Chapter 1

An Introduction to Agriculture and Agronomy

Agriculture helps to meet the basic needs of human and their civilization by providing food, clothing, shelters, medicine and recreation. Hence, agriculture is the most important enterprise in the world. It is a productive unit where the free gifts of nature namely land, light, air, temperature and rain water etc., are integrated into single ***primary unit*** indispensable for human beings. ***Secondary productive units*** namely animals including livestock, birds and insects, feed on these primary units and provide concentrated products such as meat, milk, wool, eggs, honey, silk and lac.

Agriculture provides food, feed, fibre, fuel, furniture, raw materials and materials for and from factories; provides a free fare and fresh environment, abundant food for driving out famine; favours friendship by eliminating fights. Satisfactory agricultural production brings peace, prosperity, harmony, health and wealth to individuals of a nation by driving away distrust, discord and anarchy. It helps to elevate the community consisting of different castes and clauses, thus it leads to a better social, cultural, political and economical life. Agricultural development is multidirectional having galloping speed and rapid spread with respect to time and space. After green revolution, farmers started using improved cultural practices and agricultural inputs in intensive cropping systems with labourer intensive programmes to enhance the production potential per unit land, time and input. It provided suitable environment to all these improved genotypes to foster and manifest their yield potential in newer areas and seasons. Agriculture consists of growing plants and rearing animals in order to yield, produce and thus it helps to maintain a biological equilibrium in nature.

1.0 AN INTRODUCTION TO AGRICULTURE

A. Terminology

Agriculture is derived from Latin words *Ager* and *Cultura*. *Ager* means land or field and *Cultura* means cultivation. Therefore the term agriculture means cultivation of land. *i.e.*, the science and art of producing crops and livestock for economic purposes. It is also referred as the science of producing crops and livestock from the natural resources of the earth. The primary aim of agriculture is to cause the land to produce more abundantly, and at the same time, to protect it from deterioration and misuse. It is synonymous with farming–the production of food, fodder and other industrial materials.

B. Definitions

Agriculture is defined in the Agriculture Act 1947, as including 'horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of land for woodlands where that use ancillary to the farming of land for Agricultural purposes". It is also defined as 'purposeful work through which elements in nature are harnessed to produce plants and animals to meet the human needs. It is a biological production process, which depends on the growth and development of selected plants and animals within the local environment.

C. Agriculture as art, science and business of crop production

Agriculture is defined as the art, the science and the business of producing crops and the livestock for economic purposes.

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 etc., 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, fibre and fuel. In recent years, agriculture is commercialized to run as a business through mechanization.

1.1 SCOPE OF AGRICULTURE IN INDIA

In India, population pressure is increasing while area under cultivation is static (as shown in the land utilization statistics given below) or even shrinking, which demand intensification of cropping and allied activities in two dimensions *i.e.*, time and space dimension. India is endowed with tropical climate with abundant solar energy throughout the year, which favours growing crops round the year. There is a vast scope to increase irrigation potential by river projects and minor irrigation projects. In additional to the above, India is blessed with more labourer availability. Since agriculture is the primary sector, other sectors are dependent on agriculture.

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.

In India, major allocation has been done in each five-year plan to agriculture. In 8th five-year plan, nearly 23% of the national budget allocation goes to agriculture and allied agro-based cottage industries run on small scales. More than 60% of the Indian population (60 millions/1.05 billion) depends or involved in agriculture and allied activities. Nearly 40% of the net national product is from agricultural sector. Approximately 35% employment is generated from agriculture, out of which 75% is found in rural areas either directly or indirectly.

In India, food grain production increased almost four folds from about 50 million tones at independence to more than 220 million tones in 2005 through ***green revolution.*** Despite variation in the performance of individual crops and regions, total food grain production maintained a growth of 2.7% per annum, which kept ahead of population growth at about 2.2% per annum. Through ***white revolution,*** milk production increased from 17 million tones at independence to 69 million tones (1997–98). Through ***blue revolution,*** fish production rose from 0.75 million tones to nearly 5.0 million tones during the last five decades. Through ***yellow revolution,*** oil seed production increased 5 times (from 5 million tones to 25 million tones) since independence. Similarly, the egg production increased from 2 billion at independence to 28 billion, sugarcane production from 57 million tones to 276 million tones, cotton production from 3 million bales to 14 million bales which shows our sign of progress. India is the largest producer of fruits in the world. India is the second largest producer of milk and vegetables.

In future, agriculture development in India would be guided not only by the compulsion of improving food and nutritional security, but also by the concerns for environmental protection, sustainability and profitability. By following the General Agreement on Trade and Tariff (GATT) and the liberalization process, globalization of markets would call for competitiveness and efficiency of agricultural production. Agriculture will face challenging situations on the ecological, global climate, economic equity, energy and employment fronts in the years to come.

1.2 BRANCHES OF AGRICULTURE

Agriculture has 3 main spheres viz., Geoponic (Cultivation in earth-soil), Aeroponic (cultivation in air) and Hydroponic (cultivation in water). Agriculture is the branch of science encompassing the applied aspects of basic sciences. The applied aspects of agricultural science consists of study of field crops and their management (**Arviculture**) including soil management.

Crop production - It deals with the production of various crops, which includes food crops, fodder crops, fibre crops, sugar, oil seeds, etc. It includes agronomy, soil science, entomology, pathology, microbiology, etc. The aim is to have better food production and how to control the diseases.

Horticulture - Branch of agriculture deals with the production of flowers, fruits, vegetables, ornamental plants, spices, condiments (includes narcotic crops-opium, etc., which has medicinal value) and beverages.

Agricultural Engineering - It is an important component for crop production and horticulture particularly to provide tools and implements. It is aiming to produce modified tools to facilitate proper animal husbandry and crop production tools, implements and machinery in animal production.

Forestry - It deals with production of large scale cultivation of perennial trees for supplying wood, timber, rubber, etc. and also raw materials for industries.

Animal Husbandry - The animals being produced, maintained, etc. Maintenance of various types of livestock for direct energy (work energy). Husbandry is common for both crop and animals. The objective is to get maximum output by feeding, rearing, etc. The arrangement of crops is done to get minimum requirement of light or air. This arrangement is called geometry. Husbandry is for direct and indirect energy.

Fishery Science - It is for marine fish and inland fishes including shrimps and prawns.

Home Science - Application and utilization of agricultural produces in a better manner. When utilization is enhanced production is also enhanced. *e.g.,* a crop once in use in south was found that it had many uses now.

On integration, all the seven branches, first three is grouped as for crop production group and next two for animal management and last two as allied agriculture branches. Broadly in practice, 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 and Tamil (*iii*) Mathematics (*iv*) Bio-Chemistry etc.

1.3 DEVELOPMENT OF SCIENTIFIC AGRICULTURE

Early man depended on hunting, fishing and food gathering. To this day, some groups still pursue this simple way of life and others have continued as roving herdsmen. However, as various groups of men undertook deliberate cultivation of wild plants and domestication of wild animals, agriculture came into being. Cultivation of crops, notably grains such as wheat, rice, barley and millets, encouraged settlement of stable farm communities, some of which grew into a town or city in various parts of the world. Early agricultural implements-digging stick, hoe, scythe and plough-developed slowly over the centuries and each innovation caused profound changes in human life. From early times too, men created indigenous systems of irrigation especially in semi-arid areas and regions of periodic rainfall.

Farming was intimately associated with landholding and therefore with political organization. Growth of large estates involved the use of slaves and bound or semi-free labourers. As the Middle Ages wanted increasing communications, the commercial revolution and the steady rise of cities in Western Europe tended to turn agriculture away from subsistence farming towards the growing of crops for sale outside the community *i.e.*, commercial agricultural revolution. Exploration and intercontinental trade as well as scientific investigations led to the development of agricultural knowledge of various crops and the exchange of mechanical devices such as the sugar mill and Eli Whitney's cotton gin helped to support the system of large plantations based on a single crop.

The industrial revolution, after the late 18th century, swelled the population of towns and cities and increasingly forced agriculture into greater integration with general economic and financial patterns. The era of mechanized agriculture began with the invention of such farm machines as the reaper, cultivator, thresher, combine harvesters and tractors, which continued to appear over; the years leading to a new type of large scale agriculture. Modern science has also revolutionized food processing. Breeding programmes have developed highly specialized animal, plant and poultry varieties thus increasing production efficiency greatly. All over the world, agricultural colleges and government agencies attempt to increase output by disseminating knowledge of improved agricultural practices through the release of new plant and animal types and by continuous intensive research into basic and applied scientific principles relating to agricultural production and economics.

1.3.1 History of Agriculture

Excavations, legends and remote sensing tests reveal that agriculture is 10,000 years old. Women by their intrinsic insight first observed that plants come up from seeds. Men concentrated on hunting and gathering (Paleolithic and Neolithic periods) during that time. Women were the pioneers for cultivating useful plants from the wild flora. They dug out edible roots and rhizomes and buried the small ones for subsequent harvests. They used animal meat as main food and their skin for clothing. The following Table 1.1 gives an idea about agriculture development scenario.

Table 1.1. Agriculture Development Scenario

Agricultural System	*Cultural stage or Time*	*Average cereal yield (t/ha)*	*World population (millions)*	*Per capita land availability (ha)*
Hunting and Gathering	Paleolithic	–	7	–
Shifting Agriculture	Neolithic (about 7,000 B.C.)	1	35	40.00
Medieval Agriculture	500–1450 A.D.	1	900	01.50
Livestock farming	18th Century	2	1800	00.70
Fertilizer/Pesticide in Agriculture	20th Century	4	4200	00.30

A. Shifting Cultivation

A primitive form of agriculture in which people working with the crudest of tools, cut down a part of the forest, burnt the underneath growth and started new garden sites. After few years, when these plots lost their fertility or became heavily infested with weeds or soil-borne pests, they shifted to a new site. This is also known as **Assartage system** (cultivating crops till the land is completely worn-out) contrary to the fallow system. Fallow system means land is allowed for a resting period without any crop. In India, shifting cultivation existed in different states, with different names as ***jhum*** cultivation in Assam, ***podu*** in Andhra Pradesh and Orissa, ***kumari*** in Western Ghats, ***walra*** in south east Rajasthan, ***penda bewar*** in Madhya Pradesh and ***slash and burn*** in Bihar.

B. Subsidiary Farming

Rudimentary system of settled farming, which includes cultivation, gathering and hunting. People in groups started settling down near a stream or river as permanent village sites and started cultivating in the same land more continuously, however the tools, crops and cropping methods were primitive.

C. Subsistence Farming

Advanced form of primitive agriculture *i.e.,* agriculture is considered as a way of life based on the principle of "Grow it and eat it" instead of growing crops on a commercial basis. Hence, it is referred as raising the crops only for family needs.

D. Mixed Farming

It is the farming comprising of crop and animal components. Field crop-grass husbandry (same field was used both for cropping and later grazing) was common. It is a stage changing from food gathering to food growing.

E. Advanced Farming

Advanced farming practices includes selection of crops and varieties, seed selection, green manuring with legumes, crop rotation, use of animal and crop refuse as manures, irrigation, pasture management, rearing of milch animals, bullocks, sheep and goat for wool and meat, rearing of birds by stall feeding etc.

F. Scientific Agriculture (19th Century)

During 18th century, modern agriculture was started with crop sequence, organic recycling, introduction of exotic crops and animals, use of farm implements in agriculture etc. During 19th century, research and development (R&D) in fundamental and basic sciences were brought under applied aspects of agriculture. Agriculture took the shape of a teaching science. Laboratories, farms, research stations, research centres, institutes for research, teaching and extension (training and demonstration) were developed. Books, journals, popular and scientific articles, literatures were introduced. New media, and audio-visual aids were developed to disseminate new research findings and information to the rural masses.

G. Present Day Agriculture (21st Century)

Today agriculture is not merely production oriented but is becoming a business consisting of various enterprises like livestock (dairy), poultry, fishery, piggery, sericulture, apiary, plantation cropping etc.

Now, a lot of developments on hydrological, mechanical, chemical, genetical and technological aspects of agriculture are in progress. Governments are apportioning a greater share of national budget for agricultural development. Small and marginal farmers are being supplied with agricultural inputs on subsidy. Policies for preserving, processing, pricing, marketing, distributing, consuming, exporting and importing are strengthening. Agro-based small scale industries and crafts are fast developing. Need based agricultural planning, programming and execution are in progress.

1.3.2 Global Agriculture

Advancement of civilization is closely related to agriculture, which produces food to satisfy hunger. The present food production must double to maintain the status quo. However, nearly one billion people are living below poverty line and civilized society should ensure food for these people. Some allowance should be made for increased consumption as a consequence of raising incomes in third would countries. Therefore, the increased food production should aim at trebling food production in the next century.

Year	*Development in agriculture*
70 million years ago	Trees evolved
40 million years ago	Monkeys and apes evolved
10 million years ago	Dogs were domesticated in Iraq
8700 B.C.	Sheeps were domesticated in Iraq
7700 B.C.	Goats were domesticated in Iraq
7500 B.C.	Invention of polished stone implements, cultivation of crops like wheat and barley in middle east.
6000 B.C.	Cattle and pigs where domesticated in middle east
4400 B.C.	Maize was cultivated in Mexico
3500 B.C.	Potato was grown in south America
3000 B.C.	Bronze was used to make tools in middle east
2900 B.C.	Plough was used in middle east
2700 B.C.	Silk moth was domesticated in China
2300 B.C.	Poultry, buffalo and elephant were domesticated in Indus valley.
2200 B.C.	Rice cultivation started in India
1800 B.C.	Ragi cultivation started in Karnataka (India)
1780 B.C.	Kulthi (*Dolichus biflorus*) was cultivated in Karnataka
1725 B.C.	Jowar (Sorghum) cultivation started in Rajasthan
1700 B.C.	Horse husbandry started in Central Asia
1500 B.C.	Pulses (Green and Black gram) were cultivated in Madhya Pradesh Cultivation of Barley and Sugarcane started in India. Irrigation from wells started.
1400 B.C.	Iron was in use in Middle east
1000–1600 B.C.	Iron ploughs were in use
15 century A.D.	Cultivation of sweet orange, sour orange, wild brinjal, pomegranate was there
16 century A.D.	Introduction of crops like potato, sweet potato, cassava, tomato, chillies, pumpkin, papaya, pineapple, guava, custard apple, groundnut, cashew nut, tobacco, American cotton, rubber was done into India by Portuguese.

A. Land Resources

For crop production the basic input is land. Planet earth is of 15.2 billion ha avails 3.8 ha per person (Canada 50, Australia 50, S. America 10, USSR 10, USA 4, France 1.2, India 0.8 and Japan 0.4). The continuing population increase will result in available cultivable land per capita world-wide from 0.3 ha in 1988 to 0.17 ha in 2050, with only 0.11 per capita in developing countries. The nutrient losses due to soil erosion of one of good top soil in kg are 4 N, 1 P_2O_5, 20 K_2O and 2 CaO, besides organic matter. Only 10 to 11 per cent of cultivated area is reasonably free from all constraints for crop production. The FAO's analysis of growth patterns in crop output in 93 developing countries shows that 63 per cent of the growth in production must come from higher yields and 15 per cent from higher cropping intensity. Only 22 per cent is expected from land reserve.

Of the total 6444 m. ha of rainfed agricultural potential, only 30 per cent is suitable, 10 per cent marginal and 60 per cent unsuitable in different countries. The semiarid tropics (SAT) comprise of all or part of 50 countries in five continents of the world (Central America, SW Asia, Africa, South America and South East Asia) is the home of 700 million people who are under perpetual threat drought and occasional famine. About 65 per cent of the arable land carries untapped potential cereals, pulses and oilseeds, the biggest gains to the food ladder of the globe would be from improvement of agriculture. India has the largest SAT area (10%) of any of the developing countries.

Environmental degradation is increasing at a pace that is impairing the productivity of land and undermining the welfare of rural people. Global assessment of soil degradation (GLASoD) defines soil degradation as a process that describes human induced phenomena, which lower the current and/or future capacity of the soil to support human life. The causes for degradation are:

- Removal of vegetative cover through agricultural clearing,
- Decrease in soil cover through removal of vegetation for fuel wood, fencing, etc.
- Overgrazing by livestock leading to decrease in vegetative cover and trampling of the soil
- Agricultural activities like cultivation in steep slopes, farming without anti-erosion measures in arid areas, improper irrigation and use of heavy machinery, and
- Soil contamination with pollutants such as waste discharges and over use of agrochemicals.

Modern farm technologies are more productive on good soils than on poor soils. Technology may sustain yields by making the effects of soil degradation temporarily. Yield increase through technology might have been greater if the soil has not been degraded.

B. Water Resources

Of the total volume of 1400 million cubic km (M cu km) water, 97 per cent is sea water. Of the balance 3 per cent, 22 per cent is ground water and 77 per cent locked up glaciers and polar ice caps, leaving less than one per cent of fresh water to take part in hydrological cycle. Global water use doubled between 1940 and 1980 and is expected to double again by 2010 A.D. with two-thirds of the projected water use going to agriculture. Today one-third of the world's crops come from its 280 M ha of irrigated land. After world war II, foreign aid helped carry irrigation even to arid corners of the world. As on 1990, about 270 M ha of area, contributing to 17 per cent of the total cropped area, was under irrigation in the world. Today, irrigated farming systems of the past are under serious threat of extinct due to salinity, poor drainage and weak management. Irrigated land damaged through salinisation fro the top five countries, as percentage of total area irrigated by 1985 are: India 36, China 17, USSR 18, USA 44 and Pakistan 25. Irrigated area per capita for India (1989) is 0.057 ha as against 0.049 ha for the world. In rainfed agriculture, the cropping intensity of world is 0.74. Under irrigation, the current intensity of 1.21 may increase to 1.29. To maintain a diet of 2000 Cal day^{-1} requires 300 m^3 of water per day and 420 for a diet of 3500 Cal. Bringing one ha of new land under cultivation will produce 0.9 tonnes of cereal grain, one year supply of food for about five people at FAO minimum nutritional standard of 1600 Cal day^{-1}. If the land is irrigated, the total production increases four folds to 3.5 tonnes ha^{-1}. At this level, if future irrigated area of the world reaches 1.0 billion ha, enough food for 10 billion people at twice the FAO level.

In spite of the fact that irrigation can provide food for ever increasing population, experience in the recent decades in expansion of irrigated area ran into several problems leading to land degradation. Year to year changes in world irrigated area reflect the sum of the addition of the new capacity and loss of established capacity due to aquifer depletion, lowered water tables, abandonment of waterlogged area and salted land, reservoir silting and diversion of irrigation water to non-agricultural use. The future food production from irrigated areas depends more on the gains in water use efficiency than on additional new supplies.

C. Food Scenario

Cereals area grown throughout the world to provide food for the human consumption and feed and fodder for livestock. They are grown in 73.5 per cent of the world's arable land and contribute 74.5 per cent of the global calorie production. Demand for food is growing with ever increasing world population. Compared with present production of about 1.9 billion tones, the demand for cereals is likely to go up to 2.4 billions by the year 2000 A.D. While demand for wheat and rice may be increased in the next two decades by 31 and 53 per cent, respectively, the demand for coarse grains may double. Developed nations may meet their cereal demand by increasing production at 1.8 per cent per annum. However, most of the developing countries with growth rate of 2.5 per cent per annum in cereals production fall short of this requirement, which is increasing at the rate of 3.3 per cent per annum due to high population growth rate. The FAO estimates clearly indicate the increasing shortage of cereals in 90 developing countries.

Increase in food all over world during the decades of 1972–92 was remarkable. Productivity and production in the technologically advanced agriculture of the developed countries rose to heights that would have been unbelievable half a century ago, mainly due to introduction of high yielding varieties (HYVs) responsive to inputs of fertilities and irrigation water, besides increase in area under cultivations.

Developing countries presented a different picture. Only about a third of their population (excluding China) lived in countries with satisfactory performance in agricultural production. Elsewhere, output was raising more slowly than population. Africa in 1970s became the striking example of production inadequacy. There were many constraints limiting agricultural productivity, particularly that of small farmers in developing countries.

- Land remained so unequally distributed that farms were too small and steadily became smaller as rural population grew.
- Input supplies and services were insufficient and access to them most unequal,
- Resources devoted to research, training and extension were very limited, and
- Priority was given to industry, not agriculture, and food prices were shaded in the interest of urban consumers rather than of rural producers.

The FAO aimed at doubling the agricultural production in the developing countries between 1980 and 2000. The hopeful outcome depends on achieving an ambitions transformation involving widespread modernization in technology, based primarily on massive increase in inputs to agriculture. Developed countries do not come directly into the exploration of the future as they continue to raise their farming. The strategy is:

- Heavy investment in agricultural sector to make full use of the improved technology.
- Increasing crop production sources through arable land growth, cropping intensity and crop productivity.
- Expanding and conserving the land, based through land reforms directed at bringing underused land in to more intensive exploration and soil and water conservation to the dangers of land degradation, and
- Intensifying land use in crop production through irrigation, fertilizers, improved cultivates, plant protection and mechanization.

D. Towards 21st Century

According to World Bank projections, the world population could reach a stationary level of just under 10 billion by around the end of 21 century, compared with 6.2 billions during 2000 A.D. Significance of these projections is faster growth in population than in food requirements. Almost all the population increase (95%) takes place in the present day developing countries, which have low per capita consumption levels. Simple lesson from projection is that world demand could increase by 50 per cent in the next 20 years, would more than double again in the first half of the next century.

Doubling the world's food and agricultural production between 2000 and 2055 A.D. sounds daunting. To meet satisfactorily the food and agricultural demands of about 10 billion people, taking in to account the non-agricultural use of the land and seas, will require at least indicative global source use planning. It is clear that sustained rapid increase in crop and livestock yields must be the main stay of future output growth. A continuation to the middle of the 21st century of the expansion of arable land for the next 20 years would mean that virtually all of the potential arable land would be cultivated. The backup of agricultural research and extension must be more oriented to the problem of developing country agriculture.

The 21st century must inherit a food and agricultural system in the developing countries which is much more productive and equitable than it is now. By of continuously absorbing further innovations. The foundations for enormous increase in output needs in the first part of the 21st century must, therefore, be laid in what is left of this century. Attaining the targets proposed for this later period is a pre-requisite for improving the lives not only of those now living but also of further generations.

1.3.2.1 Development of scientific agriculture in world

1. Francis Bacon (1561–1624 A.D.) : Found the water as nutrient of plants
2. G.R. Glanber (1604–1668 A.D.) : Salt peter (KNO_3) as nutrient and not water
3. Jethrotull (1674–1741 A.D.) : Fine soil particle as plant nutrient
4. Priestly (1730–1799 A.D.) : Discovered the oxygen
5. Francis Home (1775 A.D.) : Water, air, salts, fire and oil from the plant nutrients
6. Charles and Francis (1780 A.D.) : Isolated and characterized Indole -3- Acetic Acid (IAA)
7. Thomas Jefferson (1793 A.D.) : Developed the mould board plough.
8. Theodore-de-Saussure : Found that plants absorb CO_2 from air and release O_2; soil supply N_2 and ash to plants
9. Justus van Liebig (1804–1873 A.D.) : A German chemist developed the concept called "Liebig's law of minimum". It states as follows.

   "A deficiency or absence of the necessary constituent, all others being present, renders the soil barren for crops for which that nutrient is needed"–It is referred as "Barrle concept". If the barrel has stones of different heights, the lowest one establishes the capacity of the Barrel. Nitrogen has the lowest share, establishes the maximum capacity of the barrel. Accordingly, the growth factor in lowest supply (whether climatic, edaphic, genetic or biotic) sets the capacity for yield. Similarly a soil deficient in nitrogen (N) can't be made to produce well by adding more calcium (Ca) or potassium (K) where they are already abundant.

10. In 1875, Michigen State University was established to provide agriculture education on college level.
11. Gregor Johann Mendel (1866) discovered the laws of heredity.
12. Charles Darwin (1876) published the results of experiments on cross and self-fertilization in plants.
13. Thomas Malthus (1898) Proposed "Malthusian Theory" that the human race would run or later run out of food for everyone in spite of the rapid advances being made in agriculture at that time,

because of limited land and yield potential of crops.

14. Neo Malthusians have proposed birth control as answer to the problem.
15. F.T. Blackman's (1905) Theory of "Optima and Limiting Factors" states that, "when a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of the slowest factor."
16. E.A. Mitsherlich (1909) proposed a theory of "Law of diminishing returns" states that, 'The increase in any crop produce by a unit increment of a deficient factor is proportional to the decrement of that factor from the maximum and the response is curvilinear instead of linear'. Mitscherlich equation is dy/dx = C (A-Y)
    where,
    d – increment or change
    dy – amount of increase in yield
    dx – amount of increment of the growth factor x.
    A – Maximum possible yield
    Y – Yield obtained for the given quantity of factor 'x' and
    C – Proportionality constant that depends on the nature of the growth factor.
17. Wilcox (1929) proposed "Inverse Yield–Nitrogen law" states that, the growth and yielding ability of any crop plant is inversely proportional to the mean nitrogen content in the dry matter.
18. Macy (1936): Proposed a concept of "Critical Percentages of Plant Nutrients". He suggested a relationship between the sufficiency of nutrients and plant response in terms of yield and nutrient concentration of plant tissues. Macy proposed critical percentages for each nutrient in each kind of plant.

    In the tissues minimum percentage range, an added increment of a nutrient increases the yield but not the nutrient percentage. In the poverty adjustment range, an added increment of a nutrient increases the nutrient percentage but not the yield. In the luxury consumption range, added increment of nutrient have little effect of yield. But increase the nutrient composition percentage.

    The point between poverty adjustment and luxury consumption was the "Critical percentage". Macy suggested that Liebig's law holds good in the tissue minimum percentage range because there is not enough of a nutrient to allow much plant growth. Liebig's law holds good again in the luxury consumption range. Because there is a large supply of nutrient, some other nutrient becomes limiting and stops growth. Mitscherlich's law of diminishing returns holds during the poverty adjustment range because the response curve is linear representing the diminishing yield to added increments.

19. Zimmerman and Hitchcock (1942) reported that 2,4-D could act as growth promoter at extremely low concentration. Now 2,4-D is used to overcome the problem of seediness in Poovan banana.
20. In 1945, herbicide 2,4,5-T was developed.
21. In 1954, Gibberlic acid structure was identified by Japanese.
22. In 1950's Bennet and Clark identified ABA (Abscessic acid), which inhibits plant growth and controls shedding of plant parts.

Table 1.2 History of Agriculture in India

1947	CTRI at Rajmundry (Tobacco)/Food Policy Committee
1949	CPRI at Patna
1956	CPRI shifted to Simla
1950	IARI established at New Delhi
1951	Fertilizer factory at Bihar
1952	IISR at Lucknow (sugarcane)
1955	NDRI at Karnal (Dairy)
1956	PIRRCOM Project for intensification of regional research on cotton, oil seeds and millets. (Central Cotton Research Institute–Regional Centre)
1959	CAZRI at Jodhpur (Rajasthan) (Arid zone)
1960	IADP (Intensive Agriculture District Programme)
1960	IRRI, Philippines
1962	IGFRI at Jhansi, Uttar Pradesh; G.B. Pant Nagar Agricultural University and Technology at Pant Nagar
1963	CTCRI, Trivandrum (Tuber crops)/National Seed Corporation (NSC)
1965	IAAP (Intensive Agriculture Area Programme)
1966	HYVP at Bangalore (Horticulture)
1969	CSSRI (Central Soil Salinity Research Institute) at Karnal (Haryana)
1970	CPCRI at Kasargod (Kerala) (Plantation crops)/Drought Prone
1971	TNAU (Tamil Nadu Agricultural University) at Coimbatore) and All India Co-ordinated Project for Dry land Agriculture
1972	ICRISAT at Patancheru, Hyderabad/National Commission on Agriculture
1974	Command Area Development
1976	IRDP (Integrated Rural Development Programme)
1977	T&V (Training and Visit System)
1979	NARP (National Agricultural Research Project)
1980	Wealth Tax on Agriculture was abolished
1982	NABARD (National Bank for Agriculture and Rural Development)
1985	NAEP (National Agricultural Extension Project)
1995	NRCB at Tiruchirappalli, Tamil Nadu (Banana)
1998	NATP (National Agricultural Technology Project)
2006	NAIP (National Agricultural Innovation Project)

The details on history of agriculture in India are in the subsequent Chapter 2.

1.4 AGRICULTURE IN NATIONAL ECONOMY

Agriculture forms the backbone of the Indian economy and despite concerted industrialization in the last 40 years, agriculture still occupies a place of pride. Agriculture is contributing nearly 30 per cent of the national income, providing employment to about 70 per cent of the working population and accounting for a sizable share of the country’s foreign exchange earnings. It provides the food grains to feed the large population of 85 crores. It is also the supplier of raw material to many industries. Thus, the very economic structure of the country rests upon agriculture. The present role of agriculture in the Indian economy is discussed below.

A. Contribution to National Income

The data supplied by the National Income Committee and the Central Statistical Organization clearly shows that agriculture contributed about 56 per cent of the national income in 1950–51 but contributed only 22 per cent of the national income in 2006–07. The perusal of data in Table 1.3 reveals that the share of agriculture in the national income was reckoned at about 56 per cent during 1950–51 and remained above 50 per cent during the following twenty years. However, the contribution of agriculture has declined in the last fifteen years due to rapid increase in the production of industrial goods and services.

Table 1.3. Contribution of Agriculture to National Income

Year	*Percentage contribution of agriculture–GDP*
1950-51	56.1
1960-61	51.2
1970-71	50.6
1980-81	42.0
1984-85	36.9
1989-90	30.0
1999-2000	24.0
2000-01	22.3
2001-02	22.2
2002-03	20.2
2003-04	20.7
2004-05	NA
2005-06	NA
2006-07	22.0

A comparison between shares of agriculture in national income in India with that in other countries further emphasizes dominance of agriculture in the Indian economy. In 1983, agriculture contributed only two, three, four and five per cent of the national income in U.K., U.S.A., Canada and Australia respectively. It means the more developed a country, the smaller is the share of agriculture in the national income or output. Hence, the Indian economy cannot be considered as advanced.

B. Contribution to Employment

Agriculture, directly or indirectly, has continued to be the main source of livelihood for the majority of the population in India. The decennial censuses indicate that 70 per cent of the population is supported by agriculture. These censuses show that an overwhelming majority of workers have been engaged in cultivation. Dependence of working population on other fields of agriculture like livestock, fisheries, forest etc., is less. The distribution of agricultural labourer force and population is given in Table 1.4.

On the basis of above figures, it can be concluded that:

- The rate and pattern of investment in other economic sectors have not been such as to draw away surplus rural labourer and relieve the pressure of population on land.

Table 1.4. Distribution of Agricultural Labourer Force as % of Total Work Force

Year	*Cultivators labourers*	*Agricultural*	*Livestock, fishery, forestry, plantation etc.,*	*Total agricultural work force*
1951	50.0	19.7	2.4	72.1
1961	52.8	16.7	2.3	71.8
1971	43.4	26.3	2.4	72.1
1981	43.9	24.8	2.9	71.6
1988-89	41.6	24.9	3.5	70.0
1991				
2001				
2006				

Source: www.agricoop.nic.in

- Since the growth of agricultural sector was very slow it failed to create enough opportunities for additional employment. It has resulted in widespread under-employment and arising backlog of unemployed.

The proportion of working population engaged in agriculture in other countries is very small. It is only two and three per cent in the U.K. and the U.S.A., 6 per cent in Australia and 7 per cent in France. In backward and underdeveloped countries the proportion of working population engaged in agriculture is quite high. For instance, it is 42 per cent in Egypt, 52 per cent in Indonesia and 72 per cent in China.

C. Contribution of Manpower to industry

The agricultural labourer of rural sector has been the supplier of manpower to industry. The findings of the Commission on Labourer are indicative that the Indian factory operatives were nearly all migrants from the rural areas. This drift to urban areas continues. This is due to lack of opportunities for employment and income in rural areas on the one hand and lure of employment, higher income and urban facilities on the other.

D. Contribution to Foreign Exchange Resources

Agricultural products–primary produce and manufactured through agricultural raw material occupy an important place in the country's export. According to an estimate, agricultural commodities like raw cotton and jute, unmanufactured tobacco, oilseeds, spices, tea and coffee accounted for about 49 per cent of the total value of exports in 1988–89. This makes a sizable contribution to the foreign exchange resources of the country.

E. Interdependence between Agriculture and Industry

There is a close interdependence between agriculture and industry. This is to the supply of raw materials and inputs from agriculture to industry and vice-versa; secondly, the supply of wage goods to the industrial sector; thirdly, the supply of basic consumption goods to the agricultural population; and finally, the supply of materials for the building up of economic and social overheads in the agricultural sector. The interdependence between agriculture and industry is becoming stronger as the economy is developing. The application of science and technology in agriculture induces innovations in respect of industrial products, which are used for agricultural production. Agricultural inputs like fertilizers, pesticides, diesel oil, electric motor, diesel engines, pump sets, agricultural tools and implements, tractors, power tillers etc., are supplied by the industry and oil, sugar, jute and cotton textiles and tobacco industries rely heavily on the agricultural sector. Even the processing industries, which are utilizing agricultural raw material, and developing fruit canning, milk products, meat products etc.

F. Contribution to Capital Formation

The pace of development is largely determined by the rate at which production assets increase. Before independence, the capital formation in Indian agriculture was of a low order. During this period, agriculture suffered from constant low yield technology, inequitable land tenure system and exploitation of the rural masses. The capital formation includes land development, construction of houses etc. Since independence, much more investment both public and private has been made in agriculture. The creation of physical assets has generally taken the form of land development, construction of irrigation facilities, roads and communication, farm buildings, agricultural machinery and equipment, warehouses, cold storages, market yard etc. This capital formation is helping not only development of agriculture but also the entire economy.

G. Contribution to Purchasing Power of People

Agriculture provides purchasing power not only to those directly engaged in it but to others also who are in the industries and services. When farmers earn more they also spend more. In the process, they create new markets and new opportunities for hundreds of blacksmiths, carpenters, masons, weavers, potters, leather workers, utensil-makers, tailors, cotton ginners, oil pressers, transporters and countless others.

Thus, there are many industries, the prosperity and employment of which are dependent upon the purchasing power of the agricultural population. Hence, it is concluded that besides purchasing food for non-agricultural workers and raw materials for consumer industries, it has created demands for a great many new industries, which, in turn, have provided high and well paid employment. This existing role of agriculture in the Indian economy points out the necessity for the development of Indian agriculture to the fullest extent possible as the prosperity of agriculture largely stands for the prosperity of the economy. The significance of agriculture lies in the fact that the development in agriculture is an essential condition for the development of the national economy.

1.5 FOOD PROBLEM IN INDIA

A. Food Production Trends

The trends in food grains output in recent years have exhibited some significant qualitative changes. On the other hand, there was significant effect of drought on the food grains production during the year 1987–88 and 2002–2003.

Rice production fluctuated around 60 million tones for five years and then followed the rising trend from 1988–89. This was possible due to government's efforts to increase the productivity of rice in the country in general and in the eastern parts of the country in particular. What production had been staggering around 45 million tones for five years before a quantum jump in 1988–89. But there was a fall in wheat production during 1989–90, which was attributed to shift of wheat area to oilseeds for getting better prices of the produce. The production of pulses has also been stagnant around 12–13 million tones except for a fall in the drought year *i.e.*, 1987–88. The trends of coarse grains and kharif food grains are in the same line as of rice while rabi food grains followed the trend of wheat. Since the contribution of rice in the total food grains production was the greatest, therefore, total food grains also followed the trend of rice production over the years.

Table 1.5. Food Grain Production in India

Year	*Food grain production (m.t.)*
1950-51	50.82
1960-61	82.02
1970-71	108.42
1980-81	129.59
1983-84	152.40
1984-84	145.50
1985-86	150.40
1986-87	143.40
1987-88	140.40
1988-89	169.90
1989-90	171.10
1990-91	176.39
1996-97	199.30
1997-98	192.43
1998-99	195.25
2000-01	196.80
2001-02	212.00
2002-03	173.70
2003-04	213.50
2004-05	213.50
2005-06	204.60
2006-07	209.30

B. Food Problem

India's food problem dates back prior to independence. In the beginning, India's food problem was one of scarcity, shortage of rice after the separation of Myanmar (Burma) from India in 1937 and shortage of wheat, also after the partition of the country in 1947. Initially, the major concern of the Government was to increase the domestic supplies either through increased production or through imports or through both. In the second half of the 1950s and during the 1960s the major concern of the Government shifted to control of food grains prices. The Government of India entered into an agreement in 1956 with the USA known as PL 480 agreement for the import of rice and wheat. The Government found the PL 480 food imports a good tool to stabilize food prices in the country. In fact, PL 480 imports were the basis of our agricultural and industrial development.

The Government set up the Food grains Policy Committee in 1966 to review the food problem afresh. The committee found India's dependence on food imports was not likely to be easy in future. It took serious note of the fact that the food aid was used openly to influence the internal economic policies and foreign affairs policies of the Government. Between 1967–68 and 1989–90, Punjab, Haryana and Uttar Pradesh had recorded annual growth rates of 5.4, 4.0 and 3.4 per cent, respectively in food grains production. These states are the backbone of our public distribution system. These states have insulated the country from a food grains crisis. In the 1970s and particularly after 1974, there has been a growing surplus of stocks from the original target of 5.0 million tones; the Government had succeeded in accumulating over 30 million tones of buffer stock of food grains during the 1980s. Actually, it was the huge reserves of food grains which helped the Government to tide over successfully the three years of poor food grains production, culminating in the widespread drought of 1987–88.

The food problem is not any more one of shortage or of high prices but how to enable the lower income groups to purchase the available food grains and how to make use of the huge food stocks to help accelerate the process of economic growth. The food for work programme has been designed since 1977–78 to provide work for the rural poor, the unemployed and the famine stricken people and at the same time create durable community assets. The Government is also implementing a scheme to provide food grains to the weaker sections, especially in the tribal areas at a price well below the already subsidized price in the public distribution system. There has been a general agreement that the food problem in India is mainly due to the increasing population (consequently increasing food demand), inadequate supply of food grains and some aspects of the Government's policy on food.

C. Measures to Solve the Food Problem

India's food problem is older than our independence but it is a pity that no permanent solution has been found all these years. The Government of India has taken various steps to solve the food problem, which are discussed ahead.

D. Measures to Increase Production

Technological changes : Among the measures to increase the production of food grains, the least controversial are technological changes. Intensive cultivation through use of improved varieties and the liberal use of irrigation and fertilizers is being vigorously extended in the country ushering in the green revolution. The latest step is to bring about a break through in rainfed and dry land agriculture.

Organizational approach : The second approach to agricultural development is the organizational approach *i.e.*, by adequate and efficient organization, which includes not only the governmental administrative system but the entire framework of official and semi-official institutions and agencies. It is opined that the efforts to increase agricultural production through technological changes have not been very successful mainly because of an inadequate and ineffective organization. Institutional changes the other way to increase agricultural production is through bringing institutional changes *i.e.*, through land reforms. The present agrarian structure is such that there are no incentives for increased production. With tiny holdings, which are scattered all over the village, with a system of landholdings in which the tenant has no security of tenure, it is not wise to expect the tiller to put his best efforts to increase food production. The Government has been pursuing many land reform measures such as consolidation of holdings, ceiling on holdings, regulation of tenures and the formation of cooperative farms. Since there are many loopholes in the regulation of land reforms, there is urgent need to plug these loopholes through effective legislations on the part of the Government.

Distributional changes : In the last few years, the Government has expanded the public distribution system (PDS) considerably. From over two million tones in 1956, the public distribution system has handled over 19 million tones in 1987–88. In 1991, steps were taken to revamp the PDS and its reach extended to 1700 blocks in far-flung and disadvantaged areas like economically backward, drought prone, desert and hilly areas. Allocation of rice, wheat, etc., under the PDS should be increased for the lean period. There is need of the hour to strengthen the public distribution system in the country.

Stabilization of food grains prices : The main objective of the food policy in recent years has been to hold the food grains prices in check. The Government has been adopting such short-term measures as the maintenance of stocks at high level, extension of internal procurement, stepping up of government purchase of food grains for release through fair price shops, measures to curb hoarding and profiteering and fixation of maximum control prices. These measures did have some influence in keeping prices in check but past experience shows that price stability has not been fully achieved. The buffer stock operation by the Government is the key to the problem of stabilization not only of food prices but also of general price level in the country. The Government decided to build up a buffer stock of 5 m.t. of food grains by 1973–74 but the actual stock with the Government from 1979 onwards has been over 20 m.t. which is a good sign. It is opined that if it is managed with wisdom and flexibility, it would go a long way to protect both the farmer and the consumer against severe fluctuations in prices. The existence of large food stocks creates a feeling of complacency that the food shortage is a thing of the past. There is every possibility of the output becoming larger with the expansion of irrigation facilities, fertilizers availability, rural electrification, etc. But it should be very clearly understood that the highly fluctuating monsoon and the consequent ups and downs in food output can always spell danger. Naturally, efforts, should continue to keep the population in check to take full advantage of increase in agricultural production.

1.6 AN INTRODUCTION TO AGRONOMY

The word agronomy has been derived from the two Greek words, ***agros*** and ***nomos*** having the meaning of **field** and **to manage,** respectively. Literally, agronomy means the "art of managing field". Technically, it means the "science and economics of crop production by management of farm land".

Definition : Agronomy is the art and underlying science in production and improvement of field crops with the efficient use of soil fertility, water, labourer and other factors related to crop production. Agronomy is the field of study and practice of ways and means of production of food, feed and fibre crops. Agronomy is defined as "a branch of agricultural science which deals with principles and practices of field crop production and management of soil for higher productivity.

Importance : Among all the branches of agriculture, agronomy occupies a pivotal position and is regarded as the mother branch or primary branch. Like agriculture, agronomy is an integrated and applied aspect of different disciplines of pure sciences. Agronomy has three clear branches namely, (*i*) Crop Science, (*ii*) Soil Science, and (*iii*) Environmental Science that deals only with applied aspects. (*i.e.*,) Soil-Crop-Environmental relationship. Agronomy is a synthesis of several disciplines like crop science, which includes plant breeding, crop physiology and biochemistry etc., and soil science, which includes soil fertilizers, manures etc., and environmental science which includes meteorology and crop ecology.

Basic Principles

- Planning, programming and executing measures for maximum utilization of land, labourer, capital and other factors of production.
- Choice of crop varieties adaptable to the particular agro-climate, land situation, soil fertility, season and method of cultivation and befitting to the cropping system;
- Proper field management by tillage, preparing field channels and bunds for irrigation and drainage, checking soil erosion, leveling and adopting other suitable land improvement practices;
- Adoption of multiple cropping and also mixed or intercropping to ensure harvest even under adverse environmental conditions;
- Timely application of proper and balanced nutrients to the crop and improvement of soil fertility and productivity. Correction of ill-effects of soil reactions and conditions and increasing soil

organic matter through the application of green manure, farm yard manure, organic wastes, bio fertilizers and profitable recycling of organic wastes;

- Choice of quality seed or seed material and maintenance of requisite plant density per unit area with healthy and uniform seedlings;
- Proper water management with respect to crop, soil and environment through conservation and utilization of soil moisture as well as by utilizing water that is available in excess, and scheduling irrigation at critical stages of crop growth.
- Adoption of adequate, need-based, timely and exacting plant protection measures against weeds, insect-pests, pathogens, as well as climatic hazards and correction of deficiencies and disorders;
- Adoption of suitable and appropriate management practices including intercultural operations to get maximum benefit from inputs dearer and difficult to get, low-monetary and non-monetary inputs;
- Adoption of suitable method and time of harvesting of crop to reduce field loss and to release land for succeeding crop(s) and efficient utilization of residual moisture, plant nutrients and other management practices;
- Adoption of suitable post-harvest technologies.
- Agronomy was recognized as a distinct branch of agricultural science only since about since about 1900. The American Society of Agronomy was organized in 1908.

1.6.1 Agronomist

Agronomist: "Scientist who studies the principles and practices of crop production and soil management for production of food for human beings and feed for his animals".

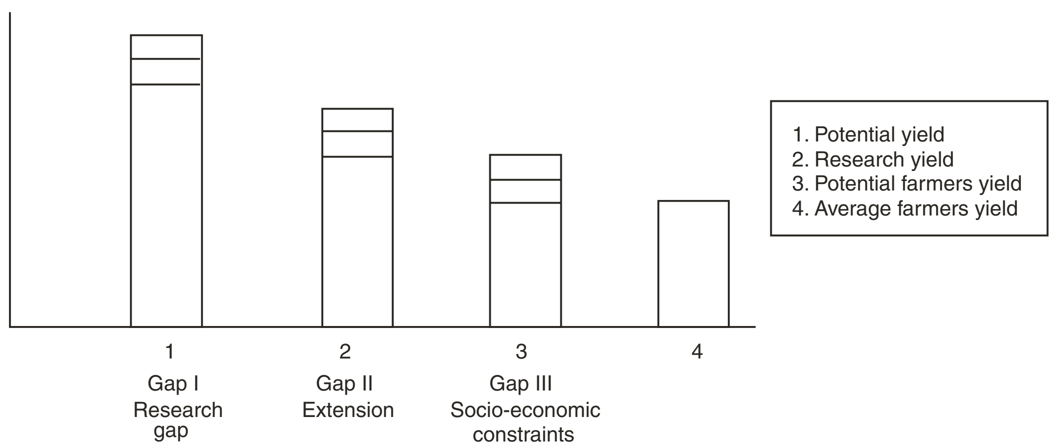
Role of Agronomist

- Generally agronomist studies the problems of crop production and develops better ways of producing food, feed and fibre.
- Agronomist aims at obtaining maximum production at minimum cost *e.g.*, developing efficient and economic field preparation method (*i.e.*) energy should be minimized (*i.e.*) what type of crop, in what season, etc.
- Agronomist shoulder the responsibilities of all social, economic, cultural problems in addition to field problems for the effective functioning of the farm in general.
- Agronomist exploits the knowledge developed by basic and allied, applied sciences for higher crop production.
- Agronomist carries out research on scientific cultivation of crops taking into account the effect of factors like soil, climate, crop varieties and adjust production techniques suitably depending on the situation.
- Since, the agronomist co-operates and co-ordinate with all the disciplines of agriculture, it is essential that an agronomist should have training in other disciplines of agriculture also.
- To develop efficient method of cultivation (whether broadcasting, nursery and transplantation or dibbling, etc.) The method may vary according to the germination period and depending upon the crop establishment and what should be the optimum plant population.
- He has to identify various types of nutrients required by crops, *e.g.,* for long duration rice (150-100–50 kg), for pulses N_2, P and K. If the method of cultivation varies the nutrient content also varies. The time and method of applying nutrients must also be taken into account. Method refers to broadcast or to apply close to the root or through leaves (*i.e.*) foliage.

- Agronomist must select a better weed management practice. Either through mechanical or physical (by human work) or chemical (herbicides or weedicides, *e.g.*; 2–4-D or cultural (by having wide space it may increase weed growth by using inter space crops). Weeds are controlled integrated means.
- **Irrigation management:** Whether to irrigate continuously or stop in between and how much water should be irrigated are calculated to find the water requirement.
- Crop planning (*i.e.,*) developing crop sequence should be developed by agronomist (*i.e.*) what type of crop, cropping pattern, cropping sequence, etc.
- Agronomists are also developing the method of harvesting, time for harvesting, etc. The harvest should be done in the appropriate time.
- Decision-making in the farm management. What type of crop to be produced, how much crop, including marketing should be planned? Decision should be at appropriate time.

1.7 POTENTIAL PRODUCTIVITY AND CONSTRAINTS IN CROP PRODUCTION

Potential Yield - It is the maximum possible economic yield for a crop from a unit land area, when all the factors affecting the crop growth and yield are available without any constraints (or) this is the maximum possible yield that could be obtained under controlled condition. Here, all the environmental factors are provided to the crop to express the full potential.



Research yield - The yield obtained in the research station under correct management and supervision by the scientist. Hence, all the technologies are being used by scientists to get maximum yield.

Potential farmers yield - The yield obtained by the progressive farmers under the guidance of scientists using new techniques.

Average farmers yield - Actual yield obtained by the farmer.

Gap I - The latest technologies developed by the scientists are not completely transformed to the extension agency. The extension agency should fill up the gap by advocating the farmers by acquiring themselves with these improved methods of cultivation.

Gap II - Here, there is no input constraints and only environmental constraints exist.

Gap III - Variation in management of field and crop. Only few farmers get higher yield. Gap can be filled up by improving the socio-economic condition of the farmers.

Constraints in Crop Production

I. Ecological

1. Weather
2. Pollution
3. Desertification

II. Production

1. Variety
2. Weed
3. Pests and Diseases
4. Soil health
5. Water (poor quality)
6. Farm machinery
7. Post harvest technology
8. Market facilities

III. Socio-economic

1. Cost and return
2. Credit
3. Risk uncertainty
4. Traditional attitude
5. Knowledge
6. Input availability
7. Institution