Oikos* meaning house abode or dwelling. The term was first introduced by E. Haeckel. It is also called environmental biology. It deals with the study of plants/animals in relation to their environments. According to Odum (1969) it is the study of interrelationships between organisms and environment. Recently functional interrelationships or physiological relationships are considered.

Environment implies

Climatic factors- temperature, precipitation, atmospheric gases

Edaphic factors- parent material, soil

Biotic factors- other living organisms

Social factors- policies, restrictions, food habit of population, profitability of particular crop *etc*.

Billings (1952) introduced two more environmental factors

Geographic- soil erosion and deposition, topography, gravity, volcanisms

Pyric- fire

Plant ecology deals with plants in relation to their environment. There are two divisions under this

Autoecology deals with the ecology of individual species and its population including the effect of other organisms and environmental conditions on every stage of its life cycle.

Synecology deals with the ecology of plant communities. It involves the study of structure, nature, organization and development of plant communities.

Ecological crop geography is branch of crop ecology which deals with the broad spacial distribution of crop plants and the rationale of such distribution in terms of physical and socioeconomic environment influencing the production of crops.

Agroecology was proposed by Bensin (1930) which deals with the detailed study of commercially important crop plants by the use of ecological methods.

Environment is the sum total of effective conditions under which a plant community lives (Tasley, 1926).

Ecosystem

System means a unified whole made of regularly interacting or independent components.

Plants like animals do not live independently in nature. They are associated in biotic communities. The biotic community, the functional unit of a habitat which is held together and is inseparable by its members, its dynamics is known as ecosystem. In a ecosystem the living organisms and nonliving entities are inseparably related and continuously interacting. In an ecosystem there is exchange of materials between living and nonliving parts and one living community depends on the other for its survival. The components of the ecosystem according to Odum (1959) are abiotic substances, producers, consumers (heterotrophic animals) decomposers (heterotrophic bacteria, fungi).

Adaptation is any feature of an organism which has survival value under the existing condition of its habitat.

The basic of successful crop production is the selection of a adapted plants species and varieties. Plants may have morphological adaptation or physiological adaptation or both for the existing environment.

Morphological adaptations eg.Reduced leaf size, leaf number, number of stomata, depth of the root system, waxy coatings, spines *etc.*
Physiological adaptations eg. presence of arenchyma tissue in aquatic plants, resistance to pest and diseases *etc.*

The adaptation of crop plants to climate, soil, and economic situation determine the desirability of growing any crop in a particular region.

Crop Distribution

Principles of plant distribution:

Environmental factors greatly influence the natural distribution of plants. Plant geographer Good (1931) formulated principles of plant distribution.

1. The plant distribution is primarily controlled by the distribution of climatic conditions
2. The plant distribution is secondarily controlled by the distribution of edaphic factors
3. The great movements of floras have takenplace in the past and are still continuing (succession of floras as evidenced by the fossil records).
4. That the species movement (plant migration) is brought about by the transport of individual plants during their motile dispersal phases.
5. That there has been great variation and oscillation in climate, especially at higher latitudes, during the geological history of angiosperms.
6. That at least some, and probably considerable, variation has occurred in the relative distribution and outline of land and sea during the history of angiosperms.

The changes in the environment particularly climate resulted in plant movement and migration. This was explained by the Good's concept - specific tolerance according to which

1. Each and every plant species is able to exist and reproduce successfully only within a definite range of climatic and edaphic conditions. This range represents the tolerance of the species to external conditions
2. The tolerance of a species is a specific character subject to the laws and process of organic evolution in the same ways as is its morphological characters, but the two are not necessarily linked.
3. Change in tolerance may or may not be accompanied by morphological change, and *vice versa.*
4. Morphologically similar species may show wide differences in tolerance and species with similar tolerance may show little morphological similarity. The relative distribution of species with similar tolerance is finally determined by the result of competition between them.
5. The range of tolerance of any larger taxonomic unit is the sum of (or total range or extent of) the ranges of tolerance of its constituent species.

Shelford (1913) proposed *a* general law of tolerance

1. Organisms with wide ranges of tolerance for all factors of the environment are likely to be widely distributed

2. Organisms may have a wide range of tolerance for one factor and narrow range for another. When the conditions are not optimum for one factor the limit of tolerance may be reduced with respect to another factor.
3. The period of reproduction usually is critical when environmental factors are likely to be limiting.

Mason (1936) added that

1. The extremes of climatic conditions are more significant than the means, which emphasize the periphery, are limits of range where extremes of climatic factors are most likely to be limiting
2. Both dispersal and establishment are essential for plant migration
3. The tolerance theory should emphasize the factor function relationship.
4. During the life cycle of the plants certain critical phases have narrow tolerance range

Cain (1944) further strengthened the tolerance theory by adding

1. That the biotic factors may be important,
2. That the environment is holocoenotic and
3. That the tolerance has a genetic basis

Biotic factors exert direct influences on plant distribution eg. obligate insect pollination, seed dissemination, grazing by livestock

Billings (1952) stated holocoenotic concept for plant distribution. He emphasized the importance of tolerance of plants to components of climatic, edaphic, and biotic factors for plant distribution.

1) Climatic- fire, water, wind pressure, atmospheric composition, cosmic radiation, solar radiation, terrestrial radiation, temperature
2) Edaphic- soil, parent material, gravity, rotational forces, topography and geographic position etc.
3) Biotic – man, animals, other plants,

Limiting factors play a significant role in the distribution of plants

- Law of Minimum (Liebig, 1840) – the growth of the plants is dependent on the amount of food stuff (or element) presented to it in minimal quantity
- Taylor (1934) included environmental factors in addition to the nutrients. The most critical season of the year, the most critical year of the climatic cycle and the critical stages of development (germination, anthesis) .
- Blackman (1905) developed the "Theory of optima and limiting factors." – according to which "when a process was conditioned to its rapidity by a number of factors, the rate of the process was limited by the pace of the slowest factors".
- Lundegardh (1931) emphasized as a factor increases in intensity its relative effect on the plant growth decreases. This principle is sometimes called "Law of relativity"
- Livingston and shreve (1921) proposed the concept of "Physiological limits" according to which for every vital function there is maximum and aminimum zero point with respect to any conditioning factor, beyond which the function ceases. Further for every distinct

climatic area there appears to be a corresponding type of vegetation and this principle is probably of primary importance in the study of plant distribution.

- Odum (1969) attempted to combine these three theories. Plants appear to be controlled by three forces

1) Quantity and variability of materials for which there are minimal requirements
2) Physical factors which are critical
3) Limits of tolerance of the plants themselves to these and other factors of the environment.

- Cain (1944) who noted that "The capacity of the species to tolerate or respond to its environment is governed by the laws of evolution and genetics, and the range of tolerance is the direct result of the diversity of the species".

Centers of origin of cultivated plants

The process of cultivation itself improved the plants taken from wild. de Candole (1882) tried to trace the ancestors of the cultivated plants by using two criteria

- Occurrence of a given cultivated plant in a locality where it also grows wild or where wild relatives were found
- Using information from archaeology, history and linguistic evidences

According to Mendel (1965) the present day cultivated plants originated by hybridization and selection.

Vavilov (1951) established the principle that "the distribution of plant species on the earth is not uniform. The success attained by Vavilov in locating the principal geographic centres of origin of cultivated species may be attributed to

- extensive cultivation of cultivated plants
- Thoroughly studied the collected plants

Vavilov recognized **eight primary centres** of origin based on the

- Diversity of heritable forms
- Based on certain endemic varietal characters
- Presence of closely related wild or cultivated forms
- Presence of genetically dominant characters generally in the core of the centres of origin
- Archaeological, historical and linguistic evidences

A great diversity of species was found which is of later development in the region other than primary centre known as the **secondary centre** (Harlon 1951).

Agro – ecological groups or gene microcenters are the smaller centres within a main centre (Vavilov).

Soil Management

Importance:

Successful farming concerns the appropriate management of soil, plants and environment in such a way that a maximum return can be obtained not only in a season or year but also over centuries. The physical, chemical and biological properties of soil and their modifying factors regulate the present and future state of soils, the source of infinite varieties of life. The most important consideration in soil management is the correct application of the relationships among the soil, the environment and the crops to be grown.

There is no substitute for soil for crop production. The soil is the precious natural gift. The land is not unlimited. The per capita availability of is 0.13ha. There is no scope for horizontal expansion but only way is to increase productivity through judicious soil management. Soil is not inherited from out ancestors but borrowed from our future generations. It should be returned without impairing the quality.

The problem of soil management vary according to soils and their situation in the land, the climatic conditions, biotic influences and crops to be grown, yet there are fundamental factors which govern the choice of a suitable soil management practice.

What are good soil management practices?

Good tilth is the first feature of good soil management. It means a suitable physical condition of the soil and implies in addition a satisfactory regulation of soil moisture and air.

The maintenance of soil organic matter which encourages granulation is an important consideration of good tilth.

Tillage operations and timings should be adjusted as to cause the minimum destruction of soil aggregates. Good tilth minimizes erosion hazards.

The choice and sequence of adaptable crops or crop rotation are other very important considerations. These are related to climate, particularly rainfall and its pattern of distribution and the characteristics of the soil profile, including drainage and extent and duration of available soil moisture. A proper sequence of crop varieties greatly influences soil conditions. It is more realistic to evolve cropping patterns and land management practices according to land capability. Cropping patterns chosen and management practices adopted should aim at soil and moisture conservation for efficient nutrient and moisture utilization.

In irrigated areas, special management practices become necessary to avoid salinity, alkalinity, water logging, leaching and the loss of plant nutrients. In rainfed areas special management practices include improving soil conditions to receive, retain and release more soil moisture., harvesting water to use as life saving irrigation or extending the cropping season when there is insufficient rainfall for raising crops, protecting the soil from degradation both in cropped and bare fields. Land shaping and leveling mulching and the use of wind brakes and vegetative cover are the other major aspects.

The productive capacity of the soil should never be allowed to diminish, but rather should be improved and maintained by providing adequate organic manures and plant nutrients through fertilizers and by including legumes in the rotation and the use of biofertilizers. Similarly the provision of irrigation facilities in semi arid and arid areas, the adoption of different remedial measures against excessive salinity and alkalinity or acidity in humid areas, the use of specific soil amendments to correct imbalances of plant nutrients and the application of micronutrients where they are deficient.

Economic plant protection measures against pests, pathogens and parasites including weeds should form part of the management practices in the cropping system. This can be achieved by following recommended cultural practices or by application of pesticides/fungicide/herbicides.

The management practices adopted should be economically profitable and emphasis should be laid on maximizing sustained income rather than yields for the time being. An integrated land plan including all the above points and economically profitable should be developed for individual situations.

Results of bad soil management

- Soil erosion : tillage practices should be oriented to conserve soil and water
- Soil exhaustion: avoid continuous cultivation of exhaustive crops, regular use of organic manures and fertilizers
- Salt accumulation: poor drainage, use of poor quality water, toxic substances from synthetic fertilizers and agro industrial wastes
- Infestation with perennial weeds:
- Structure of the soil is spoiled
- Lower productivity and profits

Requirements of ideal seed bed

1) An ideal seed bed is one which sustains all stages of crop growth and development starting from germination and emergence to maturity without great deterioration and depletion.
2) Seed bed should be free from large clods, crop residues and established weeds
3) Should be properly leveled and of a desirable physical state with the correct moisture content for good growth and yield of crop
4) There must be provision for adequate irrigation channels and drainage
5) The soil should be supplied with basal dose of manures and fertilizers
6) Stiff stubbles, stalks and other readily decomposable organic matter should be removed otherwise they may invite infestation of pests and pathogens.
7) Granulation should be retained. Avoid excessive tillage than the required. Poor granulation encourages soil erosion.

8) Depth of tillage should be need based
9) There must be adequate moisture and air supply in the seed bed.
10) Rough seed beds are favored for winter and large seeded crop Firmer and shallower seedbed for fine seeded crop. For soil moisture conservation fine seed beds during summer in light soils is essential.
11) Unweathered cloddy soil should not be brought to the surface by deep tillage.
12) Loose granular seed bed for drylands while puddle seed bed for wet lands
13) Seed beds should be prepared quickly to avoid loss of moisture. Soil moisture loss can be prevented by breaking and sealing of pores and also by reducing exposed area by leveling by planking or harrowing
14) Manures and fertilizers applied should be thoroughly mixed into the soil.
15) Proper land shaping and configuration is essential for soil moisture conservation for example ridge and furrow, broad bed and furrow or flat bed depending upon the situation and crop requirement.

Good soil management practices

- Good tilth
- Control of weeds
- Maintenance of adequate levels of organic matter
- Adequate supply of plant nutrients
- Control of pests and pathogens
- Adoption of soil and water conservation practices
- Adoption of suitable crop rotation
- Providing drainage
- Alleviating the soil from excess salts, acidity, toxic substances.

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

Tilth is the physical condition of the soil resulting from tillage. Soil is said to be in good tilth when it is mellow friable and adequately aerated.

Tilth is dynamic. Mechanical forces may change the roughness of the soil surface, the total porosity and bulk density of the tilled layer and the aggregate or clod size. Heavy rainfall and high velocity wind or water destroys the tilt for soil moisture conservation h.

The action of wetting and drying, freezing and thawing regenerates desirable tilth.

The roughness of the soil surface is an index of the amount of water that can be stored in soil depressions and may also be related to the resistance of the soil surface to sealing. Roughness may be related to rates of evaporation and transfer of heat and air between the soil and atmosphere.

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Objectives of tillage

The primary purpose of tillage is often to reduce the aggregate or clod size. Aggregates must be small enough to achieve good contact between the roots of the seedlings and soil in order to prevent drying of the soil, to provide sufficient soil solution, aeration. Yet the aggregates should not be so finely divided as to encourage sever crusting when dry.

1) To provide suitable seed bed for sowing the seeds necessary for germination and emergence of seedling or for transplanting seedlings or planting materials. Fine seed bed is desirable for smaller sized seeds while rough seed bed is enough for larger seeds.
2) To control of weeds, pests and diseases
3) The residues of the previous crop are incorporated into the soil.
4) To improve the physical condition of the soil viz. structure (development of granular structure), porosity and bulk density, aeration, water holding capacity, infiltration and reduction in run off. The hard pans are broken during ploughing which facilitate greater infiltration and root penetration into deeper layers. The positive influence of tillage on these properties will ultimately reduce soil erosion.
5) To improve the nutrient availability by physical process
6) To hasten the chemical and biological processes in the soil. This in turn has impact on the activity of microorganisms and organic matter decomposition.

Effect of tillage on soil temperature, soil moisture and root penetration

1) **Soil temperature**: tillage influences soil thermal properties. Loosening the soil decreases the heat capacity because of larger volume fraction of soil air. Thermal conductivity is decreased with decreasing fraction of solids and increased with increasing water content. Loosening the soil often results in a larger difference between maximum and minimum temperatures but this may be comparatively less than air temperature. Soil temperature affects germination, nutrient availability, plant development, grain yield and nutrient content of grains.
2) **Soil moisture**: tillage may have marked influence on soil moisture through its effect on infiltration, run off, temporary surface storage internal storage and availability to plants. Roughness of soil surface is an index of the amount of water that can be stored in depressions and may also related to resistance to sealing. Tillage creates uneven micro-relief which can store considerable water in the small depressions for later infiltration. Once water enters the soil its rate of movement will depend on the internal transmission characteristics of the profile. Increased porosity from tillage may act as an important reservoir for temporary storage of water during rains. The amount water retained by a soil may be influenced by the soil density and aggregate size. Ploughing or loosening a dense soil provides pores which can store water and may increase the storage capacity. In loose soils when surface soil is dry water vapor moves to surface. If there is rainfall infiltration is higher. In compact

soil at relatively higher moisture content there will be greater conductance of water to the evaporating surface.

3) **Soil aeration:** Soil aeration is the mechanism of exchange of oxygen and carbon dioxide between soil pore space and the atmosphere in order to prevent the deficiency of oxygen and toxicity of carbon dioxide. Respiration by plant roots and microorganisms depletes oxygen and releases carbon dioxide and minute quantities of other gases into the soil atmosphere. The amount of carbon dioxide varies widely depending on temperature, organic matter and microbial respiration. A constant inflow of oxygen and out flow of carbon dioxide is essential for plant growth. Loosening a dense soil facilitates exchange of gases between soil air and atmosphere. Air filled pores commonly fluctuate from 15 to 30 per cent of the total volume depending upon water content, soil density and structure.

<u>Causes of poor soil aeration</u>

1) Compact soil
2) Water logging
3) Soils having excessive amount of readily decomposable organic matter
4) Harmful effects of poor aeration
5) Microbial activity is reduced, slow decomposition of organic matter
6) Rhizobium cannot symbiotically fix atmospheric nitrogen
7) Abnormal development of roots ex: sugarbeet and carrot
8) Anaerobic bacteria decompose soil organic matter in the complete absence of oxygen release toxic substances like sulphides which are harmful to crop plants

9) **Root penetration:** plant roots can exert tremendous forces in penetrating the soil. In packed soils pore size may be too small for root tips to enter. Critical pore size varies with kind of plant, but there are pore diameters below which roots may not penetrate. Pore rigidity as well as size will affect the root penetration.

Types of tillage

Clean tillage / conventional tillage/ traditional tillage: is one wherein 100 per cent of the top soil is mixed or inverted.

Conventional tillage has been defined as combined primary and secondary tillage operations performed in preparing the seed bed.

With clean tillage all the plant residues are removed and buried. The growth of weeds is prevented.

Suitability

- Adopted in Class I lands

Advanatages

- Weeds are efficiently controlled
- Crop residues are thoroughly incorporated
- Better microbial activity

Disadvantages:

- More energy requirement
- Greater loss of soil moisture
- Formation of hard pan
- Surface soil is more prone to erosion

Modern concepts of tillage

- Minimum tillage:
- Zero tillage
- Conservation tillage
- Stubble mulch tillage
- Blind tillage

Minimum tillage may be defined as a group of soil preparation methods for planting in which the number of tillage operations over the field is less than conventional tillage. This can be achieved by omitting the tillage operations which do not give much benefit when the compared to the cost. For example combining seeding and fertilizer application, row zone tillage, plough plant tillage, wheel track planting

Suitability

- Medium textured soils

Advantages

- Reduced soil compaction
- Better soil conservation
- Energy requirement is less
- Reduced labour and machinery
- Time saving

Disadvantages

- Low seed germination and establishment. Difficulty in sowing
- Nodulation is adversely affected
- Use of herbicides is indispensable
- Decomposition of organic matter is slow
- Perennial weeds may become dominant

Zero tillage is an extreme form of minimum tillage. Primary tillage is completely avoided and the secondary tillage is restricted to seedbed preparation in the row zone only. Planting is done in previously unprepared soil by opening a narrow slot or trench or band only of required width and depth for sowing and covering the seed or seedling.

Weeds are taken care by using broad spectrum nonselective and non-persistent herbicide before sowing subsequent to sowing by using selective and persistent herbicides.

Till planting is one of the zero tillage method in which heavy machineries are used to clean a narrow strip over the crop row. Then a narrow band of soil is opened. Seeds are placed and covered.

Advantages

- Saving in energy, labour and time
- Reduced compaction
- Increased earthworm activity and soil organic matter
- Disadvantages
- Difficult establish optimum crop stand
- Mineralization of soil organic matter is slow
- Nitrogen requirement of crops is high
- Build up of perennial weeds and pests

Conservation tillage is the tillage operation performed to reduce soil erosion and to conserve soil moisture is referred as conservation tillage. This is achieved by covering the soil at least by 30 per cent of the surface by the crop residue. Conservation tillage operations include reduced tillage operations like minimum tillage, no tillage, mulch tillage.

Stubble mulch tillage is method of tillage in which a mulch crop grown during the fallow period or the stubbles of the previous crop are uprooted and brought to the surface and spread during tillage operation. The main objective is to protect the soil from erosion.

Suitable in sloppy areas and drylands

Advantages

- Reduced loss of soil and water
- Improved organic matter content

Disadvantages

- Less effective weed control
- Stubbles interfere in sowing operation

Blind tillage is the tillage of the soil after sowing a crop either before the crop plants emerges or while they are in early stages of growth. It is extensively employed in sorghum and drilled paddy where emergence of crop seedlings is hindered by soil crust formation on receipt of rain or by irrigation immediately after sowing. Shallow harrowing with entire blade harrow without disturbing the emerging crop seedlings will loosen the soil crust and help in emergence of seedlings. Generally weed seedlings emerge within two to three days after sowing while many cereals take 7 to 8 days for seedling emergence. By blind tillage weeds are killed at their early stages.

Planting materials

Plants are propagated by asexual/ vegetative method and sexual method

Vegetative method: parts of the plant other than the seed is used

1. Apomictic embryos: development of an embryo from cell other than a fertilized egg. eg citrus
2. By runners or stolons: long slender side branches grow above ground. At each node shoots and roots develop ex: straw berry, white clover
3. Layerings: apple, pomegranate
4. Suckers: is a laterally growing subterranean off shoot from the base of the main stem of a plant ex: cardamom, banana
5. By separation
6. Bulbs : onion, garlic, cloves
7. Corms: swollen base of a stem axis with distinct nodes and internodes ex: ginger, turmeric, gladiolus
8. By division: specialized stem structures ex: pineapple, canna
9. Offsets: pseudo bulb is long and jointed with many nodes. Offsets are developed at these nodes. Roots develop from the base.
10. Tubers: potato
11. Tuberous roots: sweet potato
12. Crowns: straw berry
13. Cuttings: red raspberry, lemon,
14. Stem cutting: rose, sugarcane, drum stick
15. Rooted slips: basal two are three internodes of the stem with a few roots ex: paragrass, guinea grass, hybrid napier
16. Leaf cutting: bignonia
17. Grafting : mango
18. Budding: rose, mango, grape
19. Micro propagation:
20. Meristem cultures: orchids
21. Tissue culture: tobacco, potato, banana

Seed is a plant embryo in a dormant state, surrounded by a food supply and protective outer skin or seed coat. Seed is produced after flower has been fertilized. Seed is a fertilized ovule.

Seed has three parts

a) Cotyledons/ embryonic leaves
b) Embryo: from which growth commences
c) Seed coat: protective covering

Embryo has two parts:

a) Radicle: which grows downwards and gives rise to root of new seedling.

b) Plumule: grows upwards gives rise to shoot or stem. Always the radicle starts growing first and then the plumule.
c) Hilum: the scar on the groove of the seed by which the seed is attached to the pod
d) Micropile: minute opening through which the seed absorbs water.

Characters of good seed

1. Seeds must be true to type they must belong to the proper variety or strain of the crop which is proposed to grow
2. Seeds must be healthy , free from inhert materials, weed seeds or other crop seeds
3. Seeds must be uniform in size, shape and colour
4. They must be viable, high germination percentage
5. Free from pests and disease causing organisms
6. The seed packet must have label

Four generation scheme is in effect in producing certified seeds

1. <u>Breeder seed or nucleus seed</u> : Produced by the originating or sponsoring breeder or institution so grown and managed as to maintain the cultivar characteristics
2. <u>Foundation seed</u>: produced fro fields planted with breeder seed and so handled as to maintain the genetic identity and purity of the cultivar. It is the source of all certified seed either directly or through registered class
3. <u>Registered seed</u>: the progeny of foundation seed so handled as to maintain genetic identity. Registered seed is of a quality suitable for the production of certified seed
4. <u>Certified seed</u>: the progeny of foundation or registered seed that has been handled so as to maintain satisfactory genetic purity and that has been approved and certified by the certifying agency.

Depth of sowing:

If sown shallow the top layer of the soil desiccates very quickly in dry weather deep sown seeds take more time for emergence of seedlings. The food stored in the seed may be exhausted for hypocotyls growth before the plumule reaches land surface. There may be failure of emergence.

Big seeds : French bean, maize, Bengal gram sown to a depth of 7.5 cm

Medium seeds : upto 5 cm deep

If shallow sown seeds are picked by the birds,

NATIONAL AND INTERNATIONAL AGRICULTURAL RESEARCH INSTITUTES IN INDIA

National institutions for Agricultural Research

Central Arid Zone Research Institute (Czari), Jodhpur-3, Rajasthan

Central Institute for Cotton Research (CICR) Nagpur, Maharastra.

Central Institute of Agricultural Engineering, Bhopal, M.P.

Central Institute of Brackish Water Aquaculture. Chennai, Tamilnadu.

Central Institute of Fisheries Technology, Cochin , Kerala

Central Marine Fisheries Research Institute, Cochin, Kerala

Central Plantation Crops Research Institute, Kasaragod, Kerala.

Central Potato Research Institute, Kufri, Shimla, H.P.

Central Research Institute for Dryland Agriculture, Hyderabad, A.P.

Central Research Institute for Jute and Allied Fibres, Barrackpore, W.B

Central Rice Research Institute , Cuttack, Orissa.

Central Sheep and Wool Research Institute, Malpura, Rajasthan

Central Soil and Water Conservation Research and Training Institute, Dehradun, Uttaranchal

Central Soil Salinity Research Institute Karnal, Haryana

Central Tobacco Research Institute, Rajamundry,A P

Central Tuber Crops Research Institute, Thiruvaanthapuram, Kerala

Indian Agricultural Research Institute, Newdelhi

Indian Agricultural Statistical Research Institute, Pusa, New Delhi

Indian Grassland and Fodder Research Institute, Jhansi, UP

Indian Institute of Horticultural Research, Hassargatta, Bangalore

Indian Institute of Pulses Research , Kanpur, UP

Indian Institute of Soil Science, Bhopal, MP

Indian Institute Of Spices Research, Calicut, Kerala

Indian institute of sugarcane Research, Lucknow, UP

Indian Lac Research Institute, Ranchi, Bihar.

Indian Veterinary Research Institute, Izatnagar, UP

Jute Technological Research Laboratories, Calcutta

National Bureau of Plant Genetic Resources, Pusa New Delhi

National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharastra

National Research Centre for Banana, Trichy, Tamil Nadu

National Research Centre for Oil palm, Eluru

National Research Centre for Weed Science, Jabalpur MP

Sugarcane Breeding Institute Coimbatore, Tamil Nadu

Important International Institutions on Agricultural Research

AVRDC- Asian Vegetable Research and Development Centre, Taiwan

CIAT – Centro International de Agricultura Tropical , Cali, Colombia

CIP – Centro International da la Papa (International potato research institute (Lima, Peru, South America)

CIMMYT – Centro International de Mejoramiento de Maizy Trigo.(International Centre for maize and Wheat development (Londress, Mexico)

IITA –International Institute for Tropical Agriculture, Ibadon in Nigeria, Africa)

ICARDA – International Center for Agricultural Research in the Dry Areas (Aleppo, Syria)

ICRISAT – International Crops Research Institute for the Semi Arid Tropics (Pattancheru in Hyderabad, India)

IIMI- International Irrigation Management Institute, Colombo, SRILANKA

IRRI – International Rice Research Institute (Los Banos, Philippines)

ISNAR- International Service in National Agricultural Research The Hague, Netherlands

WARDA - West African Rice Development Association Ivory coast, Africa.

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

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

FAO – Food and Agricultural Organization, Rome

WMO- World Meteorological Organization, Vienna,

Agro-Ecological Regions of India

Ecosystem	Region	States represented	Ecoregion	Soil type	LGP	Crops
Arid	1.Western Himalayas	Jammu & Kashmir, Himachal Pradesh	Cold arid	Shallow Skeletal	<90	Potato, Apple
	2.Western plain, Kutch and part of Kathiawar Peninsula	Gujarath, Rajasthan, Haryaana, Punjab	Hot arid	Desert & Saline	<90	Bajra, Matki, Chickpea
	3.Deccan Plateau	Andhra Pradesh, Karnataka	Hot arid	Red and Black	<90	Groundnut, Millets, Bajra/ Jowar, Redgram, Greengram
Semi Arid	4.Northern plains and Central Highlands including Aravallis	Gujarath, Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab	Hot Semi-arid	Alluvium-derived	90-150	Wheat, Chickpea, Rice and Sugarcane
	5.Central (Malwa) Highlands, Gujarath plains and Kathiawar Peninsula	Gujarath, Madhya Pradesh	Hot Semi-arid	Medium & deep black	90-150	GN, redgram, castor, cotton, chickpea, Horticulture crops
	6.Deccan Plateau	Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh	Hot Semi-arid	**Shallow & medium (with inclusion of deep) black**	90-150	Redgram, Cotton, Banana, Ginger, Sugarcane
	7.Deccan (Telangana) Plateau and Eastern Ghats	Andhra Pradesh	Hot Semi-arid	Red and Black	90-150	Redgram, Cotton, Sorghum, Castor
	8.Eastern Ghats, Tamil Nadu uplands and	Karntaka, Tamil Nadu, Kerala	Hot Semi-arid	Red loamy	90-150	Cotton, Rice, Ragi, Pulses, Maize, oil seeds

Ecosystem	Region	States represented	Ecoregion	Soil type	LGP	Crops
	Deccan (Karnataka)Plateau					
Sub humid	9.Northern plain	Bihar, Punjab, Uttar Pradesh	Hot sub humid (dry)	Alluvium-derived	150-180	Wheat, Rice, Sugarcane
	10.Central Highlands (Malwa, Bundelkhand & Eastern Satpura)	Madhya Pradesh, Maharashtra	Hot sub humid	Black & Red	150-180 (to 210)	Soybean, Chickpea
	11.Eastern Plateau (Chattisgarh)	Madhya Pradesh	Hot sub humid	Red & Yellow	150-180	Soybean, Millets, Cotton, Chickpea
	12. Eastern (Chhota Nagpur) Plateau and Eastern Ghats	Orissa, West Bengal, Bihar, Madhya Pradesh, Maharashtra	Hot sub humid	Red and lateritic	150-180 (to 210)	Rice, Millets
	13.Eastern plain	Uttar Pradesh, Bihar	Hot sub humid (moist)	Alluvium derived	180-210	Sugarcane, Rice, Chickpea
	14.Western Himalayas	Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh	Warm sub humid (to humid wirh inclusion of per humid)	Brown forest and podzolic	180-210+	Wheat, Potato
Humid-per humid	15.Bengal and Assam plains	West Bengal, Assam	Hot sub humid (moist) to humid (inclusion of per humid)	Alluvium derived	210+	Rice/ Jute
	16.Eastern Himalayas	Arunachal Pradesh, Sikkim, West Bengal	Warm per humid	Brown and Red soil	210+	Tea, Maize, Paddy

Ecosystem	Region	States represented	Ecoregion	Soil type	LGP	Crops
	17.North Eastern Hills (Purvanchal)	Tripura, Mizoram, Meghalaya	Warm per humid	Red and lateritic	210+	Tea, Paddy, Maize, Forest
Coastal	18.Eastern Coastal plain 19.Western Ghats & Coastal plain	Tamil Nadu, Pondicherry, Andhra Pradesh, Orissa, West Bengal Kerala, Goa, Daman & Diu, Maharashtra, Gujarat, Karnataka	Hot sub humid to semi arid Hot humid per humid	Coastal Alluvium derived Red, lateritic and Alluvium derived	90-210+ 210+	Rice, Coconut Rice, Spices, Cashew, Coconut
Island	20. Island of Andaman-Nicobar and Lakshwadweep	Andaman- Nicobar and Lakshadweep	Hot humid per humid	Red loamy and sandy	210+	Coconut, Rice

Agroclimatic regions of India

Agroclimatic regions	States	Soil type	Strengths	Weakness
1.Western Himalayan Region	Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh	Shallow skeletal soils of cold region, mountain meadow and hilly brown soils, silty loams		Low productivity
2.Eastern Himalayan Region	Sikkim & Darjeeling hills, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Tripura, Mizoram, Assam, Jalpaigari & Cooch behar districts of West Bengal		High potential of agricultural, forestry and horticulture	Severe erosion and degradation due to heavy rainfall
3.Lower Gangetic plains	Constitutes four regions of West Bengal	Alluvial soils		Accounts for 12% of rice production of the country frequent floods.

Agroclimatic regions	States	Soil type	Strengths	Weakness
4.Middle Gangetic plains	Eastern Uttar Pradesh, Bihar		Cropping intensity 14 2%	61% of the area under rainfed farming. Low rice productivity.
5.Upper Gangetic plains			Cropping intensity 144% productivity of rice and wheat is high. This zone has 130% irrigation intensity	Problem soils about 9 lakh ha.
6.Trans Gangetic plains region	Punjab, Haryana, Union Territory of Delhi, Chandigarh and part of Rajasthan		Highest net sown area irrigated area, cropping intensity. Scope for increasing productivity.	
7.Eastern Plateau & Hills region	Madhya Pradesh, Orissa, Chotta Nagpur, Chathisgarh	Shallow to medium deep soils		Low crop productivity due to low rainfall slope 1-10% erosion
8.Central Plateau & Hills	Madhya Pradesh, Uttar Pradesh, Rajasthan			Topography is highly variable 30% of the land not cultivable. 75% of the area under rainfed cultivation.
9.Western Plateau & Hills	Madhya Pradesh, Marashtra, Rajasthan and Peninsular India			Major is under dry farming, irrigated area 12%, Soreghum and Cotton are the major crops.
10.Sothern Plateau & Hills	Andhra Pradesh, Karnataka, Tamil Nadu			Typical semi arid zone 80% area under rainfed farming. Low cropping intensity.
11.East Coast plains and Hills region	Orissa, Andhra Pradesh, Tamil Nadu, Tanjavur	Soils are deep loam, coastal and deltaic alluvial type	Contributes 20% rice production of India	70% area under rainfed agriculture
12.West Coast plain	Tamil Nadu, Kerala,	Shallow and	Tapoaca, Rice,	

Agroclimatic regions	States	Soil type	Strengths	Weakness
& Ghats region	Karnataka, Maharashtra, Goa	Medium loamy and red and lateritic soils	Coconuts, millets	
13. Gujarath plains and hills	Gujarath	Black soils	Groundnut, cotton and castor	
14.Western Dry Region	Rajasthan		Cultivable wasteland 42% and live stock development are important	Erratic rainfall, high evaporative demand, extreme temperatures 0-45 degree Celsius in summer scanty vegetation, rainfall 4000 mm.
15.Island region	Andaman, Nicobar and Lakshwadeep	Medium to deep soils and red loamy and sandy soils	High rainfall 3000 mm or more for 8-9 months. Forest, coconut and rice are important	

Agroclimatic Zones of India and Karnataka

For the development of agriculture on more scientific basis, taking into account the agro-climatic conditions such as rainfall, soil type, vegetation etc., the country has been divided into 15 agro-climatic zones having different production potentials as well as constraints. Further, these zones have been sub divided into 127 regions, which need location specific technologies. Accordingly production programmes have to be tailored scientifically to agro-climatic zones.

Sl.No.	Zone	States/Areas
1.	Western Himalaya	Jammu & Kashmir, Parts of Himachal Pradesh, Hills of Uttar Pradesh, Western Punjab.
2.	Eastern Himalaya	Arunachal Pradesh, Himachal Pradesh, West Bengal, Assam, Nagaland, Manipur, Tripura
3.	Lower Gangetic plains	West Bengal plains
4.	Mid Gangetic plains	S&N Bihar plains, Eastern Uttar Pradesh
5.	Upper Gangetic plains	Central Uttar Pradesh, North Western Uttar Pradesh, South Western Uttar Pradesh
6.	Trans Gangetic plains	Delhi, Punjab plains, S&N Punjab, Rajasthan, Sriganganagar area
7.	Eastern Plateau & Hills	Bihar, Chhotanagpur plateau, West Bengal Plateau, Orissa inland, Chattisgarh area of Madhya Pradesh, Hills of Maharashtra
8.	Central Plateau & Hills	Bundelkhan of Uttar Pradesh, Northern plains, Plateau of Madhya Pradesh, Central Plateau, Hills of Madhya Pradesh, Vindyan Hills, Palteaum Hills of Madhya Pradesh, Rajasthan
9.	Western Plateau & Hills	Khandesh, Marathwada, Vidharbha of Maharashtra, Malura of Madhya Pradesh

10.	Southern Plateau & Hills	Telangana, Rayalaseema, Chittor of Andhra Pradesh, Tamil Nadu Inland, S&N Plateau of Karnataka
11.	East Coast Plains	Coastal Orissa, Andhra Pradesh, Tamil Nadu and East Coast delta in Tamil Nadu, Pondicherry
12.	West Coast Plain & Ghats	West Coast, Nilgiris of the Tamil Nadu, Kerala, Coastal and Western hills of Karnataka, Konkan of Maharashtra, Goa
13.	Gujarat Plains & Hills	Gujarat plains and hills
14.	Western Dry Region	Western dry areas
15.	Islands	Andaman Nicobar, Lakshadweep, Minicoy and Aminidivi islands.

AGROCLIMATIC ZONES OF KARNATAKA

Sl.No.	Zones	Rainfall range in mm.	Elevation	Soil
1	North Eastern Transition zone(7 taluks)	829.5 to 919.00	800-900 in major areas ,450-800 parts of 6 taluks	Shallow to medium black clay soils in major areas. Red lateritic soils in remaining areas.
2	North Eastern Dry Zone (11 taluks)	633.22 to 806.6	300-450 in all taluks	Deep to very deep black clay soils in major areas. Shallow to medium black soils in minor pockets.
3	Northern Dry Zone (35 taluks)	464.5 to 785.7	450-800 in 26 taluks, in remaining talukas 800 to 900	Black clay medium and deep in major areas, sand loams in remaining areas.
4	Central Dry Zone (17 talukas)	455.5 to 717.4	800-900 in major areas, in remaining areas 450-800.	Red Sandy loams in major areas, shallow to deep black soil in remaining areas.
5	Eastern Dry Zone (24 taluks)	679.1 to 888.9	800-900 in major areas, in remaining areas 900-1500.	Red loamy soils in major areas, clay lateritic soils in remaining areas.
6	Southern Dry Zone (18 taluks)	670.6 to 888.6	800-900 in major areas, 450-800 in remaining areas.	Red sandy loams in major areas and in remaining areas, pockets of black soils.
7	Southern Transition Zone (14 taluks)	611.7 to 1053.9	800-900 in major areas partly 900-1500 and in 6 talukas 450-800.	Red sandy loams in major areas and in remaining areas, red loamy soils.
8	Northern Transi-tion zone(14 talukas)	618.4 to 1303.2	800-900 in major areas, 450-800 in remaining areas.	Shallow to medium black clay soils and red sandy loamy soils in equal proportion.
9	Hilly Zone (22 talukas)	904.4 to 3695.1	800-900 in major areas in 4 talukas 900-1500 and in 6 talukas 450-800.	Red clay loamy soils in major areas.
10	Coastal Zone (13 talukas)	3010.9 to 4694.4	Less than 300 in major areas in remaining 450-800	Red lateritic and coastal alluvial

Women in Agriculture

Some historians believe that it was Women who first domesticated crop plants and thereby initiated the art and science of farming. While men went out hunting in search of food, women started gathering seeds from the native flora and began cultivating those of interest.

Women play a significant and crucial role in agril. development and allied fields (crop production, livestock production, horticulture, post-harvest operations). The extent of women's involvement in agriculture varies greatly from region to region, among castes, classes. But there is hardly any activity in agril. production, except ploughing in which women are not actively involved.

Women constitute about one half of the nation's population. Seventyfour per cent of the entire female working force is engaged in agril. operations. About 60-70% of agril. operations are handled exclusively by farm women.

Farm women – an adult female actively involved in farming operation. Women participate in several activities such as seeding, transplanting, weeding, fertilizer application, plant protection, thinning, harvesting, processing, winnowing, cleaning, storing, looking after the animals, kitchen gardening etc. Several of these operation are exclusively carried out by women only. Thus, by participating in these agril. activities they directly or indirectly influence agriculture and animal husbandry development. About two-third of human labour work hours in agriculture is done by the female labour. Accordingly to FAO, "Women produce between 60 & 80% of the food in most developing countries and are responsible for half of the world's food production.

Multi-dimensional role of women

Woman performs 4 district function – mother, wife, home maker and worker

1) **Agriculture** : sowing, transplanting, weeding, irrigation, fertilizer application, plant protection, harvesting, winnowing, storing etc.
2) **Domestic**: Cooking, child rearing, water collection, fuel wood gathering, household maintenance.
3) **Allied activities**: Cattle management, fodder collection, milking etc.

Mainly rural women are engaged in agril. activities in three different ways depending on socio-economic status of their family and regional factors. They work as:

1) Paid labourers (49%)
2) Cultivator doing labour on their own land (17%)
3) Managers of certain aspects of agril. production by way of labour supervision and the participation in post harvest operations (10%)
4) Works in her own farms and also as a wage labourer (24%).

Share of farm women in agril. operations

Activity	Involvement(%)
1. Land preparation	32
2. Seed cleaning and sowing	80
3. Inter-cultivation activities	86
4. Harvesting – reaping, winnowing, drying, cleaning, storage	84

In the peak season, an active farmwoman spends 5 to 9 hours/day on the farm. Agriculture and allied activities almost take the equal time and energy at par with household activities (7 hr. 55 min.).

Size of farm, farm commodity, marital status, control of land, children on the farm, husband 's off farm work, education and experience in farming affect the extent to which women are involved in tasks. In diversified farm, women have the highest level of involvement.

Conditions and problems of women agricultural labourer

- Agril. wages and family income of agril. workers are very low in India.
- The women labourers are discriminated in wage payment, though the constitution of India provided equal rights and privileges for men & women. Female labourers are paid less when compared to men. Gendered division of labour on farms influences the types of farm tasks performed and extent of women's involvement in farming.
- Invisibility of farm women's work.
- Women agril. labourers face the problems of unemployment and under-employment for a substantial part of the year, because there is no work on the farm, employed only for a part of the year.
- No provision for fixation of hours of work. At the time of sowing & harvesting, they have to work on the farm from dawn to dask, since they are employed on a daily basis. Long working hours under adverse climatic conditions.
- No leave/other benefits, no sick leave.
- No social security.
- No clear cut distinction among operations.
- Lack of appreciation for good work
- Not having the liberty to take individual decisions at the works – spot.
- The wager not being sufficient to provide them with enough food leading to poor nutrition and health condition.

Stress factors

Women are often sandwitched between caring for elderly and children. This can lead to role overload and increased stress.

- Farm wives keep the farm business and family life running smoothly
- Added economic stress along with role overload are consistent with the farm family stress. These multiple roles may add to the risk.

- Women have the added burden of house hold responsibilities and may feel stress because they are not able to maintain the household in the way that they would like.
- Physical factors such as age, physical stature, and physical health status (osteoporosis , vision problems), fatigue and stress.
- Female agril. labourers do not enjoy any maternity leave and do not get proper rest after child birth.
- Meager wages, long hours of work, hazardous work. Lower wages than men, over time work, walking long distance to the work spot.

<u>Measures adopted by the Govt.</u>

1) Minimum wages Act.
2) Abolition of bonded labourers
3) Providing land to landless labourers
4) Provision of housing sites
5) Special schemes for providing employment
   - Rural workers programme (RWP),
   - Employment guarantee scheme (EGS)
   - Food for work programme (FWP)
   - Notional Rural Employment Programme (NREP)
   - Rural Landless Employment Guarantee Programme (RLEGP)
6) Providing employment during off-season.
7) Development of women and children in Rural areas (DWCRA) .

Value Addition in Agriculture

The profits on agricultural commodities have greatly diminished. The cost of production has increased faster than the market price of the outputs. There is a need to increase the farmers' earning through value addition.

Value addition to raw food material in India is only 7% while it is 23, 45 & 188 per cent in China, Phillippines and U.K., respectively. In India, the difference between price paid by consumers for value added products and farmer's realization has been increasing rapidly.

Time has come when agriculture has to be run as an agribusiness rather than subsistence agriculture. To boost economic return from farming, we must find ways for farmers to earn a greater share of the product sale revenue after adding value to their own produce.

Marketing of value added products in more remunerative than selling raw commodities. The demand for agriculture produce has also been changing. With increased income, urbanization and changing eating habits, the demand for processed food has increased manifold.

Value added agriculture is a process of increasing the economic value and consumer appeal of an agricultural commodity.

Adding value to grain would probably work best for farmers who are comfortable with doing their own marketing and dealing directly with consumer.

Ways of value-addition to farm produce

There are three ways in which value addition to farm produce is possible.

Level 1: (1) Post-harvest level/primary processing - includes proper cleaning, grading and packaging.
Ex. Vegetables, potatoes, fruit etc. Dehydration of vegetables at surplus supply-fetch more price.

Level 2: (2) Secondary processing - basic processing, packaging and branding.
Ex. Packaed atta, suji, rice etc.

Level 3: (3) High end processing - supply chain management, modern processing technology, packaging of processed foods, branding and marketing.
Ex. Potato chips, breakfast food, noodle.

Value added agriculture means getting more income from your farm In innovative ways:

1. Changing the way a commodity is marketed.
2. Changing the form of a commodity before it is marketed.
3. Changing the way a commodity is packaged for market.
4. Growing a commodity for a special market.
5. Adding a new enterprise. In many cases, the value added alternatives can be combined to yield an even higher income to the farmer.

1. **Changing the way a commodity is marketed**: Add value when you market a raw agricultural product to command a higher price. Ex. Direct-market your product at a farm stand to special processors or users, to the local community etc. Commodities that require special production methods or harvesting techniques that reach speciality market can be grown under contract for a much higher net return. But you need to seek out these market alternatives.

2. **Changing the form of a commodity before it is marketed**: You also add value when you transform raw agricultural products through processing. Costs are incurred during processing. Ex. Packing and selling.

   Other value – added products include selling flour instead of wheat, or corn meal instead of corn, selling flour directly to the bakery or consumer,   selling vegetables and fruits directly to the consumer than to wholesalers or processors requires cleaning and packaging.

3. **Changing the way a commodity is packaged for market:** Value – added marketing through packaging provides a great opportunity to increase profit. Package size must meet the consumer's need, if he wants to buy a single tomato, one must not sell only by the basket.

4. **Growing a commodity for a special market:** producing speciality agricultural products for export markets.

5. **Adding a new enterprise:** A new enterprise is defined as any change in a product or service. This includes growing the commodity for a special or niche market.

   Ex. A change in production processes, for example might involve switching to organic production practices, it might mean changing corn varieties to produce a special crop for a special industry such as industrial oil. A new enterprise or activity might include adding mushroom, goat production. We need to think more broadly about our alternatives who our customers might be. Whichever alternatives you select must be driven by marketing opportunities.

How do value added enterprises contribute to sustainability: Value – added agriculture –

1. Sustains the farm by capturing a larger share of the consumer food dollar the direct marketing.
2. Creates on enterprise that is logical extension of the current farm business.
3. Provides an innovative business strategy that allows small farms to compete with large farms.
4. Create new employment opportunities and new markets for high value agricultural
   products.
5. Invigorates the local economy.

Keys to success

1. Choose something you love to do
2. Follow demand-driven production
3. Create a high-quality product
4. Start small and grow naturally
5. **M**ake decision based on good records
6. Establish a loyal customer base, preferably local
7. Provide more than just food or a product
8. Get the whole family or all the partners involved
9. Keep informed - to keep informed about your customers, your competition, the laws concerning your business and other producers.
10. Plan for the future.