OIC ACCREDITATION CERTIFICATION PROGRAMME FOR OFFICIAL STATISTICS

AGRICULTURE, FORESTRY AND FISHERY STATISTICS

TEXTBOOK

ORGANISATION OF ISLAMIC COOPERATION

STATISTICAL ECONOMIC AND SOCIAL RESEARCH AND TRAINING CENTRE FOR ISLAMIC COUNTRIES

SESRIC

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{{ABDUL ALIM BHUIYAN, BHUIYAN}}

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ACRONYMS

AWU	Annual Work Unit
BADC	Bangladesh Agricultural Development Corporation
BBS	Bangladesh Bureau of Statistics
BMDA	Barind Multipurpose Development Authority
CAP	Common Agricultural Policy
CFP	Common Fisheries Policy
DAP	Days After Planting
DOF	Department of Fisheries
EC	European Commission
EU	European Union
EUR	Euro
FAO	Food and Agricultural Organization (UN)
FSS	Farm Structure Survey
FYM	Farmyard Manure
GDP	Gross Domestic Product
Ha	Hectare
HI	Harvest Index
HYV	High Yielding Variety
NAP	National Agriculture Policy
OECD	Organization for Economic Cooperation and Development
PHT	Post Harvest Technology
TFP	Total Factor Productivity
UAA	Utilized Agricultural Area

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UNIT 1

INTRODUCTION TO AGRICULTURE

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.

1.1. Development of Agriculture

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.

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.

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 (Chandrasekaran, et. al., 2010).

1.2. Agriculture in National Economy

The OECD collects and compiles a wide range of data used to support its agricultural policy analysis and long-term forecasts. These activities are carried out in co-operation with other international organisations, notably the Food and Agriculture Organisation (FAO) and UNCTAD.

Agriculture forms the backbone of the most of the country's economy like India and despite concerted industrialization in the last 40 years, agriculture still occupies a place of pride. In India, 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.

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 (Chandrasekaran, et. al., 2010).

1.3. The Evolution of Farm Holdings

The latest agricultural census in the European Union (EU) was conducted for the 2009 or 2010 reference years. This section presents results for a selection of indicators, comparing the situation in 2010 with earlier years, in particular, 2005 when a farm structure survey (FSS) was conducted. The section focuses on the change in the number and relative importance of agricultural holdings − referred to hereafter as farms – of various size categories; their size is determined either by a physical characteristic (the utilised agricultural area – UAA) or an economic measure (the standard output).

The first part of this section focuses on a size class analysis of farms based on their utilised agricultural area. It should be noted that this indicator does not include land occupied by buildings or farmyards and that some farms may not have any utilised agricultural area if they only rear livestock in animal housing (for example, poultry farms).

In 2010, there were 12.2 million farms in the EU-28: collectively their utilised agricultural area encompassed 176 million hectares (ha), or 1.76 million km2. The land used by farms in the EU-28 accounted for approximately 40 % of the total land area. The structure of farming in the EU was made up of two contrasting types of farm: on the one hand, the vast majority of farms cultivated a relatively small area, and on the other, there were a small number of farms that cultivated much larger areas.

Around four fifths (80.3 %) of all farms in the EU-28 had less than 10 hectares of utilised agricultural area, and together these smaller farms cultivated some 12.2 % of the utilised agricultural area. By contrast, only 5.9 % of the farms in the EU-28 cultivated 50 hectares or more of land for agricultural purposes, however, these larger farms collectively cultivated two thirds (66.6 %) of the total utilised agricultural area.

The average farm size in the EU-27 rose from 11.9 hectares to 14.5 hectares between 2005 and 2010; the largest farms grew most. The share of agricultural area cultivated by smaller farms fell and that of larger farms grew. The increase in the utilised agricultural area of farms with at least 100 hectares outweighed the decrease in the utilised agricultural area of all other farms.

Between 2000 and 2010 the largest farms (with 100 hectares or more) in the EU-15 increased in number and average size (area), while the overall number of farms fell. Among the EU Member States the number of farms increased between 2005 and 2010 only in Ireland and Malta. The increase in the relative importance of larger farms (50 hectares or more) was almost universal among the EU Member States.

The average number of animals per farm increased in the EU-27 from 9.5 livestock units in 2005 to 11.2 livestock units in 2010. The shares of livestock in the farms with zero hectares of utilised agricultural area increased substantially (EU, 2015).

Farms with less than 10 hectares of utilised agricultural area occupied more than half of the labour force. The share of the labour force fell in the size classes of farms with less than 10 hectares of utilised agricultural area while it increased in all other size classes.

The second part of this section continues with the analysis of farms by size, but using size classes based on the value of their standard output: coefficients are calculated as the average monetary value of the agricultural output at farm-gate price, in euro per hectare or per head of livestock; these coefficients are calculated at a regional level for each product. The standard output of each farm can be calculated combining the coefficients with information on how many hectares of different types of crops it has and how many head of different types of livestock.

In the EU-28 in 2010 each of the size classes of farms with less than EUR 15,000 of standard output had higher shares of the number of farms than their shares of utilised agricultural area. By contrast, for each of the size classes of farms with EUR 15,000 or more of standard output the reverse was true, indicating that these farms were generally larger in terms of utilised agricultural area.

The very largest farms, with a standard output of EUR 0.5 million or more, cultivated 14.6 % of the total utilised agricultural area in the EU-28, but this size class accounted for only 0.7 % of the total number of farms. Combining several of the larger size classes, while only one in five (19.1 %) farms across the EU-28 had a standard output of EUR 15,000 or more, these farms cultivated four fifths (79.8 %) of the utilised agricultural area. By contrast, more than two fifths (44.6 %) of farms in the EU-28 had a standard output of less than EUR 2,000 and these farms accounted for just one twentieth (4.6 %) of the total utilised agricultural area.

The increase in the utilised agricultural area of farms with at least EUR 100,000 of standard output outweighed the decrease of all other farms. Around three quarters of the utilised agricultural area in Slovakia and the Czech Republic was cultivated by farms with a standard output of at least EUR 250,000 (EU, 2015).

UNIT 2

SOILS AND TILLAGE

In general, soil is defined as the more or less loose and crumby part of the outer earth crust. It is a natural dynamic body of mineral and organic constituents, differentiated into horizons, which differs among themselves as well as from the underlying parent material in morphology, physical make-up, chemical composition and biological characteristics. It is made up of small particles of different sizes. Soil is a three-dimensional body, which supports plant establishment and growth and it is a natural and dynamic medium.

For a farmer, soil refers to the cultivated top layer (surface soil) only, that is, up to 15–18 cm of the plough depth. Soils widely vary in their characteristics and properties. Understanding the properties of soils is important (1) for optimum use they can be put to and (2) for best management requirements for their efficient and productive use.

Tillage operations in various forms have been practiced from the very inception of growing plants. Primitive man used tools to disturb the soils for placing seeds. The word tillage is derived from the Anglo-Saxon words tilian and teolian, meaning to plough and prepare soil for seed to sow, to cultivate and to raise crops. Jethrotull, who is considered as Father of tillage suggested that thorough ploughing is necessary so as to make the soil into fine particles (Chandrasekaran, et. al., 2010).

2.1. Functions of Soil, Soil Phases and Properties of Soil

Functions of soil

- It provides place and anchorage for plant growth and development.
- It serves as a medium for air and water circulation.
- It acts as a reservoir for water and nutrients.
- It provides space for beneficial microorganisms.

Soil Phases

Soil is a complex system, made of solid, liquid and gaseous materials. Soil is a three phase or polyphasic system comprising of (a) solid phase, (b) liquid phase, and (c) gaseous phase in some proportions. Normally the proportion is 50:25:25, but this may vary from soil to soil. In some occasions, liquid or gaseous phase may be absent. For e.g., in water logged soil, air is not present; similarly in desert dry sandy soils, water is not present.

Soil consists of four major components. They are: (i) Mineral matter, (ii) Organic matter, (iii) water, and (iv) air. Physically, soil consists of stones, large pebbles, dead plant twigs, roots, leaves and other parts of the plant, fine sand, silt, clay and humus derived from the decomposition of organic matter. In the organic matter portion of the soil, about half of the organic matter comprised of the dead remains of the soil life in all stages of decomposition and the remaining half of the organic matter in the soil is alive. The living part of the organic matter consists of plant roots, bacteria, earthworms, algae, fungi, nematodes actinomycetes and many other living organisms.

Soil contains about 50% solid space and 50% pore space. Mineral matter and organic matter occupy the total solid space of the soil by about 45% and 5% respectively. The total pore space of the soil is occupied and shared by air and water on roughly equal basis. The proportion of air and water will vary depending upon the weather and environmental factors (Chandrasekaran, et. al., 2010).

Properties of Soil

Physical Properties of Soil

(a) Soil Texture

It refers to the nature of distribution of particles of various sizes present in the soil. It is the proportion of coarse, medium and fine particles, which are termed as sand, silt and clay respectively. Hence, it can be defined as the proportion of sand, silt and clay particles in soil. The mineral soil particles are classified according to their sizes (Chandrasekaran, et. al., 2010).

(b) Soil Structure

It is defined as the shape and arrangement of soil particles with respect to each other in a soil mass or block. The soil aggregates are not solids but possess a porous or spongy character. Most soils are having a mixture of single grain structure or aggregate structure. The number of primary particles (sand, silt and clay) is combined together by the binding effect of organic and inorganic soil colloids. The binding or cementing materials are: Iron or Aluminium Hydroxide and decomposing organic matter. The names of soil structures based on their shapes are: 1. Platy, 2. Prismatic, 3. Columnar, 4. Blocky, 5. Cloddy, 6. Granular, 7. Crumb, 8. Single grain, and 9. Massive (Chandrasekaran, et. al., 2010).

Soil /irrigability Classification

Soil is the reservoir for water in retaining and supplying the soil moisture to plant growth. The periodical recharging of water in soil pore spaces can be made either by irrigation or rainfall. The recharged water has to be supplied to plant system. This retention capacity and supply capacity varies from soil to soil based on its physical and chemical properties. Based on this, soil classification is made for its suitability for irrigation. This classification is also known as irrigability classification. Generally, soil can be broadly grouped as shallow soil and deep soil (Chandrasekaran, et. al., 2010).

i. Shallow soil - It means the actual depth of soil profile to hold moisture is very less and depth of soil medium available for plant to extend its root system for tapping water and nutrients is less.
ii. Deep soil - The soil profile depth is more to hold moisture and the depth of soil medium available for plant roots to extend its branches to tap water and nutrients is also more.

Soil Water or Soil Moisture

The soil moisture is the most important component or ingredient of the soil, which plays a vital role in crop production or plant growth. Water is retained as thin film around the soil particles and in the capillary pores by the forces of adhesion, cohesion and surface tension (Chandrasekaran, et. al., 2010).

2.2. Soil Classification and Problem Soil

Soil Classification

In order to establish the interrelationship between soil characteristics, the soils require to be classified. Soil taxonomy groups the soil in orderly and logical and hierarchical manner involving successive sub divisions. Modern soil taxonomy considers soil and natural body and has two major features.

- The classification system is based on all soil properties which can easily be verified by other scientists, and
- The unique nomenclature has given a connotation or expression of major characteristics of the soil.

Purpose

- Besides attempting the genetic relationship, it helps to communicate all scientists with a specific language, which is a shorthand impression on the nature of the soil profile.
- It helps the soil scientists to remember the soil properties very easily.

- It easily establishes the relationship between soil individuals.
- It predicts the soil behaviour with reference to the purpose for which put into.
- It identifies the soils best uses.
- It also helps to estimate the soil productivity and helps to identify soils for research and agro technology transfer.

Problem Soil

Saline Soils

Saline (Solonchak, Russian term) soil are defined as a soil having a conductivity of the saturation extract (EC) greater than 4 dSm^{-1} and an exchangeable sodium percentage (ESP) less than 15. The pH is usually less than 8.5. Formerly these soils were called white alkali soil because of surface curst of white salts. The saline soils are originating due to accumulations of soluble salts. The most soluble salts in saline soils are composed of the cations sodium, calcium, magnesium and the anions chloride, sulphate and bicarbonate. Usually smaller quantities of potassium, ammonium, nitrate and carbonate also occur (Chandrasekaran, et. al., 2010).

Alkali Soils (Sodic/Solonetz)

Alkali (or) sodic soil is defined as a soil having a conductivity of the saturation extract less than 4 dSm^{-1} and an ESP of > 15. The pH is usually between 8.5-10.0. Formerly these soils were called "black alkali soils" (Chandrasekaran, et. al., 2010).

Saline-Alkali Soils

Saline alkali soil is defined as a soil having a conductivity of (EC) greater than 4 dSm^{-1} and an exchangeable sodium percentage (ESP) greater than 15. The pH is variable and usually above 8.5 depending on the relative amounts of exchangeable sodium and soluble salts (Chandrasekaran, et. al., 2010).

2.3. Definition and Objectives of Tillage

Tillage refers to the mechanical manipulation of the soil with tools and implements so as to create favourable soil conditions for better seed germination and subsequent growth of crops. ***Tilth*** is a physical condition of the soil resulting from tillage. Tilth is a loose friable (mellow), airy, powdery, granular and crumbly condition of the soil with optimum moisture content suitable for working and germination or sprouting of seeds and propagules i.e., tilth is the ideal seed bed (Chandrasekaran, et. al., 2010).

Objectives

Tillage is done:

1. To prepare ideal seed bed favourable for seed germination, growth and establishment;
2. To loosen the soil for easy root penetration and proliferation;
3. To remove other sprouting materials in the soil;
4. To control weeds;
5. To certain extent to control pest and diseases which harbour in the soil;
6. To improve soil physical conditions;
7. To ensure adequate aeration in the root zone which in turn favour for microbial and biochemical activities;
8. To modify soil temperature;
9. To break hard soil pans and to improve drainage facility;
10. To incorporate crop residues and organic matter left over;
11. To conserve soil by minimizing the soil erosion;
12. To conserve the soil moisture;
13. To harvest efficiently the effective rain water;
14. To assure the through mixing of manures, fertilizers and pesticides in the soil;
15. To facilitate water infiltration and thus increasing the water holding capacity of the soil, and
16. To level the field for efficient water management

2.4. Characteristics of Good Tilth and Types of Tilth

Good tilth refers to the favourable physical conditions for germination and growth of crops. Tilth indicates two properties of soil viz., the size distribution of aggregates and mellowness or friability of soil. The relative proportion of different sized soil aggregates is known as size distribution of soil aggregates. Higher percentages of larger aggregates with a size above 5 mm in diameter are necessary for irrigated agriculture while higher percentage of smaller aggregates (1–2 mm in diameter) are desirable for rainfed agriculture. Mellowness or friability is that property of soil by which the clods when dry become more crumbly. A soil with good tilth is quite porous and has free drainage up to water table. The capillary and non-capillary pores should be in equal proportion so that sufficient amount of water and free air is retained respectively (Chandrasekaran, et. al., 2010).

Types of Tilth are as follows:

- **Fine Tilth** refers to the powdery condition of the soil.

- **Coarse Tilth** refers to the rough cloddy condition of the soil.
- **Fine seedbed** is required for small seeded crops like ragi, onion, berseem, tobacco.
- **Coarse seedbed** is needed for bold seeded crops like sorghum, cotton, chickpea, lab-lab etc.

2.5. Types of Tillage

- **On Season Tillage:** It is done during the cropping season (June–July or Sept.–Oct.).
- **Off Season Tillage:** It is done during fallow or non-cropped season (summer).
- **Special Types of Tillage:** It is done at any time with some special objective/purpose.

On Season Tillage

Tillage operations done for raising the crops in the same season or at the onset of the crop season are called as on season tillage. They are,

(a) Preparatory Tillage

It refers to tillage operations that are done to prepare the field for raising crops. It is divided into three types viz., (i) primary tillage, (ii) secondary tillage, and (iii) seed bed preparation (Chandrasekaran, et. al., 2010).

(i) Primary tillage - The first cutting and inverting of the soil that is done after the harvest of the crop or untilled fallow, is known as primary tillage. It is normally the deepest operation performed during the period between two crops. Depth may range from 10–30 cm. It includes ploughing to cut and invert the soil for further operation. It consists of deep opening and loosening the soil to bring out the desirable tilth. The main objective is to control weeds to incorporate crop stubbles and to restore soil structure.

(ii) Secondary tillage - It refers to shallow tillage operation that is done after primary tillage to bring a good soil tilth. In this operation the soil is stirred and conditioned by breaking the clods and crust, closing of cracks and crevices that form on drying. Incorporation of manures and fertilizers, leveling, mulching, forming ridges and furrows are the main objectives. It includes cultivating, harrowing, pulverizing, raking, leveling and ridging operations.

(iii) Seed bed preparation - It refers to a very shallow operation intended to prepare a seed bed or make the soil to suit for planting. Weed control and structural development of the soil are the objectives.

(b) Inter Tillage/Inter Cultivation

It refers to shallow tillage operation done in the filed after sowing or planting or prior to harvest of crop plants i.e., tillage during the crop stand in the field. It includes inter cultivating, harrowing, hoeing, weeding, earthing up, forming ridges and furrows etc. Inter tillage helps to incorporate top dressed manures and fertilizers, to earth up and to prune roots (Chandrasekaran, et. al., 2010).

Off Season Tillage

Tillage operation is done for conditioning the soil during uncropped season with the main objective of water conservation, leveling to the desirable grade, leaching to remove salts for soil reclamation reducing the population of pest and diseases in the soils. etc. (Chandrasekaran, et. al., 2010). They are:

(a) Stubble or Post harvest tillage - Tillage operation carried out immediately after harvest of crop to clear off the weeds and crop residues and to restore the soil structure. Removing of stiff stubbles of sugarcane crop by turning and incorporating the trashes and weeds thus making the soil ready to store rain water etc., are the major objectives of such tillage operations.

(b) Summer tillage - Operation being done during summer season in tropics to destroy weeds and soil borne pest and diseases, checking the soil erosion and retaining the rain water through summer showers. It affects the soil aggregates, soil organic matter and sometimes favour wind erosion.

(c) Winter tillage - It is practiced in temperate regions where the winter is severe that makes the field unfit for raising crops. Ploughing or harrowing is done in places where soil condition is optimum to destroy weeds and to improve the physical condition of the soil and also to incorporate plant residues.

(d) Fallow tillage - It refers to the leaving of arable land uncropped for a season or seasons for various reasons. Tilled fallow represent an extreme condition of soil disturbance to eliminate all weeds and control soil borne pest etc. Fallow tilled soil is prone to erosion by wind and water and subsequently they become degraded and depleted.

Special Types of Tillage

Special type tillage includes

1. **Subsoil tillage (sub soiling)** is done to cut open/break the subsoil hard pan or plough pan using sub soil plough/chisel plough. Here the soil is not inverted. Sub soiling is done once in 4–5 years, where heavy machinery is used for field operations and where there is a colossal loss of topsoil due to carelessness. To avoid closing of sub soil furrow vertical mulching is adopted.

2. **Levelling by tillage** - Arable fields require a uniform distribution of water and plant nutrition for uniform crop growth. This is achieved when fields are kept fairly leveled. Levellers and scrapers are used for levelling operations. In leveled field soil erosion is restricted and other management practices become easy and uniform.
3. **Wet tillage** - This refers to tillage done when the soil is in a saturated (anaerobic) condition. For example puddling for rice cultivation.
4. **Strip tillage** - Ploughing is done as a narrow strip by mixing and tilling the soil leaving the remaining soil surface undisturbed.
5. **Clean tillage** - Refers to the working of the soil of the entire field in such a way no living plant is left undisturbed. It is practiced to control weeds, soil borne pathogen and pests.
6. **Ridge tillage** - It refers to forming ridges by ridge former or ridge plough for the purpose of planting.
7. **Conservation tillage** - It means any tillage system that reduces loss of soil or water relative to conventional tillage. It is often a form of non-inversion tillage that retains protective amounts of crop residue mulch on the surface. The important criteria of a conservation tillage system are: (i) presence of crop residue mulch, (ii) effective conservation of soil and water, (iii) improvement of soil structure and organic matter content, and (iv) maintenance of high and economic level of production.
8. **Contour tillage** - It refers to tilling of the land along contours (contour means lines of uniform elevation) in order to reduce soil erosion and run off.
9. **Blind tillage** - It refers to tillage done after seeding or planting the crop (in a sterile soils) either at the pre-emergence stage of the crop plants or while they are in the early stages of growth so that crop plants (cereals, tuber crops etc.) do not get damaged, but extra plants and broad leaved weeds are uprooted.

2.6. Modern Concepts of Tillage

In conventional tillage combined primary and secondary tillage operations are performed in preparing seed bed by using animal or tractor, which cause hard pan in sub soils resulting in poor infiltration of rain water, thus it is more susceptible to run off and soil erosion. Farmers usually prepare fine seed bed by repeated ploughing, when the animal of the farm is having less work. Research has shown that frequent tillage is rarely beneficial and often detrimental. Repeated use of heavy machinery destroys structures, causes soil pans and leads to soil erosion. Moreover energy is often wasted during tillage processes. All these reasons led to the development of modern concepts namely the practices like minimum tillage, zero tillage, stubble mulch farming and conservation tillage, etc. (Chandrasekaran, et. al., 2010).

Minimum Tillage

Minimum tillage is aimed at reducing tillage to the minimum necessary for ensuring a good seedbed, rapid germination, a satisfactory stand and favourable growing conditions. Tillage can be reduced in two ways by omitting operations, which do not give much benefit when compared to the cost, and by combining agricultural operations like seeding and fertilizer application (Chandrasekaran, et. al., 2010).

Zero Tillage/No Tillage/Chemical Tillage

Zero tillage is an extreme form of minimum tillage. Primary tillage is completely avoided and secondary tillage is restricted to seedbed preparation in the row zone only. It is also known as no-tillage and is resorted to places where soils are subjected to wind and water erosion, timing of tillage operation is too difficult and requirements of energy and labour for tillage are also too high. Weeds are controlled using herbicides. Hence, it is also referred as chemical tillage (Chandrasekaran, et. al., 2010).

Stubble Mulch Tillage or Stubble Mulch Farming

In this tillage, soil is protected at all times either by growing a crop or by leaving the crop residues on the surface during fallow periods. Sweeps or blades are generally used to cut the soil up to 12 to 15 cm depth in the first operation after harvest and the depth of cut is reduced during subsequent operations. When unusually large amount of residues are present, a disc type implement is used for the first operation to incorporate some of the residues into the soil (Chandrasekaran, et. al., 2010).

Conservation Tillage

Though it is similar to that of stubble mulch tillage, it is done to conserve soil and water by reducing their losses.

UNIT 3

SEEDS AND SOWING

Plants reproduce sexually by seeds and asexually by vegetative parts. Grains, which are used for multiplication, are called seeds while those used for human or animal consumption are called grains. Good stalks of planting materials are basic to profitable crop production. The seed or planting material largely determines the quality and quantity of the produce. A good seed or stalk of planting material is genetically satisfactory and true to type, fully developed and free from contamination, deformities, diseases and pests.

Seed is a fertilized ripened ovule consisting of three main parts namely seed coat, endosperm and embryo, which in due course gives raise to a new plant. Endosperm is the storage organ for food substance that nourishes the embryo during its development. Seed coat is the outer cover that protects or shields the embryo and endosperm (Chandrasekaran, et. al., 2010).

3.1. Seed Characteristics and Seed Germination

A good quality seed should posses the following characteristics:

- Seed must be true to its type i.e., genetically pure, free from admixtures and should belong to the proper variety or strain of the crop and their duration should be according to agroclimate and cropping system of the locality.
- Seed should be pure, viable, vigorous and have high yielding potential.
- Seed should be free from seed borne diseases and pest infection.
- Seed should be clean; free from weed seeds or any inert materials.
- Seed should be in whole and not broken or damaged; crushed or peeled off; half filled and half rotten.
- Seed should meet the prescribed uniform size and weight.
- Seed should be as fresh as possible or of the proper age.
- Seed should contain optimum amount of moisture (8-12%).
- Seed should have high germination percentage (more than 80%).
- Seed should germinate rapidly and uniformly when sown.

Germination is a protrusion of radicle or seedling emergence. Germination results in rupture of the seed coat and emergence of seedling from embryonic axis. Factors affecting germination are soil, environment, water, temperature, light, atmospheric gases and exogenous chemicals required for germination of seeds (Chandrasekaran, et. al., 2010).

***Soil*:** Soil type, texture, structure and microorganism greatly influence the seed germination.

Environment: Generally, the environmental conditions favouring growth of seedling also favours germination. Germination does not occur until the seeds attain physiological maturity.

Water (soil moisture and seed moisture): Imbibitions of water is the prerequisite process for germination. Both living and dead seeds imbibe water and swell. Dead seeds imbibe more water and swell rapidly as compared to good seeds. The amount imbibed is related to the chemical composition of the seed such as proteins, mucilage's pectins and biochemical components. Cereal grains such as maize imbibe water to approximately 1/3 of its seed weight, soybean seeds to 1/2 of its seed weight. Seed germination will be maximum when the soil moisture level is at field capacity. Slower rate of germination is noticed in places where soil moisture is near or at wilting point.

Temperature: The temperature can be cardinal (Maximum, optimum and minimum temperature) for germination of the crops. The optimum temperature is that one gives the highest germination percentage in the shortest period of time.

Light: The most effective wavelength for promoting and inhibiting seed germination is red (660 nm) and infrared (730 nm), respectively.

Atmospheric gases: Most crop seeds germinate well in the ambient composition of air with 20% O_2, 0.03% CO_2 and 78.2% N.

Exogenous chemicals: Some chemicals induce or favour quick and rapid germination.

- Gibberellins stimulate germination in protoplasmic seeds.
- Hydrogen peroxide (H_2O_2) is used for legumes, tomato and barley.
- Ethylene (C_2H_4) is used for stimulating groundnut germination.

3.2. Seed Rate and Seed Treatment

Seed rate is the quantity of seed required for sowing or planting in an unit area. The seed rate for a particular crop would depend not only on its seed size/test weight, but also on its desired population, germination percentage and purity percentage of seed. It is calculated as follows:

Seed rate (kg) = (Area to be sown in m2 x Test weight of the seed x 1) / (Germination% x Purity% x Spacing (m) x 1000)

Seed treatment is a process of application either by mixing or by coating or by soaking in solutions of chemicals or protectants (with fungicidal, insecticidal, bactericidal, nematicidal or biopesticidal properties), nutrients, hormones or growth regulators or subjected to a process of wetting and drying or subjected to reduce, control or repel disease organisms, insects or other pests which attack seeds or seedlings growing there from. Seed treatment also includes control of pests when the seed is in storage and after it has been sown/planted (Chandrasekaran, et. al., 2010). The seed treatment is done for the following reasons:

- To protect from seed borne pests and diseases.
- To protect from or repel birds and rodents.
- To supply plant nutrients.
- To inoculate microorganisms.
- To supply growth regulators.
- To supply selective herbicides.
- To break seed dormancy.
- To induce drought tolerance.
- To induce higher germination percentage, early emergence.
- To obtain polyploids (genetic variation) by treating with x-rays, gamma rays and colchicines.
- To facilitate mechanized sowing.

Methods of Seed Treatment are

1. ***Dry treatment***: Mixing of seed with powder form of pesticides/nutrients.
2. ***Wet treatment***: Soaking of seed in pesticide/nutrient solutions
3. ***Slurry treatment***: Dipping of seeds/seedlings in slurry. Example–rice seedlings are dipped in phosphate slurry.
4. ***Pelleting***: It is the coating of solid materials in sufficient quantities to make the seeds larger, heavier and to appear uniform in size for sowing with seed drills. Pelleting with

pesticides as a protectant against soil organisms, soil pests and as a repellant against birds and rodents.

3.3. Sowing, Methods of Sowing and Sowing Management

Sowing is the placing of a specific quantity of seeds in the soil for germination and growth while planting is the placing of plant propagules (may be seedlings, cuttings, rhizomes, clones, tubers etc.) in the soil to grow as plants (Chandrasekaran, et. al., 2010).

Methods of Sowing: Seeds are sown directly in the field (seed bed) or in the nursery (nursery bed) where seedlings are raised and transplanted later. Direct seeding may be done by – (a) Broadcasting (b) Dibbling (c) Drilling (d) Sowing behind the country plough (e) Planting (f) Transplanting

(a) Broad casting - Broad casting is the scattering or spreading of the seeds on the soil, which may or may not be incorporated into the soil. Broadcasting of seeds may be done by hand, mechanical spreader or aeroplane. Broadcasting is the easy, quick and cheap method of seeding. The difficulties observed in broadcasting are uneven distribution, improper placement of seeds and less soil cover and compaction. As all the seeds are not placed in uniform density and depth, there is no uniformity of germination, seedling vigour and establishment. It is mostly suited for closely spaced and small seeded crops.

(b) Dibbling - It is the placing of seeds in a hole or pit made at a predetermined spacing and depth with a dibbler or planter or very often by hand. Dibbling is laborious, time consuming and expensive compared to broadcasting, but it requires less seeds and, gives rapid and uniform germination with good seedling vigour.

(c) Drilling - It is a practice of dropping seeds in a definite depth, covered with soil and compacted. Sowing implements like seed drill or seed cum fertilizer drill are used. Manures, fertilizers, soil amendments, pesticides, etc. may be applied along with seeds. Seeds are drilled continuously or at regular intervals in rows. It requires more time, energy and cost, but maintains uniform population per unit area. Rows are set according to the requirements.

(d) Sowing behind the country plough - It is an operation in which seeds are placed in the plough furrow either continuously or at required spacing by a man working behind a plough. When the plough takes the next adjacent furrow, the seeds in the previous furrow are closed by the soil closing the furrow. Depth of sowing is adjusted by adjusting the depth of the plough furrow.

(e) Planting - Placing seeds or seed material firmly in the soil to grow.

(f) Transplanting - Planting seedlings in the main field after pulling out from the nursery. It is done to reduce the main field duration of the crops facilitating to grow more number of crops in an year. It is easy to give extra care for tender seedlings. For small seeded crops like rice and ragi which require shallow sowing and frequent irrigation for proper germination, raising nursery is the easiest way.

Factors involved in **Sowing Management**: This can be classified into two broad groups.

1. Mechanical factors - Factors such as depth of sowing, emergence habit, seed size and weight, seedbed texture, seed–soil contact, seedbed fertility, soil moisture etc.

a. ***Seed size and weight***: Heavy and bold seeds produce vigorous seedlings. Application of fertilizer to bold seed tends to encourage the seedlings than the seedlings from small seeds.

b. ***Depth of sowing***: Optimum depth of sowing ranges from 2.5–3 cm. Depth of sowing depends on seed size and availability of soil moisture. Deeper sowing delays field emergence and thus delays crop duration. Deeper sowing sometimes ensures crop survival under adverse weather and soil conditions mostly in dry lands.

c. ***Emergence habit***: Hypogeal seedlings may emerge from a relatively deeper layer than epigeal seedlings of similar seed size.

d. ***Seedbed texture***: Soil texture should minimize crust formation and maximize aeration, which in turn influence the gases, temperature and water content of the soil. Very fine soil may not maintain adequate temperature and water holding capacity.

e. ***Seeds-Soil contact***: Seeds require close contact with soil particles to ensure that water can be

f. absorbed readily. A tilled soil makes the contact easier. Forming the soil around the seed (broadcasted seeds) after sowing improves the soil–seed contact.

g. ***Seedbed fertility***: Tillering crops like rice, ragi, bajra etc., should be sown thinly on fertile soils and more densely on poor soils. Similarly high seed rate is used on poor soil for non-tillering crops. Although higher the seed rate grater the yield under conditions of low soil fertility, in some cases such as cotton, a lower seed rate gives better result than a higher seed rate.

h. ***Soil moisture***: Excess moisture in soil retards germination and induce rotting and damping off disease except in swamp (deep water) rice. Adjustment in depth is made according to moisture conditions, i.e., deeper sowing on dry soils and shallow sowing on wet soils. Sowing on ridges is usually recommended on poorly drained soils.

2. Biological factors - Factors like companion crops, competition for light, soil microorganisms etc.

a. ***Companion crop***: Companion crop is usually sown early to suppress weed growth and control soil erosion. In cassava + maize/yam cropping, cassava is planted later in yam or maize to minimize the effect of competition for light. In mixed cropping, all the crops are sown at the same time.
b. ***Competition of light***: In mixed stands, optimum spacing for each crop minimizes the competition of light.
c. ***Soil microorganisms***: The microorganisms present in the soil should favour seed germination and should not posses any harmful effect on seeds/emerging seedlings.

UNIT 4

WEEDS SCIENCE

Weeds are plants “out of place” in cultivated fields, lawns and other places i.e., a plant growing where it is “not desired” or Weeds are unwanted and undesirable plant that interfere with utilization of land and water resources and thus adversely affect crop production and human welfare. Sometimes Agriculture also defined as a battle with weeds as they strongly compete with crop plants for growth factors (Chandrasekaran, et. al., 2010).

4.1. Origin and Characteristics

Origin

Weeds are no strangers to man. They have been there ever since he started to cultivate crops about 10,000 B.C. and undoubtedly recognized as a problem from the beginning. To him, any plant in the field other than his crop became weed. Again the characters of certain weed species are very similar to that of wild plants in the region. Some of the crops for example including the wheat of today are the derivatives of wild grass. Man has further improved them to suit his own taste and fancy. Even today they are crossed with wild varieties to transfer the desirable characters such as drought and disease resistance. So the weeds are to begin with essential components of native and naturalized flora but in course of time these plants are well placed in new environment by the conscious and unconscious efforts of man. Hence, it is considered that many weeds principally originated from two important and major arbitrarily defined groups (Chandrasekaran, et. al., 2010).

- By man’s conscious effort
- By invasion of plants into man created habitats

In the world, 30,000 species of weeds have been listed. Out of which nearly 18,000 species cause serious damage to agricultural production. Eighteen weeds are considered as the most serious in the world and about twenty six species have been listed as principal weeds in crop fields of India. Weeds compete with crops for water, soil nutrients, light and space (i.e., CO2) and thus reduce crop yields.

Characteristics

Weeds are highly competitive and are highly adaptable under varied adverse situations. Reproductive mechanism is far superior to crop plants particularly under unfavourable side; therefore, weeds are constantly invading the field and try to succeed over less adapted crop plants. Produces larger number of seeds compared to crops. Most of the weed seeds are small in size and contribute enormously to the seed reserves. Weed seeds germinate earlier and their seedlings grow faster. They flower earlier and mature ahead of the crop they infest. They have the capacity to germinate under varied conditions, but very characteristically, season bound. The peak period of germination always takes place in certain seasons in regular succession year after year.

Weed seeds possess the phenomenon of dormancy, which is an intrinsic physiological power of the seed to resist germination even under favourable conditions. Weed seeds do not lose their viability for years even under adverse conditions. Most of the weeds possess C4 type of photosynthesis, which is an added advantage during moisture stress. They possess extensive root system, which go deeper as well as of creeping type (Chandrasekaran, et. al., 2010).

4.2. Classification and Weed Dissemination

Classification

Out of 2,50,000 plant species, weeds constitute about 250 species, which are prominent in agricultural and non-agricultural system. Under world conditions about 30,000 species is grouped as weeds (Chandrasekaran, et. al., 2010). Weeds may be classified in the following ways:

1. Based on the morphology of the plant, the weeds are also classified into three categories. This is the most widely used classification by the weed scientists.

a. ***Grasses*** - All the weeds come under the family Poaceae are called as grasses which are characteristically having long narrow spiny leaves. The examples are Echinocloa colonum, Cynodon dactylon.
b. ***Sedges*** - The weeds belonging to the family Cyperaceae come under this group. The leaves are mostly from the base having modified stem with or without tubers. The examples are Cyperus rotundus, Fimbrystylis miliaceae.
c. ***Broad leaved weeds*** - This is the major group of weeds as all other family weeds come under this except that is discussed earlier. All dicotyledon weeds are broad leaved weeds. The examples are Flavaria australacica, Digera arvensis, Abutilon indicum.

2. Based on life span (Ontogeny), weeds are classified as Annual weeds, Biennial weeds and Perennial weeds.

a. ***Annual Weeds*** - Those that live only for a season or year and complete their life cycle in that season or year is called annual. These are small herbs with shallow roots and weak stem. Produces seeds in profusion and the mode of propagation is commonly through seeds. After seeding the annuals die away and the seeds germinate and start the next generation in the next season or year following. Most common field weeds are annuals. The examples are:
    i. ***Monsoon annual*** - Commelina benghalensis, Boerhaavia erecta;
    ii. ***Winter annual*** - Chenopodium album
b. ***Biennials*** - It completes the vegetative growth in the first season, flower and set seeds in the succeeding season and then dies. These are found mainly in non-cropped areas. e.g., Alternanthera echinata, Daucus carota
c. ***Perennials*** - Perennials live for more than two years and may live almost indefinitely. They adapted to withstand adverse conditions. They propagate not only through seeds but also by underground stem, root, rhizomes, tubers etc. And hence they are further classified into
    i. ***Simple perennials***: Plants propagated only by seeds. E.g., Sonchus arvensis.
    ii. ***Bulbous perennials***: Plants, which possess a modified stem with scales and reproduce mainly from bulbs and seeds. e.g., Allium sp.
    iii. ***Corm perennials***: Plants that possess a modified shoot and fleshy stem and reproduce through corm and seeds. e.g., Timothy sp.
    iv. ***Creeping perennials***: Reproduced through seeds as well as with one of the following.
        a. ***Rhizome***: Plants having underground stem-Sorghum halapense
        b. ***Stolen***: Plants having horizontal creeping stem above the ground-Cynodon dactylon
        c. ***Roots***: Plants having enlarged root system with numerous buds-Convolvulus arvensis
        d. ***Tubers***: Plants having modified rhizomes adapted for storage of food-Cyperus rotundus

3. Based on Ecological Affinities

a. ***Wetland weeds*** - They are tender annuals with semi-aquatic habit. They can thrive as well under waterlogged and in partially dry condition. Propagation is chiefly by seed. e.g., Ammania baccifera, Eclipta alba.

b. ***Garden land weeds*** - These weeds neither require large quantities of water like wetland weeds nor can they successfully withstand extreme drought as dry land weeds. e.g., Trianthema portulacastrum, Digera arvensis.

c. ***Dry land weeds*** - These are usually hardy plants with deep root system. They are adapted to withstand drought on account of mucilaginous nature of the stem and hairiness. E.g., Tribulus terrestris, Convolvulus arvensis.

4. Based on Soil Type (Edaphic)

a. ***Weeds of black cotton soil***: These are often closely allied to those that grow in dry condition. e.g., Aristolochia bracteata.

b. ***Weeds of red soils***: They are like the weeds of garden lands consisting of various classes of plants. e.g., Commelina benghalensis.

c. ***Weeds of light, sandy or loamy soils***: Weeds that occur in soils having good drainage. e.g. Leucas aspera.

d. ***Weeds of laterite soils***: e.g., Lantana camara, Spergula arvensis.

5. Based on their Botanical Family

a. ***Graminae*** – Cynodon dactylon

b. ***Solanaceae*** – Solanum eleaegnifolium

6. Based on their Place of Occurrence

a. ***Weeds of crop lands***: The majorities of weeds infest the cultivated lands and cause hindrance to the farmers for successful crop production. e.g., Phlaris minor in wheat.

b. ***Weeds of pasture lands***: Weeds found in pasture/grazing grounds. e.g., Indigofera enneaphylla

c. ***Weeds of waste places***: Corners of fields, margins of channels etc., where weeds grow in profusion. e.g. Gynandropsis pentaphylla, Calotropis gigantea.

d. ***Weeds of playgrounds, road-sides***: They are usually hardy, prostrate perennials, capable of withstanding any amount of trampling. e.g., Alternanthera echinata, Tribulus terestris.

7. Based on number of cotyledons it possess it can be classified as dicots and monocots.

a. ***Monocots*** e.g., Panicum flavidum, Echinochloa colona.

b. ***Dicots*** e.g., Crotalaria verucosa, Indigofera viscosa.

8. Based on pH of the soil the weeds can be classified into three categories.

a. ***Acidophile***: Acid soil weeds e.g. Rumex acetosella.
b. ***Basophile***: Saline and alkaline soil weeds e.g. Taraxacum stricta.
c. ***Neutrophile***: Weeds of neutral soils e.g. Acalypha indica.

9. Based on Origin

a. ***Indigenous weeds***: All the native weeds of the country are coming under this group and most of the weeds are indigenous. e.g. Acalypha indica, Abutilon indicum.
b. ***Introduced or Exotic weeds***: These are the weeds introduced from other countries. These weeds are normally troublesome and control becomes difficult. e.g., Parthenium hysterophorus, Philaris minor, Acanthospermum hispidum

10. Based on Nature of Stem

Based on development of bark tissues on their stems and branches, weeds are classified as woody, semiwoody and herbaceous species.

a. ***Woody weeds***: Weeds include shrubs and under shrubs and are collectively called brush weeds. e.g., Lantana camera, Prosopis juliflora.
b. ***Semi-woody weeds***: e.g., Croton sparsiflorus.
c. ***Herbaceous weeds***: Weeds have green, succulent stems are of most common occurrence around us. e.g., Amaranthus viridis.

Weed Dissemination (Dispersal of Weeds)

Dispersal of mature seeds and live vegetative parts of weeds is nature's way of providing non-competitive sites to new individuals. Had there been no way of natural dispersal of weeds, we would not have had them today in such widely spread and vigorous forms. In the absence of proper means of their dispersal, weeds could not have moved from one country to another. "Weeds are good travelers". An effective dispersal of weed seeds and fruits requires two essentials viz., a successful dispersing agent and an effective adaptation to the new environment (Chandrasekaran, et. al., 2010). Common weed dispersal agents are: (a) wind, (b) water, (c) animals and (d) human.

(a) Wind - Weed seeds and fruits that disseminate through wind possess special organs to keep them afloat. Such organs are:

i. ***Pappus*** - It is a parachute like modification of persistent calyx into hairs. e.g., Asteraceae family weeds. e.g., Tridax procumbens.

ii. ***Comose*** - Some weed seeds are covered with hairs, partially or fully e.g., Calotropis sp. Feathery, persistent styles - Styles are persistent and feathery. e.g., Anemone sp.

iii. ***Baloon*** - Modified papery calyx that encloses the fruits loosely along with entrapped air. e.g., Physalis minima.

iv. ***Wings*** - One or more appendages that act as wings. e.g., Acer macrophyllum.

(b) Water - Aquatic weeds disperse largely through water. They may drift either as whole plants, plant fragments or as seeds with the water currents. Terrestrial weed seeds also disperse through irrigation and drainage water.

(c) Animals - Birds and animals eat many weed fruits. The ingested weed seeds are passed in viable form with animal excreta (0.2% in chicks, 9.6% in calves, 8.7% in horses and 6.4% in sheep), which is dropped wherever the animal moves. This mechanism of weed dispersal in called endozoochory e.g., Lantana seeds by birds. Loranthus seeds stick on beaks of birds. Farm animals carry weed seeds and fruits on their skin, hair and hooves. This is aided by special appendages such as Hooks (Xanthium strumarium), Stiff hairs (Cenchrus sp.), Sharp spines (Tribulus terrestris) and Scarious bracts (Achyranthus aspera). Even ants carry a huge number of weed seeds. Donkeys eat Prosophis julifera pods.

(d) Man - Man disperses numerous weed seeds and fruits with raw agricultural produce. Weeds mature at the same time and height along with crop, due to their similar size and shape as that of crop seed man unknowingly harvest the weeds also, and aids in dispersal of weed seeds. Such weeds are called "Satellite weeds" e.g. Avena fatua, Phalaris minor.

(e) Manure and silage - Viable weed seeds are present in the dung of farm animals, which forms part of the FYM. Besides, addition of mature weeds to compost pit as farm waste also act as source.

(f) Dispersal by machinery - Machinery used for cultivation purposes like tractors can easily carries weed seeds, rhizomes and stolons when worked on infested fields and latter dropping them in other fields to start new infestation.

(g) Intercontinental movement of weeds - Introduction of weeds from one continent to another through 1. Crop seed, 2. Feed stock, 3. Packing material and 4. Nursery stock. e.g., Parthenium hysterophorus.

4.3. Crop-Weed Interactions

Competition and allelopathy are the main interactions, which are of importance between crop and weed. Allelopathy is distinguished from competition because it depends on a chemical compound being added to the environment while competition involves removal or reduction of an essential factor or factors from the environment, which would have been otherwise utilized (Chandrasekaran, et. al., 2010).

I. Crop Weed Competition

Weeds appear much more adapted to agro-ecosystems than our crop plants. Without interference by man, weeds would easily wipe out the crop plants. This is because of their competition for nutrients, moisture, light and space, which are the principle factors of production of crop. Generally, an increase in on kilogram of weed growth will decrease one kilogram of crop growth.

a. ***Competition for nutrients*** - Weeds usually absorb mineral nutrients faster than many crop plants and accumulate them in their tissues in relatively larger amounts.
    i. Amaranthus sp. accumulate over 3% N on dry weight basis and are termed as “nitrophills”.
    ii. Achyranthus aspera, a ‘P’ accumulator with over 1.5% P_2O_5.
    iii. Chenopodium sp. and Portulaca sp. are ‘K’ lovers with over 1.3% K_2O in dry matter.
b. ***Competition for moisture*** - In general, for producing equal amounts of dry matter, weeds transpire more water than do most of our crop plants. It becomes increasingly critical with increasing soil moisture stress, as found in arid and semi-arid areas. As a rule, C4 plants utilize water more efficiently resulting in more biomass per unit of water. Cynodon dactylon had almost twice as high transpiration rate as pearl millet. In weedy fields soil moisture may be exhausted by the time the crop reaches the fruiting stage, i.e., the peak consumptive use period of the crop, causing significant loss in crop yields.
c. ***Competition for light*** - It may commence very early in the cop season if a dense weed growth smothers the crop seedlings. It becomes important element of crop-weed competition when moisture and nutrients are plentiful. In dry land agriculture in years of normal rainfall the crop weed competition is limited to nitrogen and light. Unlike competition for nutrients and moisture once weeds shade a crop plant, increased light intensity cannot benefit it.
d. ***Competition for space (CO_2)*** - Crop-weed competition for space is the requirement for CO_2 and the competition may occur under extremely crowded plant community condition. A more efficient utilization of CO_2 by C4 type weeds may contribute to their rapid growth over C3 type of crops.

II. Allelopathy

Allelopathy is the detrimental effects of chemicals or exudates produced by one (living) plant species on the germination, growth or development of another plant species (or even microorganisms) sharing the same habitat. Allelopathy does not form any aspect of crop-weed competition, rather, it causes Crop-Weed interference, it includes competition as well as possible allelopathy. Allelo-chemicals are produced by plants as end products, by-products and metabolites liberalized from the plants; they belong to phenolic acids, flavanoides, and other aromatic compounds viz., terpenoids, steroids, alkaloids and organic cyanides. These allelochemical's action is in interfering with cell elongation, photosynthesis, respiration, mineral ion uptake and protein and nucleic acid metabolism. Allelopathy technique can be applied in biological control of weeds by using cover crop for biological control and using alleopathic chemicals as bio-herbicides.

Factors influencing allelopathy:

a. ***Plant factors***:
    i. ***Plant density***: Higher the crop density the lesser will be reaction due to allelochemicals it.
    ii. ***Life cycle***: If weed emerges later there will be less problem of allelochemicals.
    iii. ***Plant age***: The release of allelochemicals occurs only at critical stage. For e.g., in case of Parthenium, allelopathy occurs during its rosette and flowering stage.
    iv. ***Plant habit***: The allelopathic interference is higher in perennial weeds.
    v. ***Plant habitat***: Cultivated soil has higher values of allelopathy than uncultivated soil.
b. ***Climatic factors***: The soil and air temperature as well as soil moisture influence the allelochemicals potential.
c. ***Soil factors***: Physico-chemical and biological properties influence the presence of allelochemicals.
d. ***Stress factors***: Abiotic and biotic stresses may also influence the activity of allelochemicals.

4.4. Integrated Weed Management (IWM)

Definition:

Use of a judicial combination of mechanical, cultural, biological and chemical methods to achieve economic and effective weed control. It is a method whereby all economically, ecologically and toxicologically justifiable methods are employed to keep the harmful organisms below the threshold level of economic damage, keeping in the foreground the conscious employment of natural limiting factors.

IWM is the rational use of direct and indirect control methods to provide cost-effective weed control. Such an approach is the most attractive alternative from agronomic, economic and ecological point of view. Among the commonly suggested indirect methods are land preparation, water management, plant spacing, seed rate, cultivar use, and fertilizer application. Direct methods include manual, cultural, mechanical and chemical methods of weed control.

The essential factor in any IWM programme is the number of indirect and direct methods that can be combined economically in a given situation. For example, increased frequency of ploughing and harrowing does not eliminate the need for direct weed control. It is, therefore, more cost-effective to use fewer pre-planting harrowing and combine them with direct weed control methods. There is experimental evidence that illustrates that better weed control is achieved if different weed control practices are used in combination rather than if they are applied separately (Chandrasekaran, et. al., 2010).

Why IWM:

- One method of weed control may be effective and economical in a situation and it may not be so in other situation.
- No single herbicide is effective in controlling wide range of weed flora.
- Continuous use of same herbicide creates resistance in escaped weed flora or causes shift in the flora.
- Continuous use of only one practice may result in some undesirable effects. e.g., Rice–wheat cropping system–Philaris minor.
- Only one method of weed control may lead to increase in population of particular weed.
- Indiscriminate herbicide use and its effects on the environment and human health.

Concept of IWM:

- Uses a variety of technologies in a single weed management with the objective to produce optimum crop yield at a minimum cost taking into consideration ecological and socio-economic constraints under a given agro-ecosystem.
- A system in which two or more methods are used to control a weed. These methods may include cultural practices, natural enemies and selective herbicides.

Good IWM should be:

- Flexible enough to incorporate innovations and practical experiences of local farmers.
- Developed for the whole farm and not for just one or two fields and hence it should be extended to irrigation channels, road sides and other non-crop surroundings on the farm from where most weeds find their way into the crop fields.
- Economically viable and practically feasible.

Advantages of IWM:

- It shifts the crop-weed competition in favour of crop
- Prevents weed shift towards perennial nature
- Prevents resistance in weeds to herbicides
- No danger of herbicide residue in soil or plant
- Suitable for high cropping intensity

UNIT 5

IRRIGATION, WATER AND NUTRIENT

Plants and any form of living organisms cannot live without water, since water is the most important constituent of about 80-90% of most plant cell. Water is essential not only to meet agricultural needs but also for industrial purposes, power generation, live stock maintenance, rural and domestic needs etc. But the resource is limited and cannot be created as we require.

Irrigation has been practiced since time immemorial, nobody knows when it was started but evidences say that it is the foundation for all civilization since great civilization were started in the river basins of Sind and Nile. This civilization came to an end when the irrigation system failed to maintain crop production. There are some evidences that during the Vedic period (400 B.C.) people used to irrigate their crops with dug well water. Irrigation was gradually developed and extended during the Hindus, Muslims and British periods (Chandrasekaran, et. al., 2010).

5.1. Importance and Source of Water

Importance of Water

Different types of importance of water are as follows:

Physiological Importance

a. The plant system itself contains about 90% of water.
b. Amount of water varies in different parts of plant as follows.
    i. Apical portion of root and shoot > 90%.
    ii. Stem, leaves and fruits 70–90%
    iii. Woods 50–60%
    iv. Matured parts 15–20%
    v. Freshly harvested grains 15–20%
c. It acts as base material for all metabolic activities. All metabolic or biochemical reactions in plant system need water.
d. It plays an important role in respiration and transpiration.
e. It plays an important role in photosynthesis.
f. It activates germination and plays an important role in plant metabolism for vegetative and reproductive growth.
g. It serves as a solvent in soil for plant nutrients.

h. It also acts as a carrier of plant nutrients from soil to plant system.
i. It maintains plants temperature through transpiration.
j. It helps to keep the plant erect by maintaining plant's turgidity.
k. It helps to transport metabolites from source to sink.

Ecological Importance

a. It helps to maintain soil temperature.
b. It helps to maintain salt balance.
c. It reduces salinity and alkalinity.
d. It influences weed growth.
e. It influences atmospheric weather.
f. It helps the beneficial microbes.
g. It supports human and animal life.
h. It helps for land preparation like ploughing, puddling etc., weeding, fertilizer application etc., by providing optimum conditions.

Source of Water

Rainfall is the ultimate source of all kind of water. Based on its sources of availability, it can be classified as surface water and subsurface water.

Surface Water

It includes (including rainfall and dew) water available from river, tank, pond, lake etc. Besides, snowfall could able to contribute some quantity of water in heavy snowfall areas like Jammu, Kashmir and Himalaya region.

Rainfall

(a) Characteristics

- Quantity should be sufficient to replace the moisture depleted from the root zone.
- Frequency should be so as to maintain the crop without any water stress before it starts to wilt.
- Intensity should be low enough to suit the soil absorption capacity.

(b) Seasons

The seasons of rainfall may be (i) South West Monsoon, (ii) North East Monsoon, (iii) Winter Rainfall, and (iv) Summer Rainfall.

Sub Surface Water

It includes subsurface water contribution, underground water, well water, etc.

5.2. Crop Water and Irrigation Requirement

Water requirement is defined as the quantity of water required by a crop or a diversified pattern of crops in a given period of time for its normal growth at a place under field conditions. The source of water may be anything like wells, tanks, artisan wells of canals of rivers.

Crop water requirement is the water required by the plants for its survival, growth, development and to produce economic parts. This requirement is applied either naturally by precipitation or artificially by irrigation (Chandrasekaran, et. al., 2010). Hence the crop water requirement includes all losses like:

- Transpiration loss through leaves (T).
- Evaporation loss through soil surface in cropped area (E).
- Amount of water used by plants (WP) for its metabolic activities, which is, estimated as less than 1% of the total water absorption. These three components cannot be separated so easily. Hence, the ET loss is taken as crop water use or crop water consumptive use.
- Other application losses are conveyance loss, percolation loss, runoff loss etc., (WL).
- The water required for special purpose (WSP) like puddling operation, ploughing operation, land preparation, leaching requirement, for the purpose of weeding for dissolving fertilizers and chemicals etc.

Hence, the water requirement is symbolically represented as:

$$WR = T + E + WP + WL + WSP$$

The field **irrigation requirement** of crops refers to water requirement of crops exclusive of effective rainfall and contribution from soil profile and it may be given as follows.

$$IR = WR - (ER + S)$$

Where,

IR = irrigation requirement

WR = water requirement

ER = effective rainfall

S = soil moisture contribution

Irrigation requirement depends upon the (a) irrigation need of individual crop, (b) Area of crop, and (c) losses in the farm water distribution system etc. All the quantities are usually expressed in terms of water per unit of land area (cm/ha) or unit of depth (cm or mm).

5.3. Method of Irrigation and Irrigation System

Irrigation is the artificial application of water made for supplementing the moisture in the soil that is deficient and does not meet the full requirements of growing crops. Irrigation is essentially a practice of supplementing the natural precipitation for increasing production of agricultural and horticultural crops.

Application of irrigation water to cropped field by different types of layouts are called as irrigation methods. The methods of irrigation initially might have been started to check the over flow of water from one field to another. But today, it has become necessary to save the water by proper methods to arrest run-off loss, percolation loss, evaporation loss etc., and to optimize the crop water need. Hence, irrigation method can be defined as the way in which the water is applied to the cropped field without much application and other losses, with an objective of applying water effectively to facilitate better environment for crop growth (Chandrasekaran, et. al., 2010).

The irrigation methods are broadly classified as:

- Surface method or gravity method of irrigation
- Sub surface or sub irrigation
- Pressurized or micro irrigation - Drip irrigation, sprinkler irrigation and rain gun irrigation.

Various types of irrigation systems are in practice. In India, the following are some important system.

a. ***Gravity irrigation***: Here water is supplied to the land by gravitational flow. There are two types namely (i) Perennial, (ii) Inundation.
b. ***Tank irrigation***: It is the oldest irrigation system of India wherein water is stored by forming a big bund across the natural drainage to avoid the surface runoff loss through natural streams. The tank size varies according to the drainage capacity. It has irrigation capacity from 10–1000 ha. It is further classified as:
    i. ***System tank*** - The system tank receives allotted quantity of water from river system during the cropping period for its command.

ii. ***Non-system tanks*** - The Non-system tanks depend upon rainfall in their catchment area and do not have any link to river system to get water.

c. ***Lift irrigation***: In this system, water is lifted from a reservoir or river or canal or well by using mechanical or electrical power to irrigate the field. Lift irrigation includes: (1) lift canal irrigation, (2) well irrigation, and (3) tube well irrigation.

5.4. Irrigation and Water Management

Irrigation and water management for some of the important crops are as follows:

1. Rice - Total water requirement is 1100–1250 mm. The daily consumptive use of rice varies from 6-10 mm and total water ranges from 1100–1250 mm depending upon the agro climatic situation. Of the total water required for the crop, 3% or 40 mm is used for the nursery, 16% or 200 mm for the land preparation i.e., puddling and 81% or 1000 mm main field irrigation.

The growth of rice plant in relation to water management can be divided into four periods viz., seedling, vegetative, reproductive and ripening. Less water is consumed during seeding stage. At the time of transplanting, shallow depth of 2 cm of submergence is necessary to facilitate development of new roots. The same water level is required for tiller production during the vegetative phase. At the beginning of the maximum tillering stage, the entire water in the field can be drained and left as such for one or two days which is termed as mid season drainage. This mid season drainage may improve the respiratory functions of the roots, stimulate vigorous growth of roots and checks the development of non-effective tillers. Any stress during the vegetative phase may affect the root growth and reduce the leaf area.

During flowering phase 5 cm submergence should be maintained because it is a critical stage of water requirement. Stress during this phase will impair all yield components and cause severe reduction in yield. Excess water than 5 cm is also not necessary especially at booting stage, which may lead to delay in heading. Water requirement during ripening phase is less and water is not necessary after yellow ripening. Water can be gradually drained from the field 15–21 days ahead of harvest of crop. Whenever 5 cm submergence is recommended, the irrigation management may be done by irrigating to 5 cm submergence at saturation or one or two days after the disappearance of ponded water. This will result in 30% saving of irrigation water compared to the continuous submergence.

2. Groundnut - Total water requirement is 500–550 mm. Evapotranspiration is low during the first 35 days after sowing and last 35 days before harvest and reaches a peak requirement between peg penetration and pod development stages. After the sowing irrigation, the second irrigation can be scheduled 25 days after sowing i.e., 4 or 6 days after first hand hoeing and thereafter irrigation interval of 15 days is maintained up to peak flowering. During the critical stages the interval may be 7–10 days depending upon the soil and climate. During maturity period, the interval is 15 days.

3. Finger millet - Total water requirement is 350 mm. Finger millet is a drought tolerant crop. Preplanting irrigation at 7 and 8 cm is given. Third day after transplanting life irrigation with small quantity of water is sufficient for uniform establishment. Water is then withheld for 10–15 days after the establishment of seedling for healthy and vigorous growth, subsequently three irrigations are essential at primordial initiation, flowering and grain filling stages.

4. Sugarcane - Total water requirement is 1800–2200 mm. Formative phase (120 days from planting–germination and tillering phases) is the critical period for water demand. To ensure uniform emergence and optimum number of tillers per unit area, lesser quantity of water at more frequencies is preferable. The response for applied water is more during this critical phase during which the crop needs higher quantity of water comparing the other two phases. Water requirement, number of irrigation etc., are higher during this period. As there is no secondary thickening of stem, elongation of stem as sink for storage of sugar it is desirable to maintain optimum level of moisture during grand growth period. Response for water is less in this stage and this will be still less in the ripening stage. During the ripening phase as harvest time approaches, soil moisture content should be allowed to decrease gradually so that growth of cane is checked and sucrose content is increased.

5. Maize - Total water requirement is 500–600 mm. The water requirement of maize is higher but it is very efficient in water use. Growth stages of maize crop are sowing, four leaf stage, knee high, grand growth, tasselling, silking and early dough stages. Crop uniformly requires water in all these stages. Of this, tasselling, silking and early dough stages are critical periods.

6. Cotton - Total water requirement is 550–600 mm. Cotton is sensitive to soil moisture conditions. Little water is used by plant with early part of the season and more is lost through evaporation than transpiration. As the plant grows, the use of water increases from 3 mm/day and reaching a peak of 10 mm a day when the plant is loaded with flowers and bolls. Water used during the emergence and early plant growth is only 10% of the total requirement. Ample moisture during flowering and boll development stages is essential. In the early stages as well as at the end the crop requires less water. Water requirement remains high till the boll development stage. If excess water is given in the stages other than critical stages it encourages the vegetative growth because it is a indeterminate plant thereby boll setting may be decreased. Irrigation is continued until the first boll of the last flush opens, and then irrigation is stopped.

7. Sorghum - Total water requirement is 350–500 mm. The critical periods of water requirement are booting, flowering and dough stages. The crop will be irrigated immediately after sowing. Next irrigation is given 15 days after sowing to encourage development of a strong secondary root system. Irrigation prior to heading and ten days after heading are essential for successful crop production.

5.5. Organic Manures

Organic manures include plant and animal by-products such as oil cakes, fish manures and dried blood from slaughter houses. Before their organic nitrogen used by the crops it is converted through bacterial action into readily usable ammonical N and nitrate N. These manures are therefore, relatively slow acting, but they supply available N for a longer period.

Organic manures supply plant nutrients including micronutrients. Organic manures improve physical properties of the soil, water holding capacity, hydraulic conductivity, infiltration capacity of the soil. CO2 released during decomposition combines with water and forms carbonic acid and act as CO2 fertilizer. Organic manures supply energy (food) for microbes and increase availability of nutrients and improve soil fertility. Green manures have the additional advantage of fixing atmospheric nitrogen leading to nitrogen economy in crop production and green manures draw nutrients from lower layers and concentrate them in the surface soil for the use of succeeding crop (Chandrasekaran, et. al., 2010).

Organic manures can be classified as follows:

1. Bulky organic manures

- FYM: (a) Cattle manure, (b) Sheep manure, (c) Poultry manure
- Compost: (a) Village/rural compost from farm-wastes, (b) Town/urban compost from town refuses
- Sewage and sludge

2. Concentrated organic manures

- Oil cakes ***(a) Edible oil cakes*** (i.e., used for cattle feeding) - (i) Mustard cake, (ii) Groundnut cake, (iii) Sesame cake, (iv) Linseed cake; ***(b) Non edible oil cakes*** (i.e., used as manures) - (i) Castor cake, (ii) Neem cake, (iii) Sunflower cake, (iv) Mahua cake, (v) Karanja cake
- Slaughter house wastes - (i) Blood meal, and (ii) Bone meal
- Fish meal
- Guano - Material obtained from the excreta and dead bodies of sea bird

3. Green manures

- Leguminous plant (example: Sunn hemp, Sesbania sp., mungbean, cowpea, guar, senji, berseem)
- Non-leguminous plant (example: Sorghum, pearl millet, maize, sunflower)

4. Green leaf manures

Green leaves of trees like neem, pungam, glyricidia, vadhanarayana etc.

5.6. Fertilizers and Bio Fertilizers

Fertilizers are synthetic (commercially manufactured) or naturally occurring chemical compounds either dry solid or liquid that added to the soil to supply one or more plant nutrients for crop growth. The fertilizers are classified based on whether the fertilizer supplies a single or more than one nutrient, their chemical nature and commercial mode of supply as straight, compound, complex and mixed.

Straight fertilizers: When a fertilizer contains and is used for supplying a single nutrient, it is called a straight fertilizer. This is further classified as nitrogenous, phosphatic and potassic fertilizers depending on the specific macro nutrient present in the fertilizer (Chandrasekaran, et. al., 2010).

a. ***Nitrogenous fertilizers***: N fertilizers are those fertilizers containing N as major nutrient. It may be either a nitrate or ammonium or amide fertilizer depending on the form of nitrogen present.
b. ***Phosphatic fertilizers***: They are classified into three groups, based on the solubility of phosphate contained in the fertilizer.
c. ***Potassic fertilizers***: Containing Muriate of potash (KCI), Sulphate of potash (K_2SO_4), Potassium nitrate (KNO_3), and Schoenite (K_2SO_4, $MgSO_4$) $6H_2O$.

Compound fertilizers are the commercial fertilizers in which two or more primary nutrients are chemically combined. For example, Di ammonium phosphate (DAP), Mono ammonium phosphate, Urea ammonium phosphate, Ammonium phosphate.

Complex fertilizers are the commercial fertilizers containing at least two or more of the primary essential nutrients at higher concentration in one compound. The nutrients in complex fertilizers are physically mixed.

Mixed fertilizers/Fertilizers mixtures are physical mixtures of two or more straight fertilizers. Sometimes a complex fertilizer is also used as one of the ingredients. The mixing is done mechanically. The fertilizer mixtures are usually in powder form but techniques have been developed for granulation of mixtures so that each grain will contain all the nutrients mixed in the mixture.

Bio fertilizers are the living organisms capable of fixing atmospheric nitrogen or making native soil nutrients available to crops. Atmospheric nitrogen is fixed effectively by the microorganisms either in symbiotic association with plant system (Rhizobium, Azolla) or in associative symbiosis (Azospirillum) or in free living system (Azotobactor, phosphobacterium, blue green algae) or in micorhizal symbiosis (VAM fungi).

a. ***Rhizobium*** - Rhizobium bacteria can fix atmospheric nitrogen symbiotically. They live in the nodules of host plants belonging to the family leguminoceae.
b. ***Azolla*** - It is a small water fern of worldwide distribution under natural conditions. It contains the heterocystous blue green algae Anabaena azollae as a symbiont in an enclosed chamber in the dorsal leaf lobes.
c. ***Azospirillum*** - This bacterium is associated with cereals like rice, sorghum, maize, cumbu, ragi, tenai and other minor millets and also for cotton, sugarcane, oilseeds and fodder grasses. These bacteria colonizing in the roots not only remain on the root surface, but also a sizable proportion of them penetrates into the root tissues and lives in harmony with the plants.
d. ***Azatobacter*** - The beneficial effects of Azatobacter on plants was associated (non-symbiotically) not only with the process of nitrogen fixation but also with the synthesis of complex of biologically active compounds such as nicotinic acid, pyridoxine, biotin, gibberellins and probably other compounds which stimulate the germination of seeds and accelerate plant growth.

e. ***Blue green algae*** - The blue green algae occur under a wide range of environmental conditions. They are completely auto tropic and require light, water, free nitrogen (N2), carbon dioxide (CO2) and salts containing the essential mineral elements.

f. ***Phosphobacterium*** - In most of the acid and clayey soils, the applied phosphorus either as super phosphate or mussoriphos will not be available to crops due to fixation. It is essential to use the phosphobacteria (a free living bacteria in soils like Bacillus megatherium) for proper solubilisation of fixed P and release them in the available form for the crop to take-up for its growth.

g. ***Mycorrhizae (VAM)*** - Vesicular Arbiscular Mycorrhiza is a fungi used as bio-fertilizer. The mycorhizal symbiosis is an intimate association between plant root system and certain group of soil fungi.

5.7. Integrated Nutrient Management (INM)

Judicious combination of inorganic, organic and bio-fertilizers which replenishes the soil nutrients removed by the crops is referred as integrated nutrient management system. The concept of INM is to integrate the nutrient sources and methods of organic and inorganic nutrient application to maintain soil fertility and productivity i.e., the complementary use of chemical fertilizers, organic manures and bio-fertilizers to solve the problems of nutrient supply, soil productivity and environment (Chandrasekaran, et. al., 2010).

Developing an INM system for a particular crop sequence to a specific location requires a thorough understanding of (i) the effects of previous crop, (ii) contribution of legume in the cropping system, (iii) residual effect of fertilizers, and (iv) direct, residual and cumulative effect of organic manures for supplementing and complementing the use of chemical fertilizers.

The main components of the N supply system are the organic manures green manures, crop residues, crop rotation and inter cropping involving legumes and cereals, bio-fertilizers including rhizobium, azotobacter, azospirillum, phosphorus solubilizing micro-organisms like mycorrhizal fungi, azolla, blue green algae and cyanobacteria. All these can serve as an important supplementary source of nutrients along with the chemical fertilizers. Thus, INM is environmentally non-degradable, technically appropriate economically viable and socially acceptable.

UNIT 6

HARVESTING AND POST HARVEST TECHNOLOGY

Harvesting assumes considerable importance because the crop has to be harvested as early as possible to make way for another crop. Sometimes, harvesting time may also coincide with heavy rainfall or severe cyclone and floods. In view of these situations suitable technology is, therefore, necessary for reducing the harvesting time and safe storage at farm level. The post-harvest losses are estimated to be about 25 per cent.

Post-harvest operations are assuming importance due to higher yields and increased cropping intensity. Due to introduction of modern technology, yield levels have substantially increased resulting in a marketable surplus, which has to be stored till prices are favorable for sale. With increase in irrigation facilities and easy availability of fertilizers, intensive cropping is being practiced. A recent estimate by the Ministry of Food and Civil supplies put the total preventable post-harvest losses of food grains at about 20 million tons a year, which was nearly 10 per cent of the total production. The principal adviser, planning commission stated that food grains wasted during post-harvest period could have fed up 117 million people for a year (Chandrasekaran, et. al., 2010).

6.1. Harvesting, Harvest Index and Time of Harvesting

Removal of entire plant or economic parts after maturity from the field is called **harvesting**. It includes the operation of cutting, picking, plucking or digging or a combination of these for removing the useful part or economic part from the plants/crops. The portion of the stem that is left in the field after harvest is called as stubble. The economic product may be grain, seed, leaf, root or entire plant (Chandrasekaran, et. al., 2010).

Harvesting is done either manually or by mechanical means.

- ***Manual***: Sickle is the important tool used for harvesting. The sickle has to be sharp, curved and serrated for efficient harvesting. Knife is used for harvesting of plants with thick and woody stems. Now-a-days improved type of sickle is available which reduce the drudgery of harvesting labourers.

- ***Mechanical***: Harvesting with the use of implements or machines.

Harvest Index (H.I): It is the ratio of the economic yield to the total biological yield expressed as percentage.

$$H.I = (\text{Economic yield}/\text{Biological yield}) \times 100$$

Time of Harvesting

If the crop is harvested early, the produce contains high moisture and more immature ill filled and shriveled grains. High moisture leads to pest attack and reduction in germination percentage and impairs the grain quality. Late harvesting results in shattering of grains, germination even before harvesting during rainy season and breakage during processing. Hence, harvesting at correct time is essential to get good quality grains and higher yield.

Time of harvesting can be assessed by (i) calculating the growing degree days (GDD), and (ii) assessing maturity from the duration of crop.

i. ***Growing Degree Days***: A degree day or a heat unit is the mean temperature above base temperature. For example – base temperature of rice, maize and cumbu is 10°C whereas it is 4.5°C for wheat. Degree days are useful for predicting the time of harvest by calendaring the required photo thermal units (PTU) to complete each growth stage of the crop.
ii. ***Assessing Maturity***: Crops can be harvested by assessing the maturity i.e., at physiological maturity or at harvest maturity.
    a. Physiological maturity refers to a development stage after which no further increases in dry matter occurs in the economic part. Crop is considered to be at physiological maturity when the translocation of photosynthesis to the economic part is stopped.
    b. Harvest maturity generally occurs seven days after physiological maturity. The important processes during this period is loss of moisture from the plants.

6.2. Post Harvest Technology (PHT)

Post harvest processing encompasses an array of handling and processing system from the stage of maturation till consumption of the produce and includes threshing, cleaning, grading, drying, parboiling, curing, milling, preservation, storage, processing, packaging, transportation, marketing and consumption systems.

The most important factor deciding the storability of the produce is moisture content of the produce. High moisture content invites pest and disease and induce pre-germination. Moisture content for safe storage of grains of most crops is about 14% (raw rice), 15% for parboiled rice, 12% for wheat, barley, other millets and pulses, 10% for coriander, chillies and 6% for groundnut, rapeseed and mustard (Chandrasekaran, et. al., 2010).

The ***objectives*** of post harvest processing are:

- To minimize post harvest losses which is around 10–25% in cereals and 20–30% in perishables.
- To get good quality products.
- To get maximum quantity of materials by way of proper PHT.
- To get value added products by way of processing.
- For proper utilization of water from food industries.
- To create employment opportunities.
- To eliminate or minimize the pollution.

Principles involved – Rice

a. Threshing: Involves the detachment of grains from the panicle.
b. Drying: Reduction of 12–14% or 8% by evaporation. i.e., it involves heat and mass transfer operations simultaneously.
c. Parboiling: Is a hydrothermal treatment followed by drying before milling for the production of milled parboiled grain. The most important change during parboiling is the gelatinization of starch and disintegration of protein bodies in the endosperm.
d. Milling: Refers to the size reduction and separation operations used for processing of food grains into edible form by removing and separating the inedible and undesirable portions from them, Milling may involve cleaning/separating husk (dehusking), sorting, whitening, polishing, grinding etc.
e. Storage: Proper storage in storage structures is necessary to prevent the grains from storage pest and to maintain the quality of seeds.

Methods involved in Post Harvest Technology

The quantitative losses encountered at various stages are 1 to 3% during harvest, 2 to 6% during threshing, 1 to 5% during drying, 2 to 7% during handling, 2 to 10% during milling and 2 to 6%

during storage. To overcome these losses the following improved practices can be adopted (Chandrasekaran, et. al., 2010).

a. ***Harvesting***: Paddy if not harvested at the optimum time, results in loss of quality and quantity. To reduce these losses, machines like combines and reapers are being introduced to harvest paddy at an appropriate stage.
b. ***Threshing***: Threshing, done by bullocks, tractors and by hand, result in poor drying, storage and milling. The multicrop threshers have been developed to reduce these losses.
c. ***Transport***: Poor transport facilities result in losses to the farmers, millers, and eventually food grain to the country, sometimes as much as 2–3 per cent. Good transport facilities should be used to minimize these losses. When once the grain is threshed and dried, it will be transported from the field to store houses by bullock carts, or tractors by the growers.
d. ***Drying***: Sun drying methods cause more breakage of grain than other factor, resulting in low head yields and low milling yields. Moist paddy in storage deteriorates rapidly. With the introduction of heated air dryers, the losses can be reduced considerably.
e. ***Storage***: Uncleaned wet paddy accounts for the largest losses during storage. This is followed by losses due to rodents, birds, mould, fungus, insects and pilferage. These losses can be minimized by storing in good storage structures.

UNIT 7

AGRICULTURAL PRODUCTS

Statistics on agricultural products may be used to analyse developments within agricultural markets to help distinguish between cycles and changing production patterns. They can also be used to study how markets respond to policy actions. Additional agricultural product data provide supply-side information, furthering the understanding of price developments which are of particular interest to agricultural commodity traders and policy analysts.

7.1. Crops and Crop Production

The term 'crop' covers a very broad range of cultivated plants. Within each type of crop there can also be considerable diversity in terms of genetic and phenotypic (physical or biochemical) characteristics. In general, crop is an organism grown or harvested for obtaining yield. Agronomically, crop is a plant cultivated for economic purpose (EU, 2015).

a. ***Garden crop*** - Grown on a small scale in gardens. e.g., Onion, Brinjal etc.
b. ***Plantation crop*** - Grown on a large scale in estates and perennial in nature. e.g., Tea, Coffee, Cacao, Rubber etc.
c. ***Field crop*** - Grown on a vast scale under field condition. They are mostly seasonal such as rice, wheat, cotton etc.

Based on the plant products which come into the commercial field are grouped as:

a. ***Food crops***: Rice, wheat, green gram, soybean, groundnut, etc.
b. ***Food crops/Forage crops***: All fodders, oats, sorghum, maize, napier grass, stylo, Lucerne etc.
c. ***Industrial/Commercial crops***: Cotton, sugarcane, sugar beet, tobacco, jute, etc.
d. ***Food adjuvunts***: Turmeric, garlic, cumin, etc.

The classification – based on use of crop plants and their products – is an important classification as for as agronomy is concerned.

a. ***Cereals*** - They are cultivated grasses grown for their edible starchy grains (one seeded fruit–caryopsis). Larger grains used as staple food are cereals–rice, wheat, maize, barley, oats etc.

b. ***Millets*** - Small grained cereals, which form the staple food in drier regions of the developing countries, are called millets. e.g. Major - Sorghum, pearl Millet or cumbu and finger millet or ragi. Minor - Fox tail millet, little millet, common millet, barnyard millet and kodomillet
c. ***Oil seeds*** - Crops that yield seeds rich in fatty acids, are used to extract vegetable oils. e.g., groundnut or peanut, sesamum or gingelly, sunflower, castor, linseed or flax, niger, safflower, mustard and cotton.
d. ***Pulses*** - Seeds of leguminous plants used as food. They produce dal rich in protein. e.g., red gram, black gram, green gram, cowpea, bengal gram, horse gram, dew gram, soybean, peas or garden pea and garden-bean.
e. ***Feed/Forage*** - It refers to vegetative matter, fresh or preserved, utilized as feed for animals. It includes hay, silage, pasturage and fodder. e.g., bajra napier grass, guinea grass, fodder-sorghum, fodder-maize, lucerne, desmanthus, etc.
f. ***Fibre crops*** - Plants grown for their fibre yield. There are different kinds of fibre. They are: (i) seed fibre–cotton, (ii) stem fibre-jute, mesta, (iii) leaf fibre–agave, pineapple.
g. ***Sugar and starch crops*** - Crops grown for production of sugar and starch. e.g., sugarcane, sugar beet, potato, sweet potato, tapioca and asparagus.
h. ***Spices and condiments*** - Crop plants or their products used to season, flavour, taste, and add colour to the fresh or preserved food. e.g., ginger, garlic, fenugreek, cumin, turmeric, chillies, onion, coriander, anise and asafetida.
i. ***Drug crops/medicinal plants*** - Crops used for preparation of medicines. e.g., tobacco, mint etc.
j. ***Narcotics, fumitories and masticatories*** - Plants/products used for stimulating, numbing, drowsing or relishing effects. e.g., tobacco, ganja, opium poppy.
k. ***Beverages*** - Products of crops used for preparation of mild, agreeable and stimulating drinking. e.g., tea, coffee, cocoa.

Factors affecting **crop production** are: (i) Internal factors (Genetic or Hereditary) and External factors (Environmental).

Internal Factors

The increased yield and other desirable characters are related to the genetic make up of the plant. The following are the areas to improve the potential of crop plants through genetics and plant breeding techniques.

a. High yields under given environmental conditions.

b. Early maturity (in some cases late maturity).
c. Resistance to lodging.
d. Drought, flood and salinity tolerance.
e. Tolerance to insects and diseases.
f. Chemical composition of grains (high percentage of oil, increase in protein quantity or quality, etc.).
g. Quality of grains (fineness, coarseness, etc.).
h. Quality of straw (sweetness, juiciness, etc.).

Environmental Factors

Life of crop is so intimately related with the environmental factors of a place. Environmental factors do not act in isolation from one another. All these environmental factors as discussed below interact with one another to influence the crop growth and production.

a. ***Climatic factors***: The atmospheric factors, which affect the crop plants, are called climatic factors. They are (i) Precipitation, (ii) Temperature, (iii) Atmospheric humidity, (iv) Solar radiation, (v) Wind velocity, and (vi) Atmospheric gases.
b. ***Edaphic factors***: Plants grown in a land are completely dependent on the soil in which they grow for anchorage, water and mineral nutrients. The soil factors, which affect the crop growth, are: 1. Soil moisture; 2. Soil air; 3. Soil temperature; 4. Soil mineral matter; 5. Soil organic matter, 6. Soil organisms, and 7. Soil reaction.
c. ***Biotic factors***: Beneficial or harmful effects caused by other plants and animals on the crop plants are the effect of biotic factors.
d. ***Physiographic factors***: It can be studied under two categories such as: (1) Geological Strata - It accounts not only for the kind of parent material utilized in soil formation but also on the nature of crops grown in these soils for proper utilization. (2) Topography - The nature of the surface of earth is known as topography. Topographic factors affect the crops indirectly by modifying climatic and edaphic factors of a place.
e. ***Anthropic (socio economic) factors***
    i. Man/women produce changes in plant environment and are responsible for scientific crop and soil management,
    ii. breeding varieties for increased yield, and
    iii. introduction of exotic plants

    These factors affect the management of soil and crop, which leads to higher production. In addition to the above the socio economic factors affecting the crop production are:

i. the economic conditions of the farmer greatly decides the input/resource mobilizing capacity,
ii. the educational status and technical know-how of the farmer,
iii. the resource allocation ability and social values of the farmer,
iv. government price policy, and
v. marketing and storage facilities etc.

7.2. Orchards

In order to complement the yearly production data, Eurostat collects also data on structural aspects of permanent crops every 5 years. The latest data collection for orchards referred to 2012 as reference year. The species surveyed are apple trees, pear trees, apricot trees, peach trees, orange trees, small-citrus fruit trees, lemon trees, olive trees and on voluntary basis vines producing grapes for table use. Olive trees and vines producing table grapes were surveyed for the first time (EU, 2015).

The seven fruit and citrus fruit species assessed in the 2012 Orchard survey covered an area of 1.29 million hectares (ha) in the EU. This is 5.5 % (75,000 ha) less than in the 2007 Orchard survey (which did not include Croatia with about 8,000 ha).

The most common fruit tree in the EU is by far the apple tree. It accounts for more than one third (35 %) of the total surveyed European orchard area. The second and third most commonly cultivated species are oranges and peaches (including nectarines), with shares of nearly 21 % and 15 % respectively. Small citrus fruit trees cover more than 11 % of the total surveyed fruit tree area. The share of different fruit and citrus fruit species has been fairly stable between 2007 and 2012.

7.3. Livestock and Meat

There have been considerable structural changes in EU livestock farming since the 1980s. Smallholders on mixed farms have gradually given way to larger-scale, specialised livestock holdings.

In recent years, the EU has been active in harmonising animal health measures and systems of disease surveillance, diagnosis and control; it has also developed a legal framework for trade in live animals and animal products. In part, this has been in response to consumer concerns regarding public health and food safety aspects of animal health. In this regard, the European

Commission established a framework for animal health and welfare measures for the 2007‑13 period. In addition, the 2004 revision of the legislation on the hygiene of foodstuffs – known as the ‘Hygiene package’ – was implemented in the enlarged EU, with the aim of ensuring the hygiene of foodstuffs at all stages of the production process through to sale (EU, 2015).

Livestock and meat statistics are collected by EU Member States under Regulation (EC) No 1165/2008, which covers bovine, pig, sheep and goat livestock; slaughtering statistics on bovine animals, pigs, sheep, goats and poultry; and production forecasts for beef, veal, pig meat, sheep meat and goat meat.

Livestock surveys cover sufficient agricultural holdings to account for at least 95 % of the national livestock population, as determined by the last survey on the structure of agricultural holdings. Bovine and pig livestock statistics are produced twice a year, with reference to a given day in May/June and a given day in November/December. Those EU Member States whose bovine animal populations are below 1.5 million head or whose pig populations are below 3.0 million head may produce these statistics only once a year, with reference to a given day in November/December.

Sheep livestock statistics are only produced once a year, with reference to a given day in November/December, by those EU Member States whose sheep populations are 500,000 head or above; the same criteria and thresholds apply for statistics on goat populations. Statistics on the slaughtering of animals in slaughterhouses are produced monthly by each EU Member State, the reference period being the calendar month. Statistics on slaughtering carried out other than in slaughterhouses is produced annually, the reference period being the calendar year (EU, 2015).

Statistics on livestock and meat production (based on the slaughter of animals fit for human consumption) give some indication of supply-side developments and adjustments, which are important to monitor the Common Agricultural Policy (CAP).

Since the early 1980s, there has been a steady downward trend in the number of livestock on agricultural holdings across the EU. In 2013, looking at EU Member States, Germany, Spain, France and the United Kingdom held the largest number of cattle. In Germany and Spain, these are mainly pigs (28.1 and 25.5 million heads respectively), in France bovines (19.1 million heads) and in the United Kingdom sheep (22.6 million heads).

7.4. Milk and Milk Products

The EU's dairy sector operates within the framework of milk quotas, which were introduced in 1984 to address problems of surplus production but the quota system has been ended on 1st April 2015. Each EU Member State has two quotas, one for deliveries to dairies and the other for direct sales at farm level. Milk production data are used for signalling imbalances in the market. If serious enough, public intervention (of butter and skimmed milk powder) and/or private storage are triggered. When national quotas are overrun, punitive 'super-levies' are recovered from the concerned EU Member State (EU, 2015).

Milk and milk product statistics are collected under Decision 97/80/EC, implementing Directive 96/16/EC. They cover farm production and the utilisation of milk, as well as the collection and production activity of dairies. Due to the small number of dairy enterprises, national data are often subject to statistical confidentiality. Thus, providing EU totals in this context is a challenge and some of the information presented in the analysis is based on partial data for the Member States (which may exclude several countries); each exception is clearly footnoted under the tables and figures presented. On the one hand, statistics from these few enterprises provide early estimates on trends. On the other, a complete overview of the dairy sector requires detailed information from farms and this means that the final figures on milk production are only available at an EU level about one year after the reference year.

Dairy products are recorded in terms of weight. It is thus difficult to compare the various products (for example, fresh milk and milk powder). The volume of whole or skimmed milk used in the dairy processes provides more comparable figures. In such a system, some volume of used skimmed milk may acquire negative values. For instance, production of cream uses whole milk and generates skimmed milk – the production of cream is thereby expressed in relation to the quantity of used whole milk and a negative quantity of skimmed milk. Whether this skimmed milk is then used by another process or kept as such, it will be recorded as a positive quantity of used skimmed milk.

Farms across the EU-28 produced approximately 158.8 million tonnes of milk in 2013, of which 153.8 million tonnes (or 96.8 %) were cows' milk; milk from ewes, goats and buffalos represent 3.2 % of the total production. The majority of the milk produced on farms was delivered to dairies and the remaining amount was used on the farms (EU, 2015).

Between 2012 and 2013 the production of cows' milk on farms in the EU-28 increased by almost 1.7 million tonnes. The EU-28's dairy herd of 23.5 million cows in 2013 had an estimated average yield of 6 553 kg per head. The quantity of dairy in the EU-28 rose by 1.1 %, while the number of dairy cows increased by 1.6 %.

Average yields of milk per cow varied considerably between regions of the EU Member States in 2013. The apparent yield was highest – between 8,500 kg and 9,800 kg per cow per year – in the most productive regions of Portugal, Denmark, Germany and Finland. By contrast, the apparent yield was relatively low – between 3,500 kg and 3,900 kg per head – in the most productive regions of Romania and Bulgaria, where milk production was typically less specialised.

The milk delivered to dairies is converted into a number of fresh products and manufactured dairy products. Some 68.2 million tonnes of raw milk were used to produce 9.3 million tonnes of cheese in the EU-28 in 2013, while 31.5 million tonnes of raw milk were turned into a similar amount of drinking milk. 19.3 million tonnes of raw milk were converted into 2.1 million tonnes of milk powder and 41.0 million tonnes of whole milk were used to produce an estimated 2.1 million tonnes of butter as well as associated skimmed milk and buttermilk. This explains why the amount of 'whole milk' used for producing butter was higher than the 'total' milk used (EU, 2015).

Just over one fifth (21.9 %) of the estimated 31.9 million tonnes of drinking milk produced in the EU-28 in 2013 came from the United Kingdom, despite this Member State accounting for only about one tenth of the milk produced in the EU-28. This relative specialisation was also observed for other dairy products: for example, Germany, France and Italy accounted for almost three fifths (56.9 %) of the 9.3 million tonnes of cheese produced across the EU-28 in 2013.

UNIT 8

AGRICULTURAL ACCOUNTS

One of the principal objectives of the Common Agricultural Policy (CAP) is to provide farmers with a reasonable standard of living. Although this concept is not defined explicitly within the CAP, a range of indicators – including those on income development from farming activities – may be used to determine the progress being made towards this objective (EU, 2015). Economic accounts for agriculture (EAA) provide an insight, among others, into:

- the economic viability of agriculture;
- the evolution of income received by farmers;
- the structure and composition of agricultural production and intermediate consumption;
- relationships between prices and quantities of both inputs and outputs.

8.1. Agricultural Output, Input and Value Added

The economic accounts for agriculture show that the total output of the agricultural industry (comprising the output values of crops and animals, agricultural services and the goods and services produced from inseparable non-agricultural secondary activities) in the EU-28 in 2013 was an estimated EUR 412.5 billion at basic prices. The equivalent of 60.9 % of the value of agricultural output generated was spent on intermediate consumption (input goods and services). The residual gross value added at basic prices was the equivalent of 39.1 % of the value of total output in 2013 or EUR 161.2 billion (EU, 2015).

The **output** value of the EU-28's agricultural industry at producer prices (therefore excluding subsidies, less taxes on products) was an estimated EUR 408.8 billion in 2013. France was the largest agricultural producer in the EU-28 (EUR 73.6 billion or 18.0 % of the EU-28 total), followed by Germany (13.0 %), Italy (12.2 %) and Spain (10.7 %); relative to its size, the Netherlands accounted for quite a high share of the EU-28's agricultural output (6.7 %).

During the 2005‑13 period, the value of agricultural output rose in all of the EU Member States other than Greece (where output fluctuated but was largely unchanged). The highest increases in output value (in absolute terms) were recorded for the two largest producers, namely France and Germany, output rising by EUR 17.4 billion and EUR 14.4 billion respectively. There were also relatively large increases in agricultural output in the United Kingdom, Poland, Spain, Italy and the Netherlands.

Intermediate consumption covers purchases made by farmers for raw and auxiliary materials that are used as inputs for crop an animal production; it also includes expenditure on veterinary services, repairs and maintenance, and other services. Intermediate consumption within the EU-28's agricultural industry in 2013 was valued at EUR 251.2 billion at basic prices (EU, 2015).

Feeding stuffs for animals accounted for by far the highest share (38.8 %) of total intermediate inputs within the EU-28's agricultural activity in 2013, valued at more than three times the share of energy and lubricants (12.2 %) – the latter are used for both animal and crop production. Fertilisers and soil improvers (7.6 %) accounted for the highest share of intermediate inputs among those inputs used exclusively for crop production.

Gross value added at producer prices of the EU-28's agricultural industry in 2013 was an estimated EUR 157.6 billion, while overall subsidies amounted to EUR 51.7 billion. The highest subsidies were generally granted to those EU Member States with the highest levels of output (France, Spain, Italy and Germany). The value of subsidies received by farmers in Finland, Greece, Ireland and the Czech Republic accounted for a higher share of EU-28 subsidies than their relative weight in the output value of the EU-28's agricultural industry.

The type of subsidies provided to the EU-28's agricultural industry has changed over time as a result of successive reforms of the CAP, 'decoupling' subsidies from particular crops and moving towards a system of single farm payments. Subsidies on products in the EU-28 were valued at EUR 20.0 billion in 2005, which had fallen to EUR 3.8 billion by 2013. By contrast, other subsidies on production increased from EUR 29.7 billion in 2005 to EUR 51.7 billion by 2013 (EU, 2015).

8.2. Agricultural Labour Input

The vast majority of the EU's farms are relatively small, family-run holdings. Often, these holdings draw on family members to provide labour (in addition, to the farm holder). Agriculture is also characterised by seasonal labour peaks (for example, those linked to harvesting), with high numbers of workers hired for relatively short periods of time. Otherwise, some farmers are occupied on a part-time basis (and they may have alternative, sometimes important sources of income) – so while there are a large number of people providing labour within agriculture, many of these will have their main employment elsewhere. For this reason, estimates are made of the volume of labour input provided in terms of full-time labour equivalents (measured in annual work units).

EU-28 agricultural labour input was estimated at 10.1 million annual work units (AWUs) (the equivalent of 10.1 million people working full-time in 2013. Among the EU Member States, the highest levels of agricultural labour input were recorded for Poland (2.1 million AWUs), Romania (1.6 million AWUs) and Italy (1.1 million AWUs).

Between 2005 and 2013 there was a reduction of almost one fifth (21.8 %) in agricultural labour input in the EU-28; the steepest annual declines were posted in 2007 and 2010. The overall contraction of 2.5 million AWUs was almost exclusively due to a reduction in non-salaried labour input (2.4 million AWUs or 92.6 % of the total). Although the volume of agricultural labour input from salaried persons in the EU-28 fell in successive years from 2007 to 2010, there was a slight increase in the number of AWUs for salaried persons in both 2012 and 2013 (EU, 2015).

8.3. Agricultural Income

Income is a key measure for determining the viability of the agricultural sector. The nominal factor income of the agricultural industry (the income from selling the services of factors of production – land, labour and capital) in the EU-28 was valued at EUR 128.7 billion in basic price terms in 2013. Within agricultural accounts, income has traditionally been measured as an index, computed on the basis of the real factor income per AWU (EU, 2015).

From the base year of 2005 (=100), the EU-28 index of agricultural income rose for two consecutive years, before falling back in 2008 and 2009 (at the height of the financial and economic crisis) to almost the same level as in 2005. Thereafter, the index of agricultural income rebounded, with relatively rapid growth in 2010 and 2011. Agricultural income in the EU-28 remained stable in 2012 (rising by just 0.1 % compared with the year before).

8.4. Price Indices

EU-27 output prices for agricultural goods rose by 35.9 % in nominal terms from 2005‑12. Taking into account price inflation (based on the harmonised index of consumer prices – the HICP), the real increase in (deflated) output prices for agricultural goods was 14.1 %, equivalent to an average rate of 1.9 % per annum (EU, 2015).

It is shown that (deflated) output prices for agricultural goods in the EU-27 rose during the 2005‑08 period by a total of 12.0 %. This was followed by a sharp reduction in prices in 2009 (-12.3 %), as the output price index fell below its base level for 2005. Thereafter, output prices for agricultural goods in the EU-27 rose by just over 6 % in real terms in both 2010 and 2011, before price increases slowed somewhat in 2012, rising by 3.1 %. It is also shown that prices tended to rise at a faster pace for crop output (+ 18.5 % over the period 2005-12, equivalent to an average of 2.5 % per annum) than for animal output (an overall increase of 9.7 %, equivalent to an average of 1.3 % per annum).

UNIT 9
SUSTAINABLE AGRICULTURE

Agriculture has been the basic source of subsistence for man over thousands of years. It provides a livelihood to half of the world's population even today. According to the Food and Agricultural Organisation (FAO), people in the developing world where the population increase is very rapid, may face hunger if the global food production does not rise by 50-60 per cent. The contribution of developing countries to world agricultural production in 1975 was about 38 per cent, while that of developed countries, which account for 33 per cent of world's population, was 62 per cent. Only those countries, which can match the demands of the increasing population with increased production, can escape mass hunger (Chandrasekaran, et. al., 2010).

World population today is about more than 6 billion. It is projected to become over 8 billion by 2025 and nearly 10.5 billion by the end of next century. In simple terms, the basic food production must double to maintain the status quo. The hunger must be banished from the surface of earth, as a first responsibility of any civilised society to provide sufficient food for the people who are below the poverty line.

Earlier, the subsistence level of farmers forced to over exploit natural resources by way of mining soil nutrients, cultivating in steep slopes, overgrazing rangelands and excessive collection of fuel wood in order to survive. Now modern crop production technology has considerably raised the yield but has created problem of land degradation, chemical residues in farm produce and atmosphere and water pollution. Hence modern agriculture was not sustainable.

9.1. Definition and Role

Sustainable agriculture is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of environment and conserving natural resources. Sustainable agriculture is also known as ecofarming (as ecological balance is important) or organic farming (as organic matter is the main source of nutrient management) or sometimes as natural farming or permaculture. Some other designated it as regenerative agriculture or alternative farming (Chandrasekaran, et. al., 2010). Sustainable agriculture is a food and fiber production and distribution system that:

- Supports profitable production;
- Protects environmental quality;
- Uses natural resources efficiently;
- Provides consumers with affordable, high-quality products;
- Decreases dependency on nonrenewable resources;
- Enhances the quality of life for farmers and rural communities, and
- Will last for generations to come.

Role

Small landholders in the tropics are mainly fed up with rain fed farming and it is being carried out with high risk. In a constant struggle to survive, farm communities have developed numerous ways of obtaining food and fiber from plants and animals (TAC/CGAIR, 1988). A wide range of different farming systems have been developed, each adapted to the local ecological conditions (Okigbo, 1978) Richards, 1988: Dupre, 1990). A closer look at these traditional farming systems reveals that they are not static; they have changed over the generations–and particularly quickly over the last few decades–primarily as a result of the research and development activities of the local people. (Wieskel, 1989; Owasu, 1990).

However, rapid changes in economic, technological and demographic conditions demand adjustments in smallholder farming systems. New market opportunities, promotion of chemical inputs and financial constraints may lead farmers to seek short term profits and pay less attention to keeping their agriculture in balance with the ecological conditions. In recent years, the negative environmental and soil impacts of High External Input Agriculture (HEIA) have become increasingly obvious (Wali, 1992; NRC, 1993). At the same time, many disadvantaged communities of smallholders are being forced to exploit the resources available to them so intensively that, environmental degradation is setting in. Hence, it is important to seek new approaches to agricultural development, which will benefit small farmers, half degradation of natural resources and restore degraded soils and ecosystems.

9.2. Concepts and Basic Principles

The use of modern farming practices has greatly enhanced the productivity of crops. However, the hazards of the use of agricultural chemicals in causing eco-degradation have prompted many to think rationally and evolve alternatives. The negative impact of pesticides on the environment has been well documented. Pesticides are not specific to the target organisms and kill many useful organisms, thus upsetting the food web in nature. Further, some resistant pests survive even after pesticide application; therefore, higher doses are required to kill them. The pesticide residues in the food chain have endangered the life sustaining systems.

Finally, lack of safety measures in the use of pesticides pose adverse health effects on people. The synthetic fertilizers have also jeopardized the environment through nitrate poisoning and exterminating the beneficial soil microflora and microfauna by adversely altering the chemical and physical properties of the soil. Though the agricultural extension personnel are aware of the ill effects of modern technology, they are helpless without an effective alternative system. Therefore, the need for sustainable and ecological agriculture is increasingly felt in the world.

Sustainable agriculture is also referred by other names such as alternative agriculture, ecological agriculture and natural organic farming. It is that form of farming which maintains or enhances the flow of its products without damaging its own long term potential. Organic farming is an agricultural production system, which avoids or largely excludes the use of systematically compounded fertilizers and pesticides (Chandrasekaran, et. al., 2010).

To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures to maintain soil productivity and tilth to supply plant nutrients. It looks forward to alternative methods of pest-control like pest resistant cultivars, bio-control agents and cultural methods of pest-control. Such ecological farming systems are highly productive and they should not be mistaken for a reversion to inefficient and less productive farming methods.

Principle: The use of limited quantities of fertilizers and discrete application of small quantities of target specific pesticides at critical stages of crop damage thereby overcoming the effects of modern agriculture. The following **seven principles** will have to be kept in view to achieve success in promoting ecological agriculture:

a. Based on both biological potential and biological diversity, land can be classified into conservation, restoration and sustainable intensification areas. Conservation areas are rich in biological diversity and must be protected in their pristine purity. Soils with diminished biological potential are also referred as waste or degraded lands and it should be improved through the adoption of principles of restoration ecology. The diversion of land suitable for sustainable farming should be prevented by legislation. Such lands should be subjected to a continuous soil health monitoring.

b. Effectiveness in water saving, equity in water sharing and efficiency in water delivery and use are important for sustainable management of available surface and groundwater resources. There should be an integrated policy for conjunctive and appropriate use of river, rain, ground, sea and sewage water.
c. An integrated system of energy management involving the use of renewable and non-renewable resources of energy in an appropriate manner is essential for achieving desired yield levels.
d. Soils in India are often not only thirsty but also hungry. There is a need for reduction in the use of market purchased inputs and not of inputs per se. It is in this context integrated systems of nutrient supply assume importance. The components of the integrated nutrient supply system suitable for easy adoption include crop rotation, green manures and biofertilizers. Biodynamic systems that make significant use of compost and humus will help improve soil structure and fertility.
e. Genetic diversity and location specific varieties are essential for achieving sustainable advances in productivity. Genetic homogeneity characteristic of modern agricultural systems only leads to greater genetic vulnerability to biotic and abiotic stresses. Diversity of crops and crop varieties will help enhance the yield stability.
f. The control of weeds, insect pests and pathogens is one of the most challenging jobs in agriculture. Therefore, an integrated pest management system needs adoption. The conservation and wise use of genetic diversity is essential for breeding strains possessing multiple resistances to biotic and abiotic stresses. Similarly, the conservation of natural enemies of pests is important for minimizing the use of chemical pesticides and for avoiding the multiplication of insecticide resistant pests. Botanical pesticides such as those derived from neem, need popularization. Selective microbial pesticides offer particular promise, of which, strains of Bacillus thuringiensis (Bt) serve as an example. Transgenic techniques have made the transfer and expression of Bt toxin possible in several crops.
g. Whole plant utilization methods and preparation of value added products from the available agricultural biomass are important both for enhancing income and for ensuring good nutritional and consumer acceptance properties. Both producers and consumers will not derive benefit from production advances if there is a mismatch between production and post-harvest technologies.

9.3. Indices of Sustainability

Quantification of sustainability is essential to objectively assess the impact of management systems on actual and potential productivity, and on environment. One can assess sustainability or several indices (Lal, 1994). Indices may be simple involving one parameter or complex involving several parameters. Although general principles may be the same, there indices must be fine-tuned and adapted under local environments. Some indices of sustainability include the following:

1. ***Productivity (P)***: Production per unit of resource used can be assessed by,

   P = P/R; Where, P is productivity, P is total production and R is resource used.

2. ***Total Factor Productivity (TFP)***: It is defined as productivity per unit cost of all factors involved (Herdt, 1993).

   $TFP = \Sigma P/(R_i \times C_i)$; $i = 0,1,\ldots,n$; where, P is total production, R is resource used and C is cost of the resource, and n is the number of resources used in achieving total production.

3. ***Coefficient of sustainability (Cs)***: It is measure of change in soil properties in relation to production under specific management system (Lal, 1991).

   $Cs = F(Oi, Od, Om)\ t$, Where, Cs is coefficient of sustainability, Oi is output per unit that maximizes per capita productivity or profit, Od is output per unit decline in the most limiting or non-renewable resource, Om is the minimum assured output, and t is the time. The time scale is important and must be carefully selected.

4. ***Index of sustainability (Is)***: It is a measure of sustainability relating productivity to change in soil and environmental characteristics (Lal, 1993; Lal and Miller, 1993).

   $Is = f\ (Pi*Si*Wi*Ci)t$, Where, Is index of sustainability, Si is alteration in soil properties, Wi is change in water resources and quality, Ci is modification in climatic factor and t is time.

5. ***Agricultural Sustainability (As)***: It is a broad-based index based on several parameters associated with agricultural production (Lal, 1993)

   $As = d\ (Pt*Sp*Wt*Ct*)dt$, Where, As is agricultural sustainability, Pt is productivity per unit input of the limited or non-renewable resource, Sp is critical soil property of rooting depth, soil organic matter content, Wt is available water capacity including water quality, and Ct is climatic factor such as gaseous flux from agricultural activity and t is time.

9.4. Input Management for Sustainable Agricultural Systems

The concept of two global commonalities – biological diversity and nutrient cycling among agro ecosystems is supported by the literature on ecosystems and their management anecdotal account of indigenous practices, and the rapidly emerging literature on agro ecology. Organic matter is the basis of all bio-geo chemical cycles. The fundamental issues concerning efficient use of organic matter are leakage of nutrients from agro ecosystems and the rates of decomposition. Organic matter and the nutrients if contains are lost from soils by run off and mineralization (Tiuy, 1990), both of which can be controlled by appropriate tillage practices (Campbell et. al., 1995); Lal et. al., 1994). Loss of nutrients to mineralization is also controlled by assuring sufficient inputs of plant or animal material to maintain the soil organic matter (SOM) reserves (Woodmansee, 1984). Legumes are important in maintaining SOM and increasing soil N suffer. In addition, they prefect the soil from run off water and wind erosion and improve infiltration, agro forestry systems use leguminous and other trees to provide alternative crops (Steppler and Lundgren 1988), produce animal forage and fuel, recycle nutrients for crop use and project soil from wind and water erosion (Altieri, 1987).

Plant biodiversity plays an important role in pest, disease, and weed management. Crop rotations are effective in controlling pests, diseases and weeds (Altieri, 1987). Living mulches control weeds and minimize the need for herbicides (Regnion and Jahnke, 1990); Increases in structural diversity within the crop canopy leads to greater diversity in insects and less damage from insect pests (Stinner and Blair, 1990). Integration of animals into Agro ecosystems offers further diversity and stability. Mc-Infire and Cryseels (1987) summarized the potential benefits of integration of crops and animals. Integration of animals facilitates nutrients movement and increases the opportunities for efficient nutrient management across the whole farm system. Animals increase overall net productivity of the farm and reduce environmental degradation by serving as alternatives to crops on the marginal areas of farms by utilizing crop residues as feed.

The inputs that can be managed for sustainable agriculture system are – Optimizing Nutrient Availability, Micronutrient Deficiencies, Limiting Nutrient Losses, Use of Chemical Fertilizers, Nutrient Recycling, Use of Crop Residues, Biological Nitrogen Fixation, Use of Biofertilizers, Green Manuring,

UNIT 10

FORESTRY

The European Union (EU) accounts for approximately 5 % of the world's forests and contrary to what is happening in many other parts of the world, the forested area of the EU is slowly increasing. Ecologically, the forests of the EU belong to many different bio-geographical regions and have adapted to a variety of natural conditions, ranging from bogs to steppes and from lowland to alpine forests. Socioeconomically, they vary from small family holdings to state forests or to large estates owned by companies.

Forests are affected by a broad array of EU policies and initiatives. For several decades, environmental forest functions have attracted increasing attention – for example, in relation to the protection of biodiversity and, more recently, in the context of climate change impacts and energy policies. Apart from the traditional production of wood and other forest-based products, forests are increasingly valued for their environmental role and as a public amenity (EU, 2015).

10.1. Forests and Other Wooded Land

The EU-28 has approximately 180 million hectares of forests and other wooded land, corresponding to 42.4 % of its land area. As such, forests and other wooded land cover a slightly higher proportion of land area than that which is used for agriculture (some 40 %). Across the EU Member States, there were six countries that reported that in excess of half of their land area was covered by forests and other wooded land in 2010. Just over three quarters (77 %) of the land area was covered by forests and other wooded land in Finland and Sweden, while the proportion stood at 63 % for Slovenia; the remaining three countries, each with shares in the range of 54-56 %, were Estonia, Spain and Latvia (EU, 2015).

Sweden recorded the largest area covered by forest and other wooded land in 2010 (31.2 million hectares), followed by Spain (27.7 million hectares), Finland (23.3 million hectares), France (17.6 million hectares), Germany (11.1 million hectares) and Italy (10.9 million hectares). In relative terms, Sweden accounted for 17.3 % of the total area in the EU-28 that was covered by forest and other wooded land in 2010; Spain (15.4 %) and Finland (12.9 %) were the only other Member States to record double-digit shares.

Just under 60 % of the EU-28's forests were privately owned in 2010. There were 11 EU Member States where the share of privately owned forests was above the EU-28 average, peaking at 98.4 % in Portugal. By contrast, the share of privately owned forests was below 20 % in Poland and Bulgaria (where the lowest proportion was recorded, at 13.2 %).

The growing stock of forests and other wooded land in the EU-28 totalled some 24.4 billion m3 (over bark) in 2010: Germany had the highest share (14.3 %), followed by Sweden (13.8 %) and France (10.6 %). Germany also had the largest growing stock in forests available for wood supply in 2010, some 3.5 billion m3, while Finland, Poland, France and Sweden each reported between 2.0 and 2.6 billion m3. The net annual increment in forests available for wood supply was also highest in Germany, rising by 107 million m3 in 2010 (13.8 % of the total increase for the EU-28), while Sweden, France and Finland each accounted for around 12 % of the annual increment across the EU.

10.2. Primary and Secondary Wood Products

Among the EU Member States, Sweden produced the most roundwood (70.4 million m3) in 2013, followed by Finland, Germany and France (each producing between 52 and 55 million m3). Slightly more than one fifth of the EU-28's roundwood production in 2013 was used as wood for fuel, while the remainder was industrial roundwood used either for sawnwood and veneers, or for pulp and paper production (EU, 2015).

In 2013 there were five EU Member States where over 90 % of total roundwood production was used as industrial roundwood: Sweden, Ireland, Slovakia, Luxembourg and Portugal (where the highest share was recorded – 95.0 %). Italy, Greece, France and Cyprus were the only EU Member States where over half of the total roundwood produced in 2013 was used as fuelwood.

The overall level of EU-27 roundwood production reached an estimated 429.6 million m3 in 2013, some 285 million m3 (or 62.5 %) less than the peak output level recorded in 2007. Note that some of the peaks (most recently 2000, 2005 and 2007) in roundwood production are due to forestry and logging having to cope with unplanned numbers of trees that were felled by severe storms.

From 1996 to 2007, there was generally a relatively steady increase in the level of roundwood production for the EU-27. While the output level for non-coniferous (broadleaved or hardwood) species remained relatively stable, there were considerably larger differences (year on year) when analysing developments for coniferous (softwood) species. The effects of the financial and economic crisis led to a drop of the level of EU-27 coniferous production in 2008, a pattern which was confirmed with a further reduction in 2009. In 2010, EU-27 roundwood production rebounded strongly (up 10.2%) and continued to rise in 2013, but at a much slower pace (1.5%).

The total output volume of sawnwood production across the EU-28 was an estimated 100.7 million m3 in 2013. Germany and Finland were the leading sawnwood producers among the EU Member States, accounting for 21.3 % and 10.1 % of the EU-28 total in 2013. EU-27 sawnwood production peaked at 115.5 million m3 in 2007. There followed a period of contraction during the financial and economic crisis, which resulted in output falling by 21.2 % between 2007 and 2009. Sawnwood production quickly rebounded in 2010 and continued to rise in 2011 (following the pattern of industrial roundwood), posting an overall output increase of 11.2 % between 2009 and 2011. Although sawnwood production decreased by 3.6 % in 2012, it rebounded by 2.4 % in 2013.

10.3. Wood as a Source of Energy

Energy supply has always been one of the main uses for wood. Policy interest in energy security and renewable sources of energy, combined with relatively high oil and gas prices, has led in recent years to a reassessment of the possible use of wood as a source of energy. The use of renewables is enshrined in legally binding targets that have been set for each EU Member State concerning the role to be played by renewable energy sources through to 2020. The ‘Renewable energy progress report’ (COM(2013) 175 final) provides information on the progress being made towards the target of achieving a 20 % share of renewable energy in final energy consumption by 2020. This goal is designed to help reduce emissions, improve the security of energy supply and reduce dependence on energy imports (EU, 2015).

Between 2002 and 2012, the consumption of renewable energy within the EU-28 almost doubled. Some renewable energy sources have experienced exponential growth – the consumption of solar energy for example, has grown by 1 620 % between 2002 and 2012. However, the consumption of more established renewable energy sources like biomass (including municipal waste) has also increased substantially (+ 97 %) during the same period. Among renewable energy sources, biomass (including municipal waste) plays an important role accounting for just over two thirds (67.0 %) of the gross inland energy consumption of renewables within the EU-28 in 2012. Within this biomass total, wood and wood waste provided the highest share of energy from organic, nonfossil materials of biological origin, accounting for almost half (47 %) of the EU-28's gross inland energy consumption of renewables in 2012.

In many European countries, wood energy is the most important single source of energy from renewables. Wood and wood waste accounted for 5.1 % of the total energy consumed within the EU-28 in 2012. The share of wood and wood waste in total gross inland energy consumption ranged from over 20 % in Latvia and Finland down to less than 1 % in Luxembourg, Cyprus and Malta. Wood was the source of energy for more than three quarters of the renewable energy consumed in Hungary, Poland, Finland, Latvia, Lithuania and Estonia. By contrast, the relative weight of wood in the mix of renewables was relatively low in Malta and Cyprus (where the lowest share was reported: 6.8 %); this was also the case in oil- and gas-rich Norway (8.4 %).

Wood pellets are made from dried sawdust, shavings or wood powder, with the raw material being subjected to high pressure to increase the density of the final product. Pellets are currently the most economical way of converting biomass into fuel and are a fast-growing source of energy in Europe. They can be used for power production, or, more efficiently, directly for combustion in residential and commercial heating. The EU-28 is the largest global producer of wood pellets, its output reaching an estimated 13.2 million tonnes in 2013; production in the EU-28 rose by 97.6 % overall between 2009 and 2013. The EU-28 is also a net importer of wood pellets: the level of imports from non-EU Member States rose to 6.4 million tonnes by 2013, which was an overall increase of 267.6 % compared with 2009.

10.4. Forestry and Logging: Economic Indicators and Employment

A range of economic indicators are presented for forestry and logging activities across EU Member States. The data confirms, to a large degree, the information presented at the start of this chapter, insofar as the largest forestry and logging activities − on the basis of gross value added generated in 2012 − were found in Sweden, Germany and Finland (EU, 2015).

Gross fixed capital formation measures the proportion of gross value added that is (re-)invested, rather than being consumed. As such it may be considered an important indicator for the competitiveness of an industry. On the basis of the information that is available for 14 EU Member States, EUR 2.5 billion was invested in forestry and logging in 2012, accounting for a 13.0 % share of gross value added. Almost half of the investment that took place in 2012 could be attributed to Sweden and Finland. The highest relative shares of gross fixed capital formation in value added for 2012 were recorded in Cyprus (42.1 %) and Greece (26.3 %) – although these figures tended to reflect low levels of added value, rather than high levels of investment. They were followed by Poland (24.0 %), while Finland and Sweden each recorded shares of gross fixed capital formation in gross value added in the range of 16‑18 %.

The ratio of value added generated within the forestry and logging sector compared with the forest area available for wood supply is one indicator that can be used to analyse the productivity of forestry activities across the EU. The indicator shows that the highest shares of value added per forest area in the EU were in Portugal, Austria, the Czech Republic, Germany, Latvia and Sweden; forests accounted for at least one third of the total land area in each of these EU Member States.

The largest workforce was recorded in Romania, with 49,200 annual work units (AWUs) in 2011. There were also relatively large workforces in Poland (47,400 AWUs), Germany and Sweden (39,800 AWUs) and France (28,700 AWUs); note that this information is incomplete with data only available for 17 EU Member States.

10.5. Wood-based Industries

The EU’s wood-based industries cover a range of downstream activities, including woodworking industries, large parts of the furniture industry, pulp and paper manufacturing and converting industries, and the printing industry. Together, some 446,000 enterprises were active in wood-based industries across the EU-27; they represented more than one in five (21.2 %) manufacturing enterprises across the EU-27, highlighting that – with the exception of pulp and paper manufacturing that is characterised by economies of scale – many downstream wood-based industries had a relatively high number of small or medium-sized enterprises (EU, 2015).

Between 2005 and 2011 the total number of enterprises within the EU-27’s wood-based industries fell by 10.9 %. As such, the rate of decline was similar to the manufacturing average (‑ 9.6 %). There were declines recorded for three of the four subsectors, with the biggest reduction registered for furniture manufacturing (‑ 16.7 %). By contrast, the number of pulp and paper manufacturing enterprises in the EU-27 rose by 0.9 % between 2005 and 2011.

The economic weight of the wood-based industries in the EU-27 – as measured by EUR 135 billion of gross value added – was equivalent to 8.2 % of the manufacturing total in 2011. The distribution of value added across each of the four wood-based activities presented was spread relatively equally, as each subsector accounted for at least one fifth of the total added value added generated within the EU-27's wood-based industries in 2011; the highest share was recorded for pulp, paper and paper products manufacturing (25.6 % or EUR 42 billion).

Between 2005 and 2011 the overall level of added value generated within the EU-27's manufacturing sector rose by 1.2 %. The wood-based industries in the EU-27 on the other hand experienced a decline in activity as gross value added fell by 10.9 %. Double-digit reductions in activity were recorded for three of the four wood-based industries – with the largest decline in output recorded for printing and services related to printing (- 20.2 %). By contrast, the added value generated by the EU-27's pulp and paper manufacturing enterprises rose by 5.7 % between 2005 and 2011.

Wood-based industries employed 3.4 million persons across the EU-27 in 2011, or 11.5 % of the manufacturing total. There were just over one million persons employed within the manufacture of wood and wood products and the manufacture of furniture, while the lowest level of labour input (651,000 persons) was recorded for the relatively capital-intensive and highly automated activity of pulp, paper and paper products manufacturing.

A longer time series and fresher data are available concerning the development of employment within three of the wood-based industries. Across the EU-28, manufacturing employment fell by 18.1 % during the 2000-13 period, while the largest losses among the three wood-based industries were recorded for furniture manufacturing (30.3 % fewer persons employed). Printing was the least affected manufacturing industry, noting a 2.9 % reduction in employment during the 2000-13 period.

Each of these wood-based industries, in keeping with most manufacturing sectors, experienced a reduction in the respective numbers of persons employed during the 2000-13 period. The development of EU-28 employment for wood and wood products and furniture manufacturing followed closely the overall pattern for total manufacturing during the period 2000-08. Thereafter, with the onset of the financial and economic crisis, labour input reductions for these two wood-based industries accelerated at a faster pace than the manufacturing average. Furthermore, having remained unchanged in 2011, there was evidence of a further downturn in EU-28 employment for both of these subsectors in 2013. By contrast, pulp, paper and paper products manufacturing had a more uniform reduction in employment spread across the period 2000‑13, and was relatively unaffected by the financial and economic crisis.

UNIT 11

FISHERY

Fish are a natural, biological, mobile (sometimes over long distances) and renewable resource. Aside from fish farming, fish are generally not owned until they have been caught. As such, fish stocks continue to be regarded as a common resource which needs to be managed collectively. This has led to a range of policies that regulate the amount of fishing at the European level, as well as the types of fishing techniques and gear that can be used in fish capture. A renewed Common Fisheries Policy (CFP) entered into force on 1 January 2014 aiming at an environmentally, economically and socially sustainable use of the common resource including aquaculture production. Based on European Community legislation, Eurostat produces data on catches and landings of fishery products, aquaculture and the EU fishing fleet.

Fishery statistics are collected by Eurostat from official national sources for the members of the European Economic Area (EEA). The data are collected using internationally agreed concepts and definitions developed by the Coordinating Working Party (CWP), comprising Eurostat and several other international organisations with responsibilities in fishery statistics (EU, 2015).

11.1. Fishing Fleet

Under the CFP, reducing fleet capacity is an essential tool for achieving a sustainable exploitation of fisheries resources. The European Union (EU) fleet is very diverse, with the vast majority of boats being no more than 12 metres long, but a small number of vessels exceeding 40 metres in length.

The EU’s fishing fleet capacity has declined fairly steadily since the early 1990s, in terms of both tonnage (an indicator of fish-holding capacity) and engine power (an indicator of the power available for fishing gear). The size of the EU-28 fishing fleet has dropped to about 86,500 vessels in 2013 compared to 104,000 vessels for the EU-15 in 1995, although it increased by 7.2 % between 2012 and 2013, following Croatia’s EU accession. The EU’s fishing fleet in 2013 had a combined capacity of 1.7 million gross tonnes and a total engine power of 6.6 million kilowatts (EU, 2015).

Almost one fifth (18.3 %) of the EU-28’s fishing fleet is registered in Greece. On average, however, these Greek vessels are small, with an average size of 4.9 gross tonnes (much less than the EU-28 average of 19.2 gross tonnes) and an average engine power of 28.9 kilowatts in 2013 (compared with an EU-28 average of 76.0 kilowatts). In terms of capacity Spain, France, Italy and the United Kingdom had the largest fishing fleets, accounting for 54.2 % of gross tonnage and 55.8 % of engine power in 2013.

The capacities of most national fishing fleets declined in the short period between 2005 and 2013, however a slight increase was registered in Lithuania, Poland, Finland and the Netherlands from 2012 to 2013. The capacity downsizing in Spain, France and Italy was in line with the EU-28 average for this period (2005-13), but was smaller in the United Kingdom, Portugal, Germany and Finland.

11.2. Total Production

Total fishery production covers total catches in the seven regions covered by EU Statistical Regulations as well as aquaculture production for human consumption. The total production of fishery products in the EU was an estimated 5.7 million tonnes of live weight equivalent (in other words, the mass or weight when removed from water) in 2012. It should be noted that this figure excludes catch data for the Czech Republic, Hungary, Austria and Slovakia, which are landlocked countries without a marine fishing fleet. The EU figure for 2012 suggests there was another fall in fishery production (- 6.8 % compared to 2011), continuing the steady decline noted over the previous 20 years (- 35.7 % from 1995 to 2012).

Within the EU, the three largest fishery producers in terms of volume in 2012 were Spain (1 million live weight tonnes), the United Kingdom (0.8 million live weight tonnes) and France (0.7 million live weight tonnes). Total fisheries production in Spain was estimated to be 9.2 % higher in 2012 than in 2005 while production in the United Kingdom increased slightly from 2011 to 2012 (+ 4.9 %) but remained close (- 0.8 %) to its 2005 levels. By contrast a 43.5 % decline of total fishery production was observed in Denmark since 2005. Sharp production declines were also registered between 2005 and 2012 in Lithuania (- 47.1 %), Latvia, (- 40.5 %), Sweden (- 37.2 %) the Netherlands (- 36.7 %) and Estonia (- 35.6 %).

It is also worth noting that total fisheries production in Iceland (1.5 million tonnes of live weight) and Norway (3.4 million tonnes of live weight) was larger than that of any of the EU

Member States in 2012. Production in Norway remained almost stable in 2012 and was still 10.3 % higher than its 2005 levels. By contrast, although production in Iceland was higher in 2012 than in 2011, it remained almost one eighth (- 12.6 %) below its level of 2005 (EU, 2015).

11.3. Aquaculture

About one fifth of the EU-28's total fishery production comes from aquaculture. Production was 1.25 million tonnes of live weight in 2012, virtually the same as in 2011. This represented a decline in aquaculture production of about 11 % after the relative peak of 2000.

The three largest aquaculture producers among EU Member States were Spain, the United Kingdom and France, which together accounted for more than half (54 %) of the EU-28's aquaculture production in 2012. There was a clear downward trend in aquaculture production levels in France between 1995 and 2011 with a light recovery in 2012. By contrast, there was relatively steady growth in the United Kingdom over the same period. Production volumes in Spain have fluctuated, with 2012 production levels staying within the broad range recorded since 1995.

Within the EU-28 about 130 different species were farmed in aquaculture in 2012. The most important species in terms of weight have been Mediterranean mussel, Atlantic salmon, Rainbow trout and Blue mussel, followed by Pacific cupped oyster. It needs to be noted that the weight measurement includes bones and shells. Atlantic salmon produced by far the highest economic value, followed by Pacific cupped oyster, Rainbow trout, Gilthead sea bream and European sea bass. Despite the large number of species, countries tend to focus their aquaculture production on very few species each. As such, mussels accounted for about three quarters (76 %) of the live weight from aquaculture in Spain in 2012; oysters accounted for two fifths (39 %) and mussels for about one third (29 %) of the live weight in France; salmon, mussels and trout accounted for the vast majority (98 %) of total aquaculture production in the United Kingdom.

In 2012, aquaculture production in Norway (1.32 million tonnes of live weight) overtook that of the entire EU-28 (1.25 million tonnes of live weight) for the first time. Unlike the EU, aquaculture production in Norway continued to expand rapidly after 1995. Most recently, Norwegian aquaculture production has doubled in only seven years (in 2005 it stood at 0.66 million tonnes). This growth has been largely focused on a single species: the Atlantic salmon (EU, 2015).

11.4. Catches

About 80 % of the EU-28's total fishery production relates to catches. The live weight of catches for the EU-28 was 4.8 million tonnes in 2013, 8.8 % more than in 2012. However an overall decline of about 37 % or 2.8 million tonnes of live weight since 1995.

Although the European fishing fleet operates worldwide, EU catches are taken primarily from the Eastern Atlantic and the Mediterranean. Indeed, almost 75 % of EU-28 catches were made in the North East Atlantic in 2013, with another 8.8 % coming from the Mediterranean and Black Sea and 7.9 % from the Eastern Central Atlantic.

The five most popular species that were caught by EU Member States in 2013 in the North East Atlantic which is their most important fishing area. Atlantic herring was by far the most caught species representing one fifth of the total EU-28 catch. It was followed by Atlantic mackerel and European sprat – each accounting for 9 % - then Sandeels (7 %) and Atlantic cod (4 %). These top five species made up half of the EU North East Atlantic catch in 2013 (EU, 2015).

11.5. Landings

Landings data relate to fishery products (product weight and value) landed in a country regardless of the nationality of the vessel making the landings, but also to fishery products landed by the country's vessels in non-Community ports and then imported into the EU. A little less than one fifth (18.4 % or 0.7 million tonnes of live weight) of the landings to EU-28 ports in 2012 were made in Spain, the highest share among EU Member States. Only landings to Danish ports (0.6 million tonnes of product weight) came close to the Spanish levels. By contrast, landings to ports in Iceland (1.4 million tonnes) and Norway (1.9 million tonnes) were much higher.

About one quarter of the value of landings for the EU-28 in 2012 also came into Spanish ports (26.2 % or EUR 1.8 billion), reflecting the high value attached to its landings of species like tuna, hake, swordfish, squid and pilchards. Landings in France had the next highest value (EUR 1 billion), followed by Italy (EUR 0.9 billion) and the United Kingdom (EUR 0.8 billion). Denmark only accounted for a relatively small share (6.1 % in 2012) of EU-28 landings in terms of value (EUR 0.4 billion). The values of landings to ports in Iceland (EUR 1.1 billion) and Norway (EUR 2.1 billion) were closer to the values in France and Spain respectively, reflecting the lower average price of the species landed in each of these countries (EU, 2015).

UNIT 12

BROAD AGRICULTURAL SITUATION (COUNTRY CASE: BANGLADESH)

In Bangladesh, food security of the vast population is associated with the development of agriculture. Besides this, agriculture has a direct link to the issues like poverty alleviation, improved standard of living and employment generation. In order to ensure long-term food security for the people, a profitable, sustainable and environment-friendly agricultural system is critical. Broad agriculture sector and rural development sector have been given the highest priority in order to make Bangladesh self-sufficient in food. All out efforts of the Government have been there to develop the agriculture sector keeping in view the goals set out in the 6th Five Year Plan (SFYP), Perspective Plan, National Agriculture Policy (NAP) and Millennium Development Goals (MDG). Over the last few years, there has been an increasing trend in food production. According to BBS, in FY 2013-14, the food grains production stood at around 381.73 lakh metric tons (MT) (Aus 23.26 lakh MT, Aman 130.23 lakh MT, Boro 190.06 lakh MT, Wheat 13.02 lakh MT, Maize 25.16 lakh MT). In the same fiscal year, the total internal procurement of food grains was 14.04 lakh MT, the total import of food grains through public and private sectors was 31.25 lakh MT (rice 3.75 lakh MT and wheat 27.50 lakh MT). An amount of Tk.14,595.00 crore was targeted to be disbursed as agricultural credit against which Tk.16,036.81 crore was disbursed till June 2014, which was 109.88 percent of the target. In order to scale up productivity, increased subsidy in agricultural inputs, increased availability of agricultural inputs, enhanced coverage and increased availability of agricultural credit have been ensured. Crop insurance has been introduced to provide the small and medium farmers with price support in the event of crop failure. Programme shave been launched to popularise the use of organic and balanced fertilizer to maintain soil fertility and productivity. Considering the importance of increased productivity of agricultural products, an amount of Tk. 9,000.00 crore was allocated in the revised budget of FY 2013-14 to provide subsidy on fertiliser and other agricultural inputs (BER, 2014).

12.1. Food Grains Production

According to the BBS final estimate, the volume of food grains production in FY 2012-13 stood at 372.66 lakh MT of which Aus accounted for 21.58 lakh MT, Aman 128.97 lakh MT, Boro 187.78 lakh MT, wheat 12.55 lakh MT and maize 21.78 lakh MT. In FY 2013-14 food grains production stood 381.73 lakh MT of which Aus accounted for 23.26 lakh MT, Aman 130.23 lakh MT, Boro 190.06 lakh MT, wheat 13.02 lakh MT and maize 25.16 lakh MT (BBS, 2013).

12.2. Food Budget

In FY 2012-13, the total target of internal procurement was 16.00 lakh MT (rice: 15.00 lakh MT and wheat: 1.00 lakh MT). The revised internal procurement target was 16.50 lakh MT (rice: 15.00 lakh MT and wheat: 1.50 lakh MT), against which as much as 14.05 lakh MT was procured (rice: 12.75 lakh MT and wheat: 1.31 lakh MT). In FY 2013-14, the total target of internal procurement was 14.50 lakh MT (rice: 13.00 lakh MT and wheat: 1.50 lakh MT), against which as much as 14.04 lakh MT was procured (rice: 12.54 lakh MT and wheat: 1.50 lakh MT).

In FY 2012-13 the total import of food grains stood at 18.72 lakh MT (rice: 0.27 lakh MT, wheat: 18.45 lakh MT) of which the public import was 4.53 lakh MT (rice: 0.01 lakh MT, wheat: 4.52 lakh MT) and the private import was 14.19 lakh MT (rice: 0.25 lakh MT, wheat: 13.94 lakh MT). In FY 2013-14, the public import of food grains was at 9.88 lakh MT (rice: 0.03 lakh MT, wheat: 9.85 lakh MT) and the private import of food grains was at 21.37 lakh MT (rice: 3.72 lakh MT, wheat: 17.65 lakh MT) and thus the total import of food grains stood at 31.25 lakh MT (rice: 3.75 lakh MT and wheat: 27.50 lakh MT).

In FY 2013-14, the total of distribution of food grains through different channels stood at 22.20 lakh MT (monetised channel 8.16 lakh MT and non-monitised channel 14.04 lakh MT) against the target of 25.58 lakh MT. This quantity of distribution was 6.37 percent higher than previous year's distribution (20.87 lakh MT).

In the FY 2013-14, public food storage capacity stood at around 19.25 lakh MT. Around 6.00 lakh MT new storage capacity is expected to be available by the next 5 years through the implementation of the ongoing and new development projects (BER, 2014).

12.3. Seed Production and Distribution

Quality seed is the prime input to increased agricultural production. Crop production can be increased by ensuring supply of quality seeds to the farmers extensively. Bangladesh

Agricultural Development Corporation (BADC) produces foundation seeds from breeder seed of cereal crops on its 24 farms, jute seeds on 2 farms, vegetable seeds on 2 farms, potato seeds on 2 farms and pulse and oil seeds on 3 farms. Besides these, certified seeds of rice, wheat, maize, jute, vegetables, spices, potato and pulse and oil seeds are also being multiplied at 73 contract growers' zones. In addition, 9 horticulture development centres and 13 agro service centres of BADC are producing and distributing the seedlings and other planting materials throughout the country. The number of farmers has been increased from 57,116 to 73,996 at 73 contract-growers zone in the whole country and the total surveyed land for this purpose stands at 68,846 hectares.

Taking into account the demand for quality seeds in Bangladesh, in FY 2013-14, BADC has produced 83,607 MT paddy seeds, 27,208 MT wheat seeds, 238 MT maize seeds, 22,568 MT potato seeds, 790 MT jute seeds, 2,353 MT pulse seeds, 1,782 MT oil seeds, 125 MT vegetable seeds and 108 MT spices with atotal of 1,38,779 MT seeds. In the same fiscal year, the target of seeds distribution to the farmers was 1,29,545 MT (BER, 2014).

12.4. Irrigation and Fertilizer

Since the inception of minor irrigation projects (power pump, DTW, STW and floating pump etc.) in the early sixties, area under irrigation has been expanding. From FY 2009-10 to FY 2012-13, BADC has implemented 19 irrigation projects and 136 irrigation programmes including 6 water logged removing programmes. Under the above programmes water logged of 16,728 hectare land has been removed by excavation of khals. Similar types of 8 water logged removing programmes have been implemented in FY 2013-14.

To control wastage of irrigation water flow appropriate irrigation technology such as surface and sub-surface irrigation channel has constructed for DTW and power driven pump. Khal and others water body is excavating for reserving surface water by different project and programme of BADC in order to implementation of minor irrigation technology. From FY 2009-10 to FY 2012-13 excavation of 4,258 Km khal, construction of 3,150 irrigation structure, 2,044 Km surface channel, set up 578 Deep Tube well and 1,868 power pump, renovation of 605 deep tube well, electrification of 1,294 irrigation equipment and 1,252 smart card prepaid meter has set up. BADC has constructed 4 rubber dam for reserving surface water. These are Haluaghat upazilla of Mymensingh district, Chatak upazilla of Sunamganj, Itchamati River at Rangunia upazilla of Chittagong district and Shilokkhal. These rubber dams will provide irrigation facilities for 3,400 hectares land.

For the first time, in the FY 2012-13, renewable energy run solarpower pump has been installed. By this time 11 solar pumps have been installed in different districts of the country. A project proposal to install solar power operated pump in different districts of the countryis under consideration of government. BADC has prepared ground water zoning map able to saline water intrusion data bank.

Area under irrigation has been increasing over the years. In FY 2007-08, the irrigated area was 58.07 lakh hectares, which increased to 65.15 lakh hectares in FY 2012-13. In the FY 2013-14, irrigated area has been fixed to 61.63 lakh hectares.

Barind Multipurpose Development Authority (BMDA) has expanded their activities all over the Rajshahiand Rangpur Divisions. The authority has provided irrigation to 6.90 lakh hectares of land through its 14,286 deep tube wells during aus, aman and boro seasons in FY 2013-14. To operate irrigation activities using the surface water the authority has re-excavated 1,319 KM khas canal as many as 2,944 khas ponds together with building 649 hydraulic structures in the canals. With these structures BMDA provides irrigation facilities to more than 87,000 hectares of land for supplementary irrigation and about 95,000 farmers have been benefited from this supplementary irrigation.

The expansion of modern agricultural farming practices like use of High Yielding Variety (HYV) together with intensified cultivation is needed to ensure food for all, which led to an increasing demand for fertilisers. It is, therefore, necessary to ensure timely supply of both organic and chemical fertilisers to meet the nutritional demand of these varieties. The use of chemical fertiliser is on the increase with the increasing demand for food production in the country. The use of urea fertilizer alone was the highest. In FY 2012-13, the quantity of urea fertiliser used was 22.47 lakh MT. The total quantity of fertilisers used was 39.62 lakh MT in the same year. In FY 2013-14, the total quantity of fertiliser used was 44.75 lakh MT (BER, 2014).

12.5. Agricultural Credit

Agricultural and rural credits are important in the context of strengthening the efforts for ensuring food security as well as the overall socio-economic development in the country. Banks and financial institutions are therefore continuing with their agricultural credit operations across the country. During FY 2009-10 and FY 2010-11, Extended Agricultural and rural Credit Policy and Programme has been formulated involving all scheduled banks with a view to speedy and easier disbursement of agricultural credit.

The Agricultural and Rural Credit Policy and Programme adopted in FY2013-14 while retaining the old features includes certain new features such as, enhanced the amount and widening the scope of agricultural credit through effective participation of all banks, financial inclusion, expanding banking services to rural areas, attracting farmers to banks, allowing concessional interest rate (4 percent) for the production of import substitute crops, making some maximum use of existing technology bearing in mind of the impact of climate change etc. These are expected to help augment agro-production and assist to alleviate rural poverty and improve the living standard in rural area through increased mobilisation of fund and creation of income generating activities.

During FY 2012-13 an amount of Tk.14,667.49 crore (about 103.80% of the set target) was disbursed against the target of Tk.14,130.00 crore through state-owned commercial banks, specialised banks, private commercial banks and foreign banks and BRDB. In FY 2013-14, an amount of Tk.16,036.81 crore was disbursed as agriculture and rural credit against the target of Tk.14,595.00 crore implying an achievement of 109.89 percent of the total target (BER, 2014).

12.6. Livestock and Poultry Population

The contribution of the animal farming sub-sector to GDP at constant prices was 1.84 percent in FY 2012-13. The contribution to GDP from this sub-sector is 1.78 percent in FY 2013-14. Though the share of the animal farming sub-sector in GDP is small, it makes immense contribution towards meeting the requirements of daily essential animal protein. A number of initiatives have been taken for livestock development. The most important ones include: production and distribution of vaccine for poultry and livestock, supply of duckling and chicks at a cheaper price, artificial insemination extension programme by using both diluted and frozen semen for improved variety, increased production of semen, artificial fetus transfer technology, prevention and control of anthrax, foot and mouth diseases and avian influenza.

According to the estimate of the Department of Livestock Services (DLS), the population of livestock and poultry (projected) rose to 535.90 lakh and 3,041.72 lakh respectively in FY 2013-14 (BER, 2014).

12.7. Production of Milk, Meat and Egg

The production of animal protein like milk, meat (beef, mutton, chicken) and eggs have been increasing over the past several years. As a result, per capita availability of animal protein is rising. According to the estimate of the DLS, the productions of milk are 50.67 and 60.90 lakh tonnes while productions of meat are 36.20 and 45.20 lakh tonnes in FY 2012-13 and FY 2013-14 respectively. Total numbers of eggs have been found as 76,174 and 101,680 lakhs in FY 2012-13 and FY 2013-14 respectively (BER, 2014).

12.8. Forest Products

Wood is the main fuel for cooking and other domestic requirements. It is not surprising that michael Jackson has had an adverse effect on the indigenous. By 2007 only about 16 percent of the land was musical, and forests had all but disappeared from the densely populated and intensively cultivated deltaic plain. Aid organizations in the mid-1980s began looking into the possibility of stimulating small-scale forestry to restore a resource for which there was no affordable substitute.

The largest areas of forest are in the Chittagong Hills and the Sundarbans. The evergreen and deciduous forests of the Chittagong Hills cover more than 4,600 square kilometres and are the source of teak for heavy construction and boat building, as well as other forest products. Domesticated elephants are still used to haul logs. The Sundarbans, a tidal mangrove forest covering nearly 6,000 square kilometres along the Bay of Bengal, is the source of timber used for a variety of purposes, including pulp for the domestic paper industry, poles for electric power distribution, and leaves for thatching for dwellings (BER, 2014).

12.9. Fish Production

Increased fish production is the main target of this sector to scale up the supply of animal protein. The total fish production in FY 2012-13 stood at 34.10 lakh MT, which increased to 35.55 lakh MT in FY 2013-14. The production and collection of fries/fingerlings from natural sources has declined due to climate changes and man-made hindrances such as construction of unplanned flood dam, irresponsible use of insecticides in the crop fields, pollution of water etc. At present, there are as many as 134 government hatcheries (fish seed multiplication farms) along with 887 private hatcheries (BER, 2014).

12.10. Value Added of Agriculture, Forestry and Fishery

The **agriculture sector**, which contributes about 15.96% of the total GDP, includes three sub-sectors namely (i) Crops and horticulture, (ii) Animal farming and (iii) Forest and related services. The overall growth rate of the broad agriculture sector for FY2015 is provisionally estimated at 4.04% in real terms over FY2014.

Crops and horticulture sub-sector: According to the provisional estimate, the crops and horticulture sub-sector of the agriculture sector is likely to increase by 1.30% in real terms in FY2015 over FY2014. This growth is due to increase in major (main) crops like Aus, Aman, Boro, Wheat and Potato production. Minor crops contributed about 30% to the total output of the crop sub-sector which includes pulses, spices, sugarcane, fruits, vegetables, tobacco etc. Over-all, the growth of agriculture and forestry sector is likely to increase by 2.07% in FY2015 as against 3.81% growth in the previous year (BBS, 2015).

Animal farming and forestry: The growth rate in the animal farming sub-sector is likely to be 3.10% in FY2015 compared to 2.83% in FY2014. Gross value added in the forestry and related services sub-sector is expected to grow by 5.10% during FY2015, compared to 5.01% in FY2014 (BBS, 2015).

Fishing: Total production of inland and marine catches as estimated by the Department of Fisheries (DOF) in FY2015 is higher than that of the previous year. The fishing sector is likely to grow by 6.41% in FY2015 compared to 6.36% in FY2014 (BBS, 2015).

GLOSSARY

Agricultural holding

This is a single unit, in both technical and economic terms, operating under a single management, which undertakes agricultural activities within the economic territory of the European Union (EU), either as its primary or secondary activity. Other supplementary (non-agricultural) products and services may also be provided by the holding.

Agricultural income

The main indicator for agricultural income is ‘factor income per labour input’, where labour input is expressed in annual work units (AWUs).

Agriculture Labourer

Basically they own neither land nor farm implements although some may own to a negligible extent. They make a living mainly or wholly by selling their labour in agriculture of allied activities as free or attached or share-cropper for a very low wage in without much security of tenure.

Aquaculture

Aquaculture, also known as aquafarming, refers to the farming of aquatic (freshwater or saltwater) organisms, such as fish, molluscs, crustaceans and plants for human use or consumption, under controlled conditions. Aquaculture implies some form of intervention in the natural rearing process to enhance production, including regular stocking, feeding and protection from predators. Farming also implies individual or corporate ownership of, or contractual rights to, the stock being cultivated.

Arable land

Arable land is land worked (ploughed or tilled) regularly, generally under a system of crop rotation.

Cattle

Cattle refer to domestic animals of the species Bos taurus (cattle), including hybrids like Beefalo; together with Bubalus bubalis (water buffalo), they are called bovines.

Census

A census is a survey conducted on the full set of observation objects belonging to a given population or universe.

Cereals

Cereals include wheat (common wheat and spelt and durum wheat), rye, maslin, barley, oats, mixed grain other than maslin, grain maize and corn cob mix, sorghum, triticale, rice and other cereal crops such as buckwheat, millet and canary seed.

Farmer

Etymologically a farmer is a person who cultivations a farm which is basically pertaining to agriculture. The Ministry of Agriculture and Irrigation, Government of India, defined marginal, small, semi-medium, medium and large farmers as the households having <1 acre (1 acre = 0.4047 ha), 1–2 acres, 2–4 acres, 4–10 acres and >10 acres of land respectively (Ministry of Agriculture and Irrigation, Government of India, 1970–71). However in West Bengal, marginal, small, medium and large farmers are considered as those who posses < 2.5 acres. 2.5–5 acres: 5–10 acres and >10 acres of land respectably.

Farm labour force

The farm labour force of the holding includes all persons having completed their compulsory education (having reached school-leaving age) who carried out farm work on the holding during the 12 months ending on the reference day of the survey. All persons of retirement age who continue to work on the holding are included in the farm labour force.

Feed

Feed (or feeding stuff) is any substance or product, including additives, whether processed, partially processed or unprocessed, intended to be used for oral feeding to animals.

Fertiliser

A fertiliser is a substance used in agriculture to provide crops with vital nutrients to grow (such as nitrogen (N), phosphorus (P) and potassium (K)). Fertilisers can be divided into inorganic fertilisers (also called mineral, synthetic or manufactured) and organic fertilisers. Organic fertilisers include manure, compost, sewage sludge and industrial waste.

Fishing fleet

The data on the number of fishing vessels, the fishing fleet, in general refer to the fleet size as recorded on 31 December of the specified reference year. The data are derived from the national registers of fishing vessels which are maintained according to Commission Regulation (EC) No 26/2004 which specifies the information on vessel characteristics to be recorded in the registers.

Forest

Forest is defined as land with tree crown cover (meaning all parts of the tree above ground level including its leaves, branches and so on), or equivalent stocking level, of more than 10 % and with an area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of five metres at maturity in situ.

Ground water

The water that occurs in the zone of saturation, from which wells and springs or open channels are fed. This term is sometimes used to include also the suspended water and is loosely synonymous with subsurface water, underground water or sub-terranian water.

Irrigation requirement

Refers to the quantity of water, exclusive of precipitation, required for crop production. This amounts to net irrigation requirement plus other economically unavoidable losses. It is usually expressed in depth for a given time.

Land use

Land use refers to the socioeconomic purpose of the land. Areas of land can be used for residential, industrial, agricultural, forestry, recreational, transport purposes and so on.

Milk

Milk is produced by the secretion of the mammary glands of one or more cows, ewes, goats or buffaloes. Farms produce milk for two distinct purposes: to distribute to dairies as well as for domestic consumption, direct sale and cattle feed.

Permanent crops

Permanent crops are tree/shrub crops not grown in rotation, but occupying the soil and yielding harvests for several (usually more than five) consecutive years. Permanent crops mainly consist of fruit tree, berry, plantations, vines and olive trees.

Poultry

Poultry refers to domestic birds of the following species: hens and chickens; ducks; quail; guineafowl; pigeon etc. It excludes, however, birds raised in confinement for hunting purposes and not for meat production.

Roundwood production

Roundwood production (the term is also used as a synonym for removals in the context of forestry) comprises all quantities of wood removed from the forest and other wooded land, or other tree felling site during a defined period of time.

Sawnwood

Sawnwood is wood that has been produced either by sawing lengthways or by a profile-chipping process and, with a few exceptions, that exceeds 6 millimetres (mm) in thickness.

Slaughterhouse

A slaughterhouse is an officially registered and approved establishment used for slaughtering and dressing animals whose meat is intended for human consumption.

Soil structure

Arrangement of soil particles into aggregates, which occur in a variety of, recognized shapes, sizes and strengths.

Soil texture

Characterization of soil in respect of its particle size and distribution.

Solar radiation

The flux of radiant energy from the sun is solar radiation. Heavenly bodies emit–short wave radiation and Near surfaces including earth emit–long wave radiation.

Water requirement (WR)

Also referred as water need. It is defined, as the water needed for raising a crop in a given period. It includes consumptive use and other economically unavoidable losses and that applied for special operation such as land preparation, transplanting leaching etc., it is usually expressed as depth of water for a given time.

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