
Agriculture for Engineers

The Scenario in the food production is changing fast in the country with the advances made in all branches of Agricultural sciences.

Agriculture is derived from the Latin words…

- '***agar***' or '***agri***' means **Soil** and
- '***cultura***' means **Cultivation**

Agriculture as art, science and business of crop production

- **As an art**

it embraces knowledge of the way to perform the operations of the farm in a skillful manner. The skill is categorized as;

Physical skill: It involves the ability and capacity to carry out the operation in an efficient way for e.g., handling of farm implements, animals, sowing of seeds, fertilizer and pesticides application etc.

Mental skill: The farmer is able to take a decision based on experience, such as,

(i) Time and method of ploughing,

(ii) Selection of crop and cropping system to suit soil and climate,

(Iii) Adopting improved farm practices etc.

- **As a science :**

  It utilizes all modern technologies developed on scientific principles such as crop improvement/breeding, crop production, crop protection, economics etc., to maximize the yield and profit.

  For example, new crops and varieties developed by hybridization, transgenic crop varieties resistant to pests and diseases, hybrids in each crop, high fertilizer responsive varieties, water management, herbicides to control weeds, use of bio-control agents to combat pest and diseases etc.

- **As the business :**

  As long as agriculture is the way of life of the rural population, production is ultimately bound to consumption. But agriculture as a business aims at maximum net return through the management of land, labour, water and capital, employing the knowledge of various sciences for production of food, feed, fiber and fuel. In recent years, agriculture is commercialized to run as a business through mechanization.

	Agriculture	Industry
a)	Resources are self generated	Depends on raw materials
b)	Direct producer	Indirect producer
c)	Subjected to natural calamities	Protected from natural calamities
d)	Production is not under control	Production is under control
e)	All the process is carried out by single person or family	There are separate units and subunits
f)	Owner himself is the labour	Owner as a labour is less in industry

Agriculture is grouped in four major categories as,

A. Crop Improvement	(i) Plant breeding and genetics (ii) Bio-technology
B. Crop Management	(i) Agronomy (ii) Soil Science and Agricultural Chemistry (iii) Seed technology (iv) Agricultural Microbiology (v) Crop-Physiology (vi) Agricultural Engineering (vii) Environmental Sciences (viii) Agricultural Meteorology
C. Crop Protection	(i) Agricultural Entomology (ii) Plant Pathology (iii) Nematology
D. Social Sciences	(i) Agricultural Extension (ii) Agricultural Economics
Allied disciplines	(i) Agricultural Statistics (ii) English (iii) Mathematics (iv) Bio-Chemistry etc.

- **Norman (1980)** has define Agronomy as the science of manipulating the crop environment complex with duel aims of improving agriculture productivity and gaining a degree of understanding of the process involved

1

What is Agronomy ?

Agronomy is a branch of Agriculture which deals with the study of the principles and practices of soil, water and crop management.

- it is derived from greek words…

- *agros* means field
- *nomas* means to manage

Scope of Agronomy

- Agronomy is a dynamic discipline. With the advancement of knowledge and better understanding of plant and environment, agricultural practices are modified or new practices developed for higher productivity. For example;-

- ✓ Availability of chemical fertilizers and herbicides for control of weeds has led to development of a vast knowledge about time, method and quantity of fertilizer and herbicide application.

- ✓ Big irrigation projects are constructed to provide irrigation facilities. However, these projects created side effects like water logging and salinity. To overcome these problems, appropriate water management practices are developed.

- ✓ Population pressure is increasing but the area under cultivation is static. Therefore, to feed the increasing population, more number of crops have to be grown on the same piece of land in an year. As a result, intensive cropping has come into vogue.
- ✓ Similarly, no tillage practices have come in place of clean cultivation as a result of increase in cost of energy.(Fuel prices of oil) Likewise, new technology has to be developed to overcome the effect of moisture stress under dry land conditions.
- ✓ As new varieties of crops with high yield potential become available, package of practices has to be developed to exploit their full yielding potential.

Land utilization statistics

Total geographical area	**:**	328.848 million ha.
Total reporting area	**:**	304.300 million ha.
Area under cultivation	**:**	143.000 million ha.
Total cropped area	**:**	179.750 million ha.
Area sown more than once	**:**	36.750 million ha.
Area not available for cultivation	**:**	161.300 million ha.
Area under forest	**:**	66.400 million ha.

Developments of Agriculture

COLLECTION AND GATHERING

↓

SOWING OF CROPES

↓

REMOVAL OF UNWANTED PLANTS

↓

WATERING

↓

PROTECTION FROM PEST

↓

TILLAGE

↓

TILLAGE IMPLEMENTS

↓

APPLICATION OF NUTRIENTS

↓

CHEMICAL FERTILIZERS

↓

PESTICIDS

↓

DRIP IRRIGATION

↓

COMBINES

3

REVOLUTION IN AGRICULTURE

4

- **Green Revolution in India** began in the 1960s, through the introduction of high-yield crop varieties and application of modern agricultural techniques, and led to an increase in food production in India. It began after high-yielding wheat was first introduced to India in 1963 by American agronomist Dr. Norman E Borlaug, who is known as "the Father of the Green Revolution".
- India's programme of Green Revolution was led by Dr. M. S. Swaminathan, known as "the Father of the Green Revolution in India". The introduction of High-yielding varieties of seeds and the increased use of chemical fertilizers and irrigation led to the increase in production needed to make India self-sufficient in food grains, thus improving agriculture in India. The methods adopted included the use of high yielding varieties (HYV) of seeds along with the use of modern farming methods.

Green revolution	Food grain production
White revolution/ Operation food	Milk production (dairy)
Yellow revolution	Oilseeds production
Blue revolution	Fish production
Golden revolution	Fruit production
Gray revolution	Fertilizer production
Pink revolution	Prawn production
Red revolution	Meat/ Tomato production
Round revolution	Potato production
Silver revolution	Egg/poultry production
Rainbow revolution	All round growth in the production of foodgrains, edible oils, fruits and vegetables, animal and fish production
Energy revolution	Provision of required food, nutrition and environmental security to future generation

Relationship of Agronomy with other Science

It is a Synthesis of Several disciplines like…

- Soil science
- Plant ecology
- Entomology
- Plant pathology

➢To understand Soil physical, chemical and biological properties as well as physiology of crops.

➢ Developments in these subjects help in developing new practices which are simpler and economical to provide favorable environment to the crop.

➢ Agronomy mainly deals with different management practices.

- Important management practices for crop growth and yield are…
  - Tillage
  - Seeds and sowing
  - Nutrient management
  - Water management
  - Weed management
  - Harvesting
  - Storage
  - Marketing

Classification based on climate:

1. **Tropical:** Crops grow well in warm & hot climate.
   E.g. Rice, sugarcane, Jowar etc

2. **Temperate:** Crops grow well in cool climate.
   E.g. Wheat, Oats, Gram, Potato etc.

- **Classification Based on growing season:**

1. **Kharif/Rainy/Monsoon crops:** The crops grown in monsoon months from June to Oct-Nov, Require warm, wet weather at major period of crop growth, also required short day length for flowering.

   E.g. Cotton, Rice, Jowar, bajara.

2. **Rabi/winter/cold seasons crops:** Require winter season to grow well from Oct to March month. Crops grow well in cold and dry weather. Require longer day length for flowering.

   E.g. Wheat, gram, sunflower etc.

3. **Summer/Zaid crops:** Crops grown in summer month from March to June. Require warm day weather for major growth period and longer day length for flowering.

   E.g. Groundnuts, Watermelon, Pumpkins, Gourds.

Use and Agronomic classification:

1. **Grain crops:** May be cereals as millets cereals are the cultivated grasses grown for their edible starchy grains. The larger grain used as staple food is cereals.

   E.g. Rice, Jowar, Wheat, Maize, Barley(Jav), and Millets are the small grained cereals which are of minor importance as food. E.g. Bajara.

2. **Pulse/legume crops:** Seeds of leguminous crops plant used as food. On splitting they produced Dal which is rich in protein.

   E.g. Green gram, Black gram, Soybean, Pea, Cowpea, Lentil (Masur) etc.

3. **Oil seeds crops:** Crop seeds are rich in fatty acids, are used to extract vegetable oil to meet various requirements.

   E.g. Groundnut, Mustard, Sunflower, Sesamum, Linseed (Alsi) etc.

4. **Forage Crop:** It refers to vegetative matter fresh as preserved utilized as food for animals. Crop cultivated & used for hay and silage.

   E.g. sorghum, Elephant grass, Guinea grass, Berseem & other Pulse etc.

5. **Fibre crops:** Grown for fibre yield. Fibre may be obtained from seed.

   E.g. Cotton, Jute, Mesta, Sun hemp, Flax.

6. **Roots crops:** Roots are the economic produce in root crop.

   E.g. Sweet potato, Sugar beet, Carrot, Turnip etc.

7. **Tuber crop**: Crop whose edible portion is not a root but a short thickened underground stem.

   E.g. Potato, Elephant yam.

8. **Sugar crops:** The two important crops are sugarcane and sugar beet cultivated for production for sugar.

9. **Starch crops:** Grown for the production of starch.

   E.g. Tapioca, Potato, Sweet potato.

10. **Dreg crop:** Used for preparation for medicines.

    E.g. Tobacco, Mint.

11. **Spices & condiments/spices crops:** Crop plants as their products are used to flavour taste and sometime color the fresh preserved food.

    E.g. Ginger, Garlic, Chili, Cumin, Onion, Coriander, Cardamom, Pepper, Turmeric etc.

12. **Vegetables crops:** May be leafy as fruity vegetables. E.g. Palak, Mentha, Brinjal, Tomato.

13. **Green manure crop:** Grown and incorporated into soil to increase fertility of soil.

    E.g. Sun hemp, Guar

14. **Medicinal & aromatic crops:** Medicinal plants includes Cinchona, Isabgoli, Opium poppy, Senna, Belladonna, Rauwolfra and aromatic plants such as Lemon grass, Citronella grass, Palmorsa, Japanese mint, Peppermint, Rose geranicem, Jasmine, Senna etc.

NATIONAL AND INTERNATIONAL RESEARCH INSTITUTES IN INDIA

NATIONAL RESEARCH INSTITUTES:

- **CAZRI :** Central Arid Zone Research Institute, Jodhpur, Rajasthan
- **CFTRI:** Central Food Technological Research Institute, Mysore, Karnataka
- **CICR:** Central Institute for Cotton Research, Nagpur, Maharashtra
- **CPRI:** Central Potato Research Institute, Simla, H.P.
- **CRIJAF:** Central Research Institute for Jute and Allied Fibres, Barrackpore, W.B.
- **CIAE:** Central Institute of Agricultural Engineering, Bhopal, M.P.
- **CPCRI:** Central Plantation crops Research Institute, Kasargod, Kerala

- **CRIDA:** Central Research Institute for Dryland Agriculture, Hyderabad, A.P.
- **CRRI:** Central Rice Research Institute, Cuttack, Orissa
- **CSWCRTI:** Central Soil and Water Conservation Research and Training Institute, Dehradun, U.P.
- **CTCRI**: Central Tuber Crops Research Institute, Thiruvananthapuram, (Trivendrum), Kerala
- **CSSRI :** Central Soil Salinity Research Institute, Karnal, Haryana
- **CTRI :** Central Tobacco Research Institute, Rajahmundry, A.P.
- **DOR :** Directorate of Oilseeds Research, Hyderabad, A.P.
- **DRR :** Directorate of Rice Research, Hyderabad, A.P.
- **DWR :** Directorate of Wheat Research, Karnal, Haryana

- **DWMR:** Directorate of Water Management Research Institute, Jhansi, U.P.
- **FRI:** Forest Research Institute, Dehradun, U.P.
- **IARI:** Indian Agricultural Research Institute, Pusa, New Delhi
- **IGFARI:** Indian Grassland Fooder and Agroforestry Research Institute, Jhansi, U. P.
- **IISR:** Indian Institute of Sugarcane Research, Lucknow, U.P.
- **IISS:** Indian Institute of Soil Science, Bhopal, M.P.
- **IIPR:** Indian Institute of Pulses Research, Kanpur, U.P.
- **IIHR**: Indian Institute of Horticultural Research, Bangalore, Karnataka.
- **ILRI:** Indian Lac Research Institute, Ranchi, Bihar
- **JTRL:** Jute Technological Research Laboratory, Kolkata, W.B.

- **NCMRT:** National Centre for Mushroom Research and Training, Solan, H.P.
- **NRCG**: National Research Centre for Groundnut, Junagadh, Gujarat
- **NRCS:** National Research Centre for Sorghum, (Directorate of Sorghum Research) Hyderabad, A.P.

  NRC for Soybean, Indore, M.P.

  NRC for Spices, Calicut, Kerala

  NRC for Cashew, Pattur, Karnataka

  NRC for Citrus, Nagpur, Maharasthra

  NRC for Rapeseed and Mustard, Bharatpur, Rajasthan

  NRC for Oil Palm, Pedavegi, Andhra Pradesh.

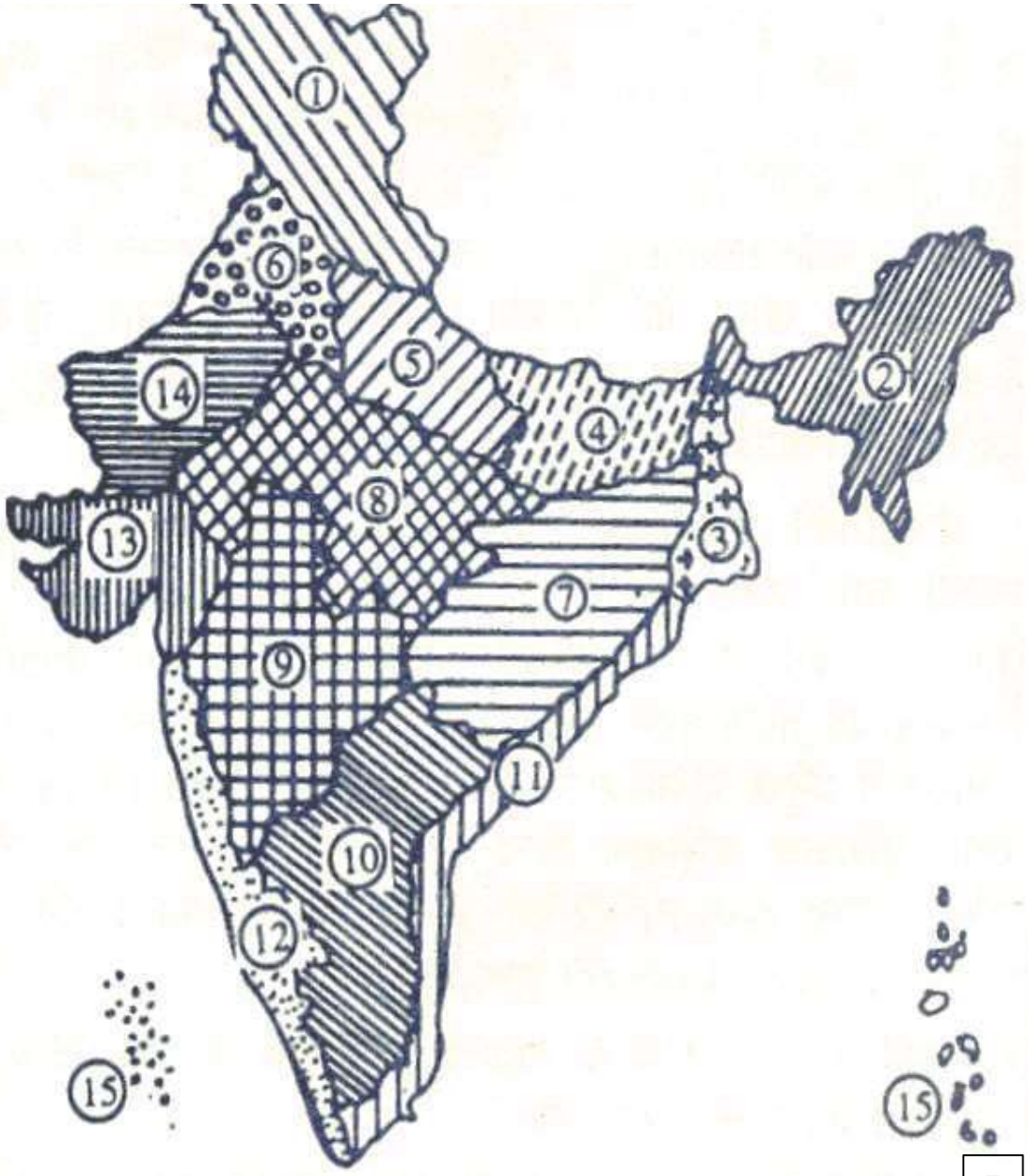
- **NCWS:** National Centre for Weed Science, Jabalpur, M.P.
- NBPGR : National Bureau of Plant Genetic Resources, New Delhi
- **NAARM:** National Academy of Agricultural Research Management, Hyderabad
- **NBSSLUP:** National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharashtra
- **NPPTI**: National Plant Protection Training Institute, National Institute of plant v Health Management, Hyderabad, A.P.-NIPHM.
- **PDCSR:** Project Directorate for Cropping Systems Research, Meerut, U.P.
- **SBI:** Sugarcane Breeding Institute, Coimbatore, Tamilnadu

- **INTERNATIONAL RESEARCH 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
- **IPGRI:** International Plant Genetic Resources Institiute
- **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
- **IWMI/IIMI:** International Irrigation Management Institute, Colombo, Sri Lanka
- **ICRISAT:** On water
- **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

Agro-climatic zones of India



1	Western Himalayan zone
2	Estern Himalayan zone
3	Lower Gangetic plains
4	Middle Gangetic plains
5	Upper Gangetic plains
6	Trans Gangetic plains
7	Eastern Plateau & hills
8	Central Plateau & hills
9	Western Plateau & hills
10	Southern Plateau & hills
11	East Coast Plains & hills
12	West Cost Plains & Ghats
13	Gujarat Plain & hills
14	Western Dry Region
15	Island Zone

Agro Climatic Zone of Gujarat State			
Zone -I	South Gujarat Heavy Rainfall Zone	**Zone -V**	North-west Zone
Zone -II	South Gujarat Zone	**Zone -VI**	North Saurashtra Zone
Zone -III	Middle Gujarat Zone	**Zone -VII**	South Saurashtra Zone
Zone -IV	North Gujarat Zone	**Zone -VIII**	Bhal and Coastal Zone

Agro-climatic zones of Gujarat

Sr. No.	NARP Zone	Zonal Research Station	Districts	Suitable Crops
1	**South Gujarat Heavy Rainfall Zone**	**Navsari**	Dang, Valsad and Valod, Vyara, songadh and Mahuva taluks of Surat.	Rice, Sorghum, Ragi, Kodra, Seasamum, Pigeonpea, Groundnu, Cotton, Sugarcane, Chillies, Wheat, Gram
2	**South Gujarat Zone**	**Surat**	Surat and Amod, Ankleshwar, Broach, Dekdopada, Honsot, Jhagadia, Nanded, Sagbara and Valia talukas of Broach.	Rice, Wheat, Gram, Perlmillets, Sorghum, Maize, Kodra, Ragi, Pigeonpea, roundnut, Sesamum, Castor, Cotton, Sugarcane, Chillies,
3	**Middle Gujarat Zone**	**Anand**	Panchmahals, Baroda and Anand, Balasinor, Borsad, Kapadvanj, Kheda, Matar, Ahmedabad, Nadiad, Petlad and Thasara and taluks of Kheda.	Rice, Wheat, Gram, Perlmillets, Sorghum, Maize, Kodra, Ragi, Pigeonpea, Groundnu, Sesamum, Castor, Cotton, Sugarcane, Chillies, Chickpea, Tobacco, Potato, Rapeseed & Mustard.
4	**North Gujarat Zone**	**Dantiwada**	Sabarkantha, Gandhinagar, Dehgam, Daskroi, Sanand talukas of Ahmedabad, Deesa, Dhenera, Palanpur, Dandta, Wadgam taluks of Banaskantha and Chanasma, Kadi, Kalol, Kheralu, Mehsana, Patan, Sidhpur, Visnagar, Vijapur taluks and Mehsana.	Rice, Wheat, Gram, Perlmillets, Sorghum, Maize, groundnut, Sesamum, Castor, Cotton, Sugarcane, Cumin, Rapeseed & Mustard.

Sr. No.	NARP Zone	Zonal Research Station	Districts	Suitable Crops
5	North-west Zone	Bhachau	Kutch, Rajkot, Malia Halvad, Dhrangdhra, Dasada taluks of Surendranagar, Sami and Harij taluks of Mahsana, Santhalpur, Radhanpur, Kankrej, Deodar, Vav, Tharad taluks of Banaskantha and Viramgam taluka of Ahmedabad.	Rice, Wheat, Gram, Perlmillets, Sorghum, Maize, Pigeon pea, groundnut, Sesamum, Castor,Cotton, Rapeseed & Mustard, Barley.
6	North Saurashtra Zone	Targhadia	Jamnagar, Rajkot, Chotila, Limdi, Lakhtar, Muli, Sayla, Wadhwan talukas of Surendranagar and Gadheda, Umrala, Botad, Kundla, Dihor, Garidhar, Palitana talukas of Bhavnagar and Amreli, Babra, Lathi, Lalia, Kunkavav, Khamba, Dhari taluks of Amreli.	Pearlmillets, Sorghum, Groundnut, Seasamum, Castor, Cotton, Pulses.
7	South Saurashtra Zone	Junagarh	Junagadh, Ghodha, Talaja, Mahava taloukas of Bhavnagar Kodinar, Rajula and Jafrabad talukas of Amerli and Dhoraji, Jetpur, Upleta talukas of Rajkot.	Rice, Maize, Wheat, Sugarcane, Gram, Pearlmillets, Pulses, Sorghum, Cotton, Groundnut, Seasamu, rapeseed & mustard
8	Bhal and Coastal Zone	Arnej	Bhavnagar (Vallabhipur, Bhavnagar talukas), Ahmedabad (Dholka, Dhanduka talukas), and Vagra, Jambusa talukas of Bharauch.	Rice, Pearl millets.

- Father of tillage - Jethro Tull

Plants absorb minute particles of soils. Therefore, he suggested that through ploughing and other operations were necessary so as to make soil into fine particles.

Ideal condition of soil can be achieved by manipulating the soil properly & bringing it in good tilth through a series of mechanical operations like ploughing, clod crushing, harrowing, leveling, compacting, interculturing etc. by tillage implements.

What is Tillage ?

- Tillage of the soil consists of breaking the hard compact surface to a certain depth and other operations that are followed for plant growth.
- Tillage is the physical manipulation of soil with tools & the tilling of land for the cultivation of crop plants i.e. the working of the surface soil for bringing about conditions favourable for Raising of crop plants.
- Tillage is the manipulation of soil with tools & implements for loosening the surface crust & bringing about conditions favourable for the germination of seeds and the growth of crops.

Objects of Tillage:

1. To make the soil loose & porous
2. To aerate the soil
3. To have repeated exchange of air / gases
4. To prepare a good seed bed which helps the germination of seeds.
5. To create conditions in the soil suited for better growth of crops.
6. To make the soil capable for absorbing more rain water.
7. To increase the soil temperature
8. To control weeds
9. To remove stubbiest
10. To destroy insect pests
11. To destroy hard pan
12. To incorporate organic & other bulky manures
13. To Invert soil to improve fertility

Aims and objectives of tillage

1. Moisture management:- Soil configuration for in situ moisture conservation, to increase infiltration rate to increase moisture storage capacity of soil profile, to increase aeration to reduce evaporation losses through inter tillage operations to provide drainage to remove excess water etc.
2. Erosion control:- Contour tillage, contour cultivation tillage across the slope.
3. Weed control:- Check weed growth & avoid moisture competition.
4. Management of crop residues:- Mixing of trash and decomposition of crop residues retention of trash on top layers to reduce erosion.

5. Improvement of tilth: - Minimize the resistance to root penetration, improve soil texture & structure etc.
6. Improvement of soil aeration:- For good growth of crop.
7. Providing food seed:- Soil contact.
8. Preparing fine surface for seeding operation.
9. Incorporation of manures, fertilizers and agro chemicals (weedicide & soil amendments) into the soil.
10. Insect control.
11. Temperature control for seed germination.

Types of Tillage Operations

1. **Preparatory tillage:**
   Tillage operations that are carried out from the time of harvest of a crop to the sowing of the next crop are known as preparatory cultivation/ Tillage. OR Operations carried out in any cultivated land to prepare seedbed for sowing crops are preparatory tillage.

   a) **Primary tillage:** It mainly includes the ploughing operation which is opening of the compacted soil with the help of different ploughs. Ploughing is done to:
      1) Open the hard soil,
      2) Separate the top soil from lower layers,
      3) Invert the soil whenever necessary and
      4) Uproot the weeds & stubbles.

   b)Secondary tillage : Lighter or finer operation performed on the soil after primary tillage are known as secondary tillage which includes the operations performed after ploughing, leveling, harrowing etc.

2. **Seedbed preparation:**

   After preparatory tillage the land is to be laid out properly for irrigating crops if irrigation is available for sowing or planting seeding which are known as seedbed preparation.

   It includes harrowing, levelling, compacting the soil, preparing irrigation layouts such as basins, borders, rides & furrows etc.

3. **Inter tillage/ Inter cultivation/ Interculture/ after care operation:**

   The tillage operations that are carried out in the standing crop are called inter tillage operations.

Modern Concepts of Tillage

1. Minimum Tillage:

It is aimed at reducing tillage operations to the minimum necessary for ensuring a good seedbed, rapid germination, a satisfactory stand & favourable growing conditions, Tillage can be reduced by:

1)Omitting operations which do not give much benefit when compared to the cost and
2)Combining agricultural operations like seeding & fertilizer application.

- **Advantages:**

  1)Improve soil condition due to decomposition of plant residues *in situ*,

  2)Higher infiltration caused by decomposition of vegetation present on Soils & channels formed by decomposition of dead roots.

  3) Less resistance to root growth due to improved structure.

  4)Less soil compaction by reduced movement of heavy tillage vehicles.

  5) Less soil erosion compared to conventional tillage.

- **Disadvantages:**

  1) Less seed germination,

  2)More ‘N’ has to be added as rate of decomposition of organic matter is slow.

  3) Nodulation may affect in some legumes.

  4) Sowing operations are difficult with ordinary implements.

2. Zero tillage:

It is an extreme form of minimum tillage. Primary tillage is completely avoided & secondary tillage is restricted to seedbed preparation in the row zone only.

It is followed where,

1) Soils are subjected to wind & water erosion,
2) Timing of tillage operations is too difficult &
3)Requirements of energy & labour for tillage are too high.

- **Advantages:**

  1)Soils are homogenous in structure with more no. of earth worms.

  2) Organic matter content increased due to less mineralization.

  3)Surface runoff is reduced due to presence of mulch. Several operations are performed by using only one implement. In these weeds are controlled by spraying of herbicides.

- **Disadvantages:**

  1)Higher ‘N’ is too applied due to slower mineralization of org. matter.

  2) Large population of perennial weeds appears.

  3) Build up of pests is more.

3. Stubble mulch tillage:

The soil is protected at all times either by growing a crop or by crop residues left on the surface during fallow periods. It is year round system of managing plant residue with implements that undercut residue, loosen the soil and kill weeds. Soil is tilled as often as necessary to control weeds during the interval between two crops. However, it presents the practical problem as the residues left on the surface interfere with seedbed preparation & sowing operations. The traditional tillage & sowing equipment is not suitable under these conditions.

Modern methods of tillage are not practiced in Indian condition because:

a) Left over residue is a valuable fodder & fuel.
b)Limited use of heavy machinery & therefore problem of soil compaction is rare.

4. Peddling:

Pudding is ploughing the land with standing water so as to create an impervious layer below the surface to reduce deep percolation losses of water and to provide soft seedbed for planting rice.

5. Conservation tillage:

It is disturbing the soil to the minimum extent & leaving crop residues on the soil. It includes minimum & zero tillage which can reduce soil loss up to 99% over conventional tillage. In most cases, it reduces soil by 50% over conventional tillage. Conventional tillage includes ploughing twice or thrice followed by harrowing & planking. It leaves no land unploughes & leaves no residues on the soil.

Ploughing:

- Ploughing is done almost every year by wooden or iron ploughs to open the land, to dig out deep-rooted weeds or stubbles, to aerate the soil and to trap and store water for crops.
- On an average one plough opens up half an acre of land in a day. Deep ploughing, up to about 10" depth, is absolutely necessary for sugarcane and root crops like suran and sweet potatoes.

Reference/ Sources

- *1.http://www.google.co.in/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=0CAgQjRw&url=http%3A%2F%2Fwww.normanborlaug.org%2F&ei=udajVKruKsm9uATVuYDgAg&psig=AFQjCNExuZ39Me_WhOMjauoLmcHyHd4Tnw&ust=1420109881837063*
- *2.https://www.google.co.in/search?sa=G&q=norman+ernest+borlaug&tbm=isch&tbs=simg:CAQSZRpjCxCo1NgEGgIIPQwLELCMpwgaPAo6CAISFPIi8yKdIZMh2SamIdcS7higIasTGiBmqjyui7EpGY18CKrCV3EX5XQz1O2JUUcSRLE9EQLwCwwLEI6u_1ggaCgoICAESBHs4sFQM&ei=NdajVMSfIpepuwTIsoCICg&ved=0CBkQwg4oAA&biw=1366&bih=633*
- *3.https://www.google.co.in/search?sa=G&q=norman+ernest+borlaug&tbm=isch&tbs=simg:CAQSZRpjCxCo1NgEGgIIPQwLELCMpwgaPAo6CAISFPIi8yKdIZMh2SamIdcS7higIasTGiBmqjyui7EpGY18CKrCV3EX5XQz1O2JUUcSRLE9EQLwCwwLEI6u_1ggaCgoICAESBHs4sFQM&ei=NdajVMSfIpepuwTIsoCICg&ved=0CBkQwg4oAA&biw=1366&bih=633*
- *4. https://lh3.ggpht.com/oVmq_rTdAMoCzYUOL9DS79oiV_nT7qia9EoHpBkNNxqBHAowknYXt-4Inkn0OX97rOds9DQ=s85*
- *5. https://lh4.ggpht.com/Lh9YUoTeb1Vk8_ToYPibXd-ooGYuuuDPmtDWZi9cPDMCbFPfwJSl_sPIjnHMZsb4lpK-=s85*
- *6. https://lh4.ggpht.com/wUZalrifkB3uIRPMyeN4U5D2tEp-F1d9q8d7A7VhaRcmkU0dEnTKs4iSARlqPMJ83nQwCA=s140*
- *7. https://lh3.ggpht.com/3n-zuit7tXA8XRcOkjnGatk2y07snvtyB8GV3-O7PolWCMfGLiesLMR3cPzX4RNPe1k3kA=s85*

Text book and Web sources

- *www.agriinfo.in*
- *ecourses.iasri.res.in*
- *Principles of Agronomy by T. Yellamanda Reddy and G.H. Sankara Reddy*