**МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ**

**ЦЕНТРАЛЬНОУКРАЇНСЬКИЙ НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ**

**КАФЕДРА ІНОЗЕМНИХ МОВ**

# ІНОЗЕМНА МОВА

**Методичні вказівки до практичних занять для здобувачів освіти першого (бакалаврського) рівня, спеціальність 201 "Агрономія"**

**Кропивницький 2023**

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Методичні вказівки призначені для здобувачів освіти 1-го рівня спеціальності “Агрономія”.

У цьому посібнику основну увагу звернено на розуміння специфіки лексико-граматичних засобів мовного стилю, вдосконалення навичок ознайомлювального, переглядового і вивчального читання літератури.

Тематика текстів не тільки забезпечує багатий лексико-граматичний навчальний матеріал, а й має велике пізнавальне значення.

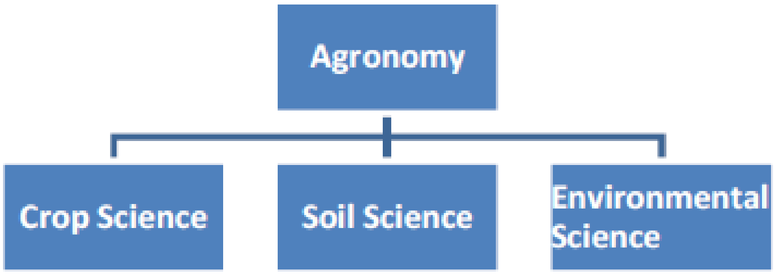
## 1. Principles of Agronomy and Agriculture

Agriculture is a significant segment for the country's economy as it is not only a source of revenue but a part culture. It not only provides food but also fiber, fuel, furniture, raw materials, etc., for the manufacturing sectors. Agriculture includes multi-dimensions and multidiscipline, which is fast-growing and speedily and rapidly blowout along with the time and territory with the spatial specifications. The Green Revolution is one of the biggest revolutions within the agricultural sector which aimed to achieve food self-sufficiency along with improvement of agricultural practices and agricultural inputs that help to augment the production for the unit of land over time and lower expenditure. The term 'Agriculture' is derived from two Latin terms 'Ager' and 'Cultura'. Ager means land or field and Cultura cultivation.

'Agriculture' has several meanings with various dimensions of crop production and allied aspects such as livestock farming, fisheries and forestry. The meaning of the word agriculture is the farming of land, i.e., a combination of science and art for the production of crops and rearing of livestock for financial determinations. Agriculture as a scientific discipline has made a contribution in the process of enhancement and up-gradation of development of countries. It provides surplus food and exportable commercial crops on a cost-effective basis. Any country seeking to develop its economy has to give a priority to agriculture, particularly scientific agriculture. Whenever agriculture has been undertaken scientifically, it revolutionizes agriculture by way of technological intervention and the green revolution occurred. Another term 'agronomy' comes from two Greek words, i.e., 'agros', which means field and 'nomos', meaning to manage. Agronomy is a discipline that includes both art and science. The art part involves cultivation, creation, production and enhancement of the production of field crops, while the effective practice of all the resources and the decision to apply it appropriately is the science part. Such as strategy to use resources like soil, water, human resources and the relevant factors required for crop production.

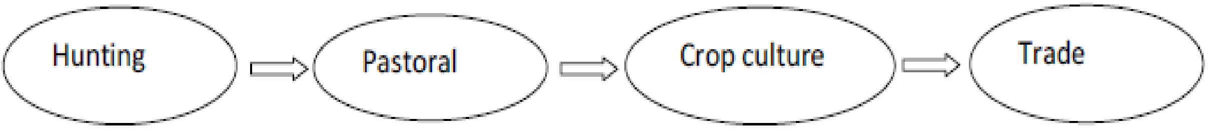
Agronomy as a discipline is a combination of three components, viz., crop science, soil science and environmental science, which is an integration of the Soil-Crop-Environmental relationship.

There is one more sub-stream of agriculture that can be defined as the sustainable land management system where other aspects are covered such as the production of crops, trees, forest plants and management of allied sectors. Apart from the production of crops, other units of production enhance the sustainability of agriculture like cultural practices of the local population which may involve animal rearing or livestock production. Agrometeorology is the stream under the broader arena of agriculture which is to learning the interrelation amongst meteorological factors with hydrological features on the one side and agriculture on the other. Meteorology is a discipline dealing with weather elements and their connection to agriculture with the impact on crop production.




**Agriculture: Evolution**

Even the most efficient hunting and gathering could hardly support the survival of the human race. The pastoral activities can support the survival of lives, but agriculture alone can support the masses to survive in a sustained manner. During the period 8700 BC to 7700 BC humans domesticated animals and turned as herdsmen. Man first domesticated sheep and later goat. Between the period 7500 BC and 6500 BC, he slowly moved from chasing and assembling to agribusiness. Stone hatchets were used for cutting trees and fire for consuming wood. Grains of oats were drilled with pointed sticks. Cereals grown during this period were wheat, barley, and later rice, maize, and millets. The evolution involved various stages of development in the process of agriculture development. It started from hunting activities and reached up to trade by pastoral activities and crop cultivation. As India was a peaceful nation before agribusiness was begun, advancement of yields and animals occurred simultaneously, prompting different kinds of cultivating frameworks that are currently observed in its various parts.




With the advent of some activities in various periods, agriculture became transformed from crop culture to scientific agriculture. Evidence from excavations to remote sensing tests show that agriculture is around 10,000 years old. It is also clear that women pioneered agriculture as they observed that plants emerged from seeds. They started cultivating plants from the undomesticated wild flora by digging out the eatable roots and rhizomes of the plants and suppressed the minor ones for succeeding yields. Animal rearing was also done for meat and skin for clothing.

**Shift in Farming Practices**

Many farming practices emerged over a period of time. Various cultivation practices were shifting cultivation, subsidiary farming, subsistence farming, mixed farming, advanced farming and so on.

**Shifting Cultivation**

This is a primitive form of agriculture in which people cut down the forest, burnt the underneath growth and started cultivating the land. Land was cultivated with the crudest of tools. It had high fertility in the beginning. But as the fertility of land gets down, it is infested with weeds, insects, pests and diseases, and the people move to a new location. They undertake the same operations in the new place, and this type of cut and burn practice of cultivation is called slash and burn cultivation too.

**Subsidiary Farming**

This is the farming system, which is comparatively not much developed, it may include cultivation, gathering, and hunting. This is the system, where people start the farming practice near to the water availability, the water stream or river as a permanent settlement started in a gregarious manner and underway cultivating in the same piece of land on the regular basis. This system includes a primitive way of farming practice, which may include tools, crops, and cropping methods.

**Subsistence Farming**

This is also a primitive type of farming practice, while it is comparatively advanced and latest, where agriculture is considered the essential part of the lifespan, which is founded on the principle of "Grow it and eat it" rather than the production of crops for the business purpose to make it commercialize. This farming practice is mainly produced for consumption purposes only not for commercial purposes.

**Mixed Farming**

This is a more diversified farming system, which includes crop and animal rearing components. The land can be used for both the purpose, initially for cultivation purpose and later used for grazing for animals. The system was a transition stage from the collection of food to the production of food.

**Advanced Farming**

The upgraded cultivation practice consists of various advanced components like the selection of seeds, organic composting, selection of varieties and seeds, green manuring with legumes, cropping pattern, crop rotation, etc. it includes various practices with advancements like the application of animal cow dung, crop residues as compost, irrigation practices, integrated pest management, nutritional management, rearing of livestock for milk purpose, rearing of bullocks, sheep, goats for various purposes like meat and wool.

**Scientific Agriculture (from 19th Century)**

Agriculture has been advanced and updated over a period. Till the eighteenth century, agriculture had been modernized with crop rotation, sequencing, organic recycling, exotic crops and animals and farm tools had been used, etc. With the commencement of the nineteenth century, agriculture has been more scientifically dealt with because of research and development (R&D). Fundamental and elementary sciences had been amalgamated for application to agriculture. Agriculture has been considered as multidisciplinary. As a teaching domain, it had laboratories, farm-based activities, research centers, research institutes, teaching and extension activities along with training and demonstration. Several academic works of literature including books and journals were created. Various media and audio-visual aids have spread research findings and disseminated information to the actual users.

**Contemporary Agriculture (21st Century)**

This is the recent version of agriculture. It is not limited to production. In the contemporary scenario, agriculture is an enterprise rather than just farming. With it are associated commercial ventures such as dairy, poultry, fisheries, piggery, sericulture, apiary, plantation crops, etc. Technological advancements have been added with components like hydrological, mechanical and genetic which have transformed the progress of agriculture. Governmental interventions in terms of subsidy, budgetary support, etc., have been introduced. There are policy interventions like introduction of food preservation and processing, pricing strategies, marketing and distribution mechanism, export and import policies, etc., which have commercialized agriculture rather than confining it to food production. Need-based and region-based agricultural planning has been executed.

**Streams of Agriculture**

Agriculture is multidisciplinary involving various branches of sciences including functional components such as basic sciences. The pragmatic parts of farming science comprise an investigation of field crops and their administration, i.e., agriculture, which means crop and soil management. Agriculture includes three important spheres, i.e., geoponic cultivation in earth-soil, aeroponic cultivation in air, and hydroponic which is cultivation in water.

Apart from these, there are various streams of agriculture which are agronomy/crop production, horticulture, agricultural engineering, forestry, animal husbandry, fisheries and home science.

**To Do Activity**

1. List down various types of the farming system. Discuss the components which make differentiations in all the types of farming.
2. There can be a discussion on various farming practices in various parts of Ukraine to understand agriculture in its multidisciplinary and vivid regions.

## 2. Resource Management

### Introduction

Multiple resources are required for growth of crops such as land, water, soil, etc. It also depends on the aerial and soil environmental conditions. Soil environment can be altered by multiple methods like tillage, fertilizers applications, irrigation facilities, reduced mechanical resistance, provision of nutrients and water. Environment can be studied under various components like chemical, physical and biological.

### Soil Environment and Soil Conservation

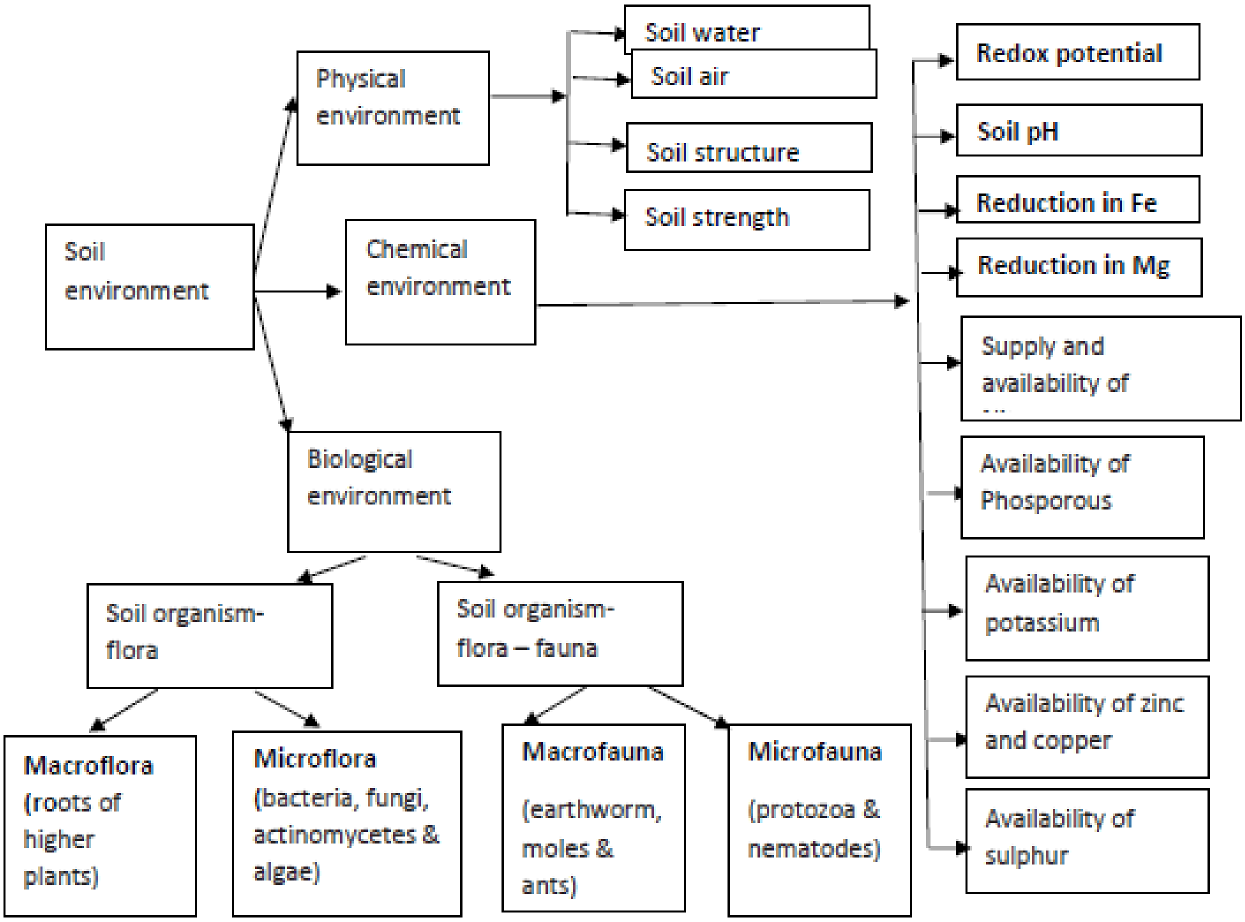
Soil environment can be classified based on various conditions such as physical, chemical and biological. Soil classification is based on the proportion of predominant size fraction of sand, silt and clay. Significance of soil texture is that it is a permanent feature of soil and its changes over a period are negligible. Soil texture affects its physical and chemical properties such as water holding capacity, nutrient availability, the compressibility of soil thermal, bridging of soil nutrient fixation and drainage. It is especially about the soil particle that is sand, silt and clay which are grouped in the form of aggregates.

**USDA particle-size classification**

| Common names of soils (general texture) | Sand | Silt | Clay | Textural class |
|---|---|---|---|---|
| Sandy soils (coarse texture) | 86-100 | 0-14 | 0-10 | Sand |
| | 70-86 | 0-30 | 0-15 | Loamy sand |
| Loamy soils (moderately coarse texture) | 50-70 | 0-50 | 0-20 | Sandy loam |
| Loamy soils (medium texture) | 23-52 | 28-50 | 7-27 | Loam |
| | 20-50 | 74-88 | 0-27 | Silty loam |
| | 0-20 | 88-100 | 0-12 | Silt |
| Loamy soils (moderately fine texture) | 20-45 | 15-52 | 27-40 | Clay loam |
| | 45-80 | 0-28 | 20-35 | Sandy clay loam |
| | 0-20 | 40-73 | 27-40 | Silty clay loam |
| Clayey soils (fine texture) | 45-65 | 0-20 | 35-55 | Sandy clay |
| | 0-20 | 40-60 | 40-60 | Silty clay |
| | 0-45 | 0-40 | 40-100 | Clay |

Soil structure is important because it influences soil environment and its porous space availability of plant nutrients, water holding capacity and growth of microorganisms. Soil is very dynamic and depends on various factors such as clay minerals, cation and anion exchange capacity and pH of soil. pH is the negative logarithm of hydrogen ion activity which indicates the acidity and alkalinity of the soil. Nutrients in the soil determine the physical, chemical and biological changes or transformation in soil.

The biological environment is composed of several micro-organisms that belong to plants as well as the animal kingdom. The activity of soil organisms can be changed by managing various practices within the soil environment for plant growth. Soil organisms in flora and fauna are divided into microflora and microfauna. Microorganism secretes several enzymes such as sulfatase, phosphatase, cellulose and proteinase which are utilized for the breakdown of complex compounds.




**Soil Environment classification**

Soil conservation is the cycle of separation of soil particles from the parent body and transportation of isolates of soil molecules by wind or water. The segregating agent for soil particles is falling raindrops, flow and wind. Various factors cause soil erosion such as rainfall, type of vegetation and soil which influence erosion. High-intensity rainfall of long duration causes erosion. The impact of raindrops is absorbed by the vegetation present on the soil surface and therefore, more breakdown of soil aggregates and it depends on the type of vegetation, porosity, height, rainfall and precipitation. Soil characteristics, degree and length of the slope also determine the amount of runoff as well as the extent of erosion. The physical properties of soil like soil structure and texture influence the detachable ET as well as transportation of soil particles. Higher exchange capacity, calcium and magnesium cation exchange have favorably influence on soil structure and are less susceptible to illusion, while soils with high salt and sodium content are more susceptible which causes soil dispersion.

Soil preservation utilizes and oversees land-based capacities of the land which include the use of best practices without harming the land. There are different methods of soil protection.

- Land utilization dependent on its ability.
- Conservation of soil and keeping away from harm to soil.
- Rectification of acridity, alkalinity and seepage.

**Land Degradation**

Soil degradation is the reduction in the potential and diminished capacity of any land which is beneficial for humanity. There are various causative factors for land degradation such as:

- Improper land clearing methods,
- Soil compaction from mechanization,
- Acidification,
- Crop intensification,
- Wrong use of fertilizers,
- Salinization,
- Organic matter,
- Soil biota desertification.

**Soil Erosion**

There are numerous operators for causing soil disintegration which is wind and water. Soil is comprehensively grouped into land or common or ordinary disintegration and another is quickened disintegration.

- Geological disintegration can happen normally where is soil is changing into the residue. Soil disintegration is adjusted by the cycle of soil development.

**Soil erosion by water**

Soil erosion by water occurs in three stages, the process is called detachment, transportation and deposition. There are various types of water erosion such as splash erosion, sheet erosion, gully erosion, integral erosion and landslide. Various factors influence soil erosion by water such as climate, rainfall, soil and its characteristics, presence of vegetation, presence of crop forest, vegetation management, topography of the land, human behavior as well as land exploitation.

**Soil erosion by the wind**

In this case process of detachment, transportation and deposition of soil material by wind takes place. There are various types of soil erosion. Suspension happens when exceptionally fine earth and residue particles are lifted into the breeze which tend to be tossed to air with different particles by the wind itself.

Saltation is a process in which fine particles of 2.5 mm. in diameter are lifted from the soil surface by turbulence. Saltation is the case when the major fraction of soil is moved by the wind. In this case, all particles move in the process of saltation and can cause serious damage to the soil surface as well as vegetation. Various factors affect wind erosion such as soil moisture, height, wind turbulence, surface roughness, soil properties, vegetation and length of the exposed area.

**Methods of Soil Water Conservation**

There are two methods by which crop damage can be reduced due to drought. These methods are:

- conservation as much water as possible in the soil, and
- the second method is irrigation.

There are some agronomic practices to conserve the soil water erosion. These are the production of evaporation from the water surface, reduction of pollution from the soil surface, utilizing store water efficiency, reduction of seepage, losses from reservoirs and reduction of the percolation losses from cropland.

• In the case of a reduction of evaporation from water surfaces, covering the water surface with barriers that prevent vaporization, blocking rafting that are capable of floating and sand and rockfill dam are the ways.

• In the case of a reduction of seepage from losses from the reservoir, some of the methods are contacting the soil as well as chemical treatment of soil covers such as plastic sheet rubber.

• A reduction of evaporation from soil surface can be achieved with the help of covering it with a large amount of the water light, water retardant mulches as well as putting wind brakes or trees and fences to reduce the wind velocity.

• Percolation losses can be more in the case of a humid region where elevated agriculture is practised. These losses can be reduced by using plastic sheets and a thick layer of compost manure.

• In case of utilizing stored water efficiency, reduce the losses of water by reduction of

transpiration losses, use of windbreak, plantation of optimum seed rate and growing crops which utilize water efficiently.

**Soil Profile and Texture**

Soil development is a process caused by climate, weathering and living matter which acting upon parent material and condition which occurs over a period. There are multiple layers in the soil profile that is called Horizon with distinctive features, structure, color and properties.

• Soil surface can profoundly affect numerous properties, most significantly physical properties.

The soil surface is an after effect of the enduring cycle and physical and concoction breakdown of rocks and minerals. Because weathering is a slow process, it takes time and so soil texture remains constant and doesn't change.

• Soil colloids are the finer size fractions of the soil (clay and organic matter) which are also considered as the most chemically active portion of the soil because of their large surface area and the chemical structure of the materials involved.

• Soil structure is the arrangement as well as binding of the soil particles together in two large clusters that are called aggregate or peds.

• Soil porosity is another important soil process that takes place in the soil force, soil texture and structure that influence porosity by determining the size, number and inter-connections of pores.

Regarding the water and plant relationship, soil texture and properties like porosity affect directly the water and moment in the soil with subsequent effects on the plant growth. Chemical properties of soil include exchange capacity soil, pH, salt-affected soils, calcareous soils, etc.

The ion exchange capacity of soil- It is a measure of the ability of an insoluble material to undergo displacement of ions previously attached and loosely incorporated into its structure by oppositely charged ions present in the surrounding solution. Most chemical interactions happen in the soil in collide surfaces because they are charged surfaces. In the case of fine-textured soil, it has a great exchange capacity than the coarse because it has higher proportions of colloids.

2 types of ion exchange capacity - **a.** Anion exchange capacity (AEC) represents the positive charge available to attract anions in solution. **b.** Cation exchange capacity (CEC)

is the total capacity of a soil to hold exchangeable cations. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification. In most soils CEC > AEC.

Soil pH is a soil acidity or alkalinity. It is a measure of hydrogen ion of the soil, and affects the cation exchange and anion exchange capacities by changing the surface charges of colloids. Therefore, at high (alkaline) pH values, the hydrogen ion concentration is low. Most soils have pH values between 3.5 and 10. In higher rainfall areas the natural pH of soils typically ranges from 5 to 7, while in drier areas it is 6.5 to 9.

Salt affected area can adversely affect the function and management of the soil which include mostly in the arid and semi-arid regions where evaporation is more than the precipitation and dissolved solids are left behind to accumulate in an area where there is an elevation and changes have caused the salt to reach down and accumulate in low-lying places. There are three salt-affected soils: Saline, Sodic, and Saline sodic. Saline soils have a high amount of soluble salts such as calcium, magnesium and potassium, while in sodic soils is dominated by sodium. Saline sodic soil has both high salt and sodium.

Calcareous soil is dominated in northern great plains and has more calcium and magnesium carbonate. It affects the soil properties related to plant growth, whether they are physical such as soil-water relations and soil crusting, or chemical such as the availability of plant nutrients. Cultivation of calcareous soils presents many challenges such as low water holding capacity, high infiltration rate, poor structure, low organic matter (OM) and clay content, low CEC, loss of nutrients via leaching or deep percolation, surface crusting and cracking, high pH and loss of nitrogen (N) fertilizers. That is why it is important to consider the presence of carbonates before analyzing the soil texture as a calcareous soil both in field as well as laboratory.

The soil profile is a three-dimensional section of the soil that includes various Horizon layers. Out of all these layers, the physical, chemical and biological characteristics of soil vary. Origins of different soil-forming factors like drainage, freezing and management as well as result are in great variance in the appearance of the soil. Soil Horizons can be defined as the individual layer within the soil profile and each profile consists of at least one Horizon which can be divided as topsoil, subsoil and rock. Soil profile which can be divided into three classes according to the level of texture changes vertically down.

**To Do Activity**

1. Discuss the soil profile and texture of your location and map on the basis of soil texture.
2. What are the factors for soil erosion in your region? Find out conservation practices.

## 3. SOIL CONSERVATION PRACTICES

Such practices can be a tool for the farmers to reduce soil degradation as well as double organic matter. Several practices model for soil conservation such as crop rotation, reduced tillage, mulching, cover cropping, cross-slope farming, etc.

• Crop rotation enables farmers to increase soil's organic matter content, soil structure and rooting depth. It is accomplished by growing secondary crops that enhance soil health.

• Cover cropping and mulching are effective in reducing soil erosion by leaving a cover over the soil which reduces soil displacement associated with the impact of raindrops hitting soil particles. They also reduce the volume and velocity of runoff over the soil. Mulching consists of applying organic material over the exposed soil. Hay makes the best mulch, but it is important to ensure that it is harvested before weeds mature. Straw can also be used.

• Conservation Tillage is a field operation aimed at preserving soil aggregates, organic matter and surface residue from previous crops.

• Cross-slope farming is the practice of conducting field operations perpendicular to the field slope. It is an effective method to control large volumes of runoff that flow over a field. Other soil conservation practices can be effectively integrated with cross-slope farming.

• Buffer strips are vegetative areas that separate field boundaries from watercourses. They are effective in stabilizing stream banks with their extensive root system. They are also efficient at preventing soil and contaminants from entering watercourses by providing an area for field runoff to collect.

**Water Management and Irrigation System**

Irrigation is a process where the artificial application of water is given to the soil for crop production to supplement the rainfall and groundwater. There is importance of delegation to the plants which contains 90% water which gives turgidity which is an essential part of transportation as well as protoplasm and maintaining the balance of temperature of the plant. Crops draw water from moisture which is stored into the soil. But when the presence of water in the soil is low, the plant's requirement is met artificially. The upper limit of the optimum soil moisture range is the field capacity and the lower limit is just above the wilting point. The purpose of irrigation is to store the water in the soil between these limits.

Since the plant dries due to lack of water from evaporation and transpiration, plants start wilting during the daytime and become normal at night. This condition is called a wilting coefficient. The latter is defined as the percentage of water content of soil when the plants growing in that soil are first reduced to a wilted condition from which they cannot recover in an approximately saturated atmosphere without the addition of water to the soil. There are various methods of irrigation, i.e.,

• surface,
• subsurface and
• pressurized irrigation.

There are multiple criteria for the selection of irrigation methods as water supply sources, topography of the plot, quantity of water to be applied, kind of crop as well as the method of cultivation. Surface irrigation methods include border irrigation, check basin irrigation and furrow.

**Types of Irrigation**

There are various types of irrigation methods. The major methods are surface irrigation, sprinkler irrigation and trickle irrigation. The purpose of providing various types of irrigation methods is to apply an adequate amount of water to the crop so that water can uniformly apply all over the crops and avoiding the unnecessary wastage as well as ensuring that there is no long-term problem such as salinity or soil erosion.

For the selection of the best method of irrigation, the important to understand the crop-soil-water conditions as well as the maintenance and method used by the farmers. Technical consideration of irrigation may include soil infiltration rate, soil water holding capacity, crop, climate, cost, capital and operating cost, water supply quantity and quality, as well as labour cost.

• Surface irrigation includes basin irrigation, border irrigation and furrow irrigation. Surface irrigation is a common method of irrigation which accounts for almost 95% of irrigation in the world. Surface irrigation methods are often selected because they are simple and can be used by farmers with little or no knowledge of irrigation.

• Basin irrigation is one of the simplest and commonly used methods in surface irrigation. In this case, basins can be adopted which is suitable for most of soils and farming practices, and a wide range of crops can be grown in a small basin. Basin can be constructed primarily for flooded rice and now it is increasingly used for diversified cropping.

• Border irrigation is less popular and done where the rectangular-shaped and suitable large farms exist.

• Furrow irrigation is the most widespread method for row crops. It is practiced where the slope of the land is up to 2% in arid climate, while it is restricted to 0.3% in the humid areas because there's a lot of risk of erosion due to intensive rainfall. It may be useful to reduce the cost of irrigation and drainage, and it makes mechanization.

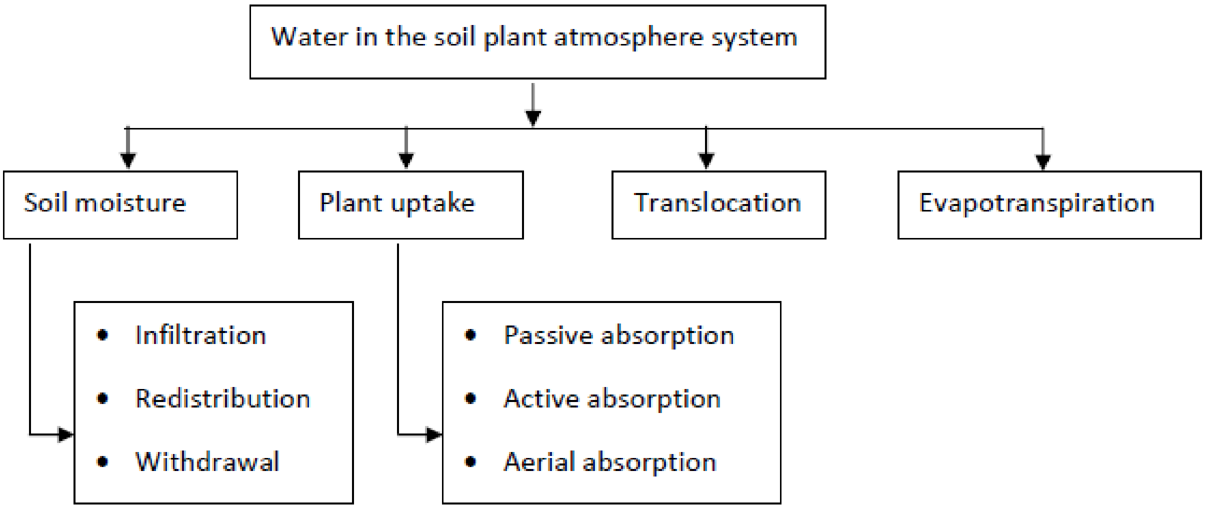
• Sprinkler irrigation is used in approximately 5% of the irrigated area. It is a method of applying irrigation water that is similar to rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air and irrigation done in the entire soil surface through spray heads so that it breaks up into small water drops that fall to the ground. Sprinkler irrigation is simple to operate requiring little water management skills. It is better for places where there are large farmers as in many developing countries.

**Irrigation Water Management**

Irrigation water management is for the prevention of excessive use of water for irrigation. The purpose is preventing aggregation-induced frozen, reduce labour, minimizing pumping cost, maintaining or improving quality of groundwater and downstream surface water as well as increased crop biomass and product quality. There are various tillage practices and crop rotations to assist irrigation in applying proper irrigation water management. The latter is the act of timing and regulating irrigation water application in a way that will satisfy water requirement of the crop without wasting water, energy and plant nutrients or degrading the soil. This involves applying water according to crop needs in amounts that can be held in the soil and at rates consistent with its intake characteristics. A primary objective is to give irrigators an understanding of conservation principles by showing them how they can judge the effectiveness of their irrigation practices, make good water management decisions and recognize the need to make adjustments in the existing systems or to install new systems. Proper irrigation water management:

- Prevents excessive use of water
- Minimizes pumping costs
- Prevents excessive soil erosion
- Reduces labour
- Maintains or improves the quality of groundwater and downstream surface water
- Increases crop biomass yield and product quality

Irrigation scheduling is a part of proper irrigation water management that involves decisions like when to irrigate and how much water to apply. Scheduling tools provide information that irrigation decision makers can use to develop irrigation strategies for each field. Such strategies may be based on long term data that represent average conditions or may be developed as the season progresses, using real time information and short-time predictions. In both cases, information about the crop, soil, climate, irrigation system, water deliveries and management objectives must be considered to tailor irrigation scheduling procedures to a specific irrigation decision-maker and field condition. An irrigation scheduling tool needs be accurate enough to make the decision when and how much to irrigate.




**Steps in water movement in the soil plant atmosphere system**

Water movement in soil includes three phases, viz., infiltration, redistribution and withdrawal. It may be downward, depending on the difference in water potential in different parts of soil below the depth of 5 to 10 cms. The vapor pressure is generally greater than that of the atmosphere in the daytime and the solar energy is absorbed by the shallow layer of soil which becomes warmer than the atmosphere.

Above and underline the soil layers water vapor moves upwards from the surface layer in the atmosphere and downward into a cooler layer where it condenses.

Evapotranspiration is a process where the evaporation happens from the surface of the soil or free water surface with the help of the diffusion process by which water in the form of vapor is transferred to the atmosphere. There are two steps involved in vapor transpiration where water is the first transfer from liquid to vapor and then the vapor is transported from the evaporating surface into the atmosphere. Transpiration is a process where water vapors leave the living plant body and enter the atmosphere in an evaporator process. There are two aspects of soil water, viz., there are amounts of water present in the unit mass or volume of soil and the energy status of water in the soil is important in plant-water relationship.

**Irrigation Scheduling**

Irrigation scheduling is the process used by irrigation system managers to determine the correct frequency and duration of watering. Water system booking is a dynamic cycle commonly in every year which includes when to inundate how much water is needed to meet every standard impact, and the amount and nature of the yield. It shows how much water in the water system is required and how frequently it should be given. Abundant water in the water system is likewise undesired since it squanders water. Below root zone excess irrigation can mean loss of fertilizer nutrients which can cause water stagnation and salinity, ultimately damaging the crop. Irrigation scheduling is important for irrigation engineers, social scientists and economists as it helps to cover more area with available quantity of water or to satisfy the whole command area from head to tail in the canal or river system. In the soil of the forest too irrigation scheduling should not be over delegated or underrated because in both the conditions it can spoil the chemical and physical equilibrium of the soil. For agronomic delegation, scheduling is important to get the use of per unit quantity of water in a normal situation as well as to protect the crop to get it as much as possible.

**Manures, Fertilizers and Nutrients Management**

Manures are the plant and animal waste. They are used as a source of plant nutrients after their decomposition which can be grouped into bulky organic manure and concentrated organic manure. The former are in the main used as manure, compost from organic waste, night soil large image or green manures, while the latter comes from the edible or non-edible oil cakes or bone meal.

Fertilizers include industrial manufacturing chemicals that contain plant nutrients. There are more nutrients in fertilizers than organic minerals and nutrients. There are three groups of fertilizers:

• straight fertilizers which supply single nutrients such as murate of potash,

• complex fertilizers supplying two or more nutrients such as NPK Complex, and

• mixed fertilizers that supply two or more nutrients such as groundnut mixture.

Fertilizers and manures have multiple roles in crop production such as:

• they bind the sandy soil and improve water holding capacity which opens the clay soil,

• they help in aeration which means a better root growth,

• organic manure helps plant nutrients to add in the soil in a small percentage which adds micronutrients which are essential for the growth of plants,

• manures increase the microbial activities in the soil,

• fertilizers supply essential nutrients to the crops which are manufactured in forms that are ready to use by plants directly and there is a rapid transformation in them.

The dose of fertilizer can be adjusted after the testing of soil that can provide a balanced application of nutrients which is required for the crop.

**Integrated Nutrient Management**

In this concept there is a judicious combination of inorganic or organic and biofertilizers required as a soil nutrient. The concept of INM includes the nutrient sources, method of irrigation, method of organic and inorganic matter, and application to maintain soil fertility and productivity of crops. Complimentary use of chemical fertilizers, organic chemicals or organic fertilizers and biofertilizers is done to ensure the nutrient supply. A thorough understanding of the effect of the previous crop is required. The contribution of legume in the cropping system is a dual effect of fertilizers and residual and cumulative effect of organic manure for supplementing and implementing the use of fertilizers and chemicals.

The balanced fertilization in the case of integrated nutrient management means it doesn't require the proportion of nitrogen, phosphorus, and potassium but it should be taken into account the availability of nutrients which is already available in the soil crops requirement. Along with the same, other factors such as the removal of nutrients, economy of fertilizers and ability of the farmer to invest through techniques of soil moisturizing, weed control, seed rate, sowing time and many more aspects have also to be considered. Therefore, this is a dynamic concept where the balanced use of fertilizers should be having certain purposes such as the correction of inherent soil nutrient deficiency, increased crops quality, increased farm income, maintenance of lasting soil fertility, avoiding damage to environment, and restoration of productivity of land.

To put balanced nutrition into the soil, one of the important tools is soil testing. In the case of balanced fertilizer rate, the difference from area to area as well as a crop to crop through soil testing will help farmers to know how much and what kind of fertilizers are required for each crop.

**Fertilizer Use Efficiency**

Various economic measures are used to increase the fertilizer use efficiency such as the best fertilizer sources using balanced fertilizer, using adequate research and diagnostic techniques, integrated nutrient management as well as utilization of residual nutrients. Best fertilizer resources are one of the fundamental requirements of better crop production where the source of fertilizer depends on the crop as well as the variation of climatic and soil conditions, etc.

There are various forms of fertilizers such as:

• for nitrogen in the form of nitrate,

• for Phosphorus water-soluble or insoluble Phosphorus is required,

• for Potassium Murate of Potash is required,

• for Sulphur, sulfate for elemental sulfur is required,

• for multi-nutrients there are MAP, DAP, SSP and Nitrophophates, and

• there are various combinations of NPK, while in the case of four or five fertilizers such as neem coated urea, zincate urea, carbonated SSP, NPKS mixture, etc., for increase of multimixer.

It is important to use an adequate rate of a recommended fertilizers with the diagnostic techniques so that it can meet the demand of crops at any point of growth. There are several diagnosing methods such as:

• The state recommended generalized fertilizer doses,
• chlorophyll meter,
• leaf color chart,
• soil test based on fertilizer recommendations,
• soil test crop response-based recommendations, and
• plant analysis for diagnosis and nutrient deficiencies.

This is important to apply a balanced fertilizer requirement that includes an adequate supply of all the essential elements with the proper method of application at the right time as well as nutrient interrelationships.

**Classification of Organic Manures**

They are divided into bulky organic manure and concentrated organic manure.

• Bulky organic manures include farmyard manure, compost, sewage and sludge.

• Concentrated organic manures include oil cake and waste of slaughterhouses.

Green manures include leguminous plants and non-leguminous plants, while green leaf manures cover

trees like neem, Gliricidia, etc.

• Farmyard manure is produced on the farm made up of excreta such as cow urine of farm animals, bedding material provided for them, and various forms of household waste. Farmyard manure is not a standardized product and its value depends on the kind of feed to the animals and the amount of straw used in storage. There is a considerable variation due to bacterial activities and a rise in temperature in manure.

• Compost is derived from the decomposed plant residue made by fermentation of waste plant material which gives output into a pit usually in a larger area which brings the plant nutrients in a more readily available form.

• In cities the human excreta are flushed out with large quantities of water called the sludge. It includes two components, one is the solid portion and another liquid which is called sewage water.

• Concentrated organic manures have a higher nutrient content than bulky organic manure. Important concentrated organic manures are oilcakes, blood and bone meal, fish manure and pressmud, etc. They are also known as organic nitrogen fertilizers.

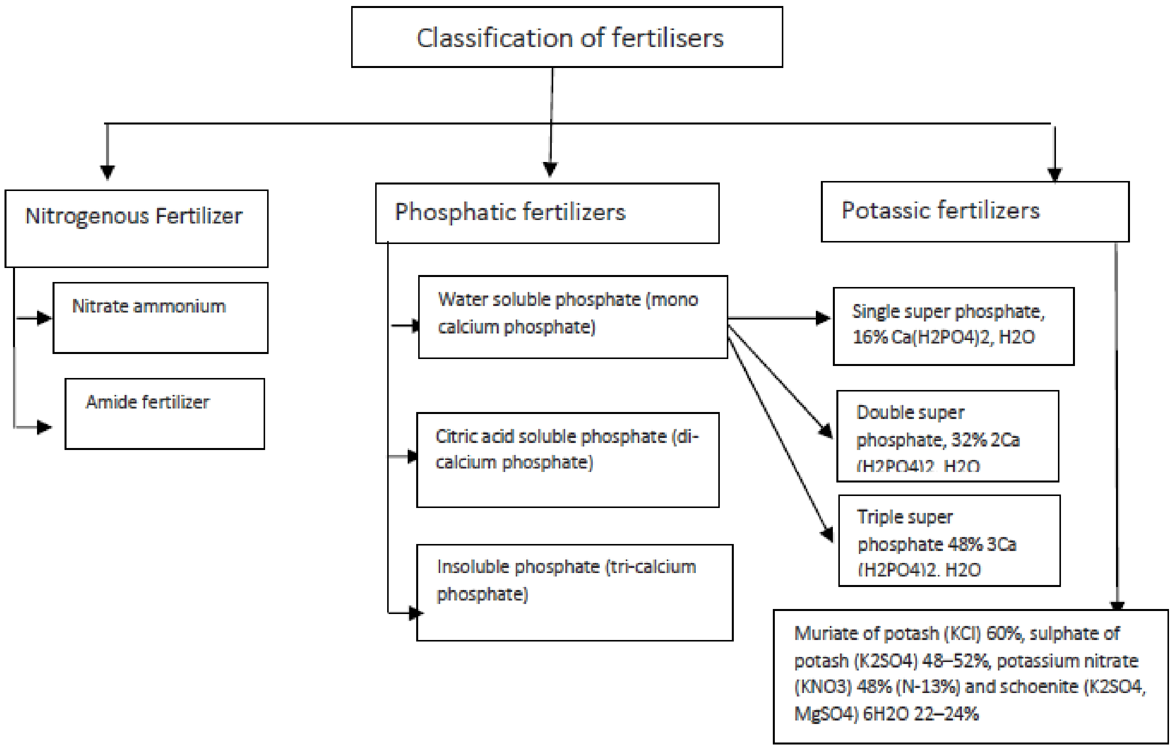
• Oil cakes, the coarse residue obtained after the oil is removed from oilseeds, are rich in protein and minerals and valuable as poultry and other animal feed. They may be broken up and sold or grounded into oil meal. Content of nitrogen varies between 3% and 9%. CN ratio is usually 32:15 for most of the oil cakes.

• Green manure is a cover crop sown on an agricultural plot to fertilize the soil. It provides an improvement in soil structure with its root system and a relatively little supply of stable organic matter. It acts as a boon for roots, preferably grown in situ and incorporated into the soil, while the green leaf manures are the incorporation of green manure into the soil and transported from elsewhere.

• Stem nodulating green manure includes leguminous green manure plants that produce root nodules and fix atmospheric nitrogen such as Sesbania rostrata that produce nodules on their stem beside root nodulation. Almost 22 tons of fresh biomass could accumulate 150 kg nitrogen per hectare and 45 days which contains 3.3 % nitrogen. Green manure adds acid in the reclamation process besides improving the fertility status of the soil. Daincha crop helps in the reclamation of saline and alkaline soils. Placing sodium on the exchange complex with a more favourable cation is helpful for the reclamation of alkali soil. Replacing exchangeable sodium is the consequence of the improvement of alkali soil.

**Classification of Fertilisers**

A fertilizer is any material of natural or synthetic origin that is applied to soil or plant tissues to supply one or more plant nutrients essential for the growth of plants. Many sources of fertilizer exist, both natural and industrially produced. Fertilizers enhance the growth of plants. This goal is met in two ways, the traditional one being additives that provide nutrients. The second mode by which some fertilizers act is to enhance the effectiveness of the soil by modifying its water retention and aeration.




**Biofertilizers**

Biofertilizers contain microbes which help in promoting the growth of plants and trees by increasing the supply of essential nutrients to them. They comprise of living organisms which include mycorrhizal fungi, blue-green algae and bacteria. Mycorrhizal fungi preferentially withdraw minerals from organic matter for the plant whereas cyanobacteria are characterized by the property of nitrogen fixation. The latter is defined as the process of converting the di-nitrogen molecules into nitrogen compounds. For instance, some bacteria convert insoluble forms of soil phosphorus into soluble forms. As a result, phosphorus is available for plants.

Rhizobium is a genus of bacteria associated with the formation of root nodules on plants. These bacteria live in symbiosis with legumes. They take in nitrogen from the atmosphere and pass it on to the plant, allowing it to grow in soil low in nitrogen. There are various types of the family of Rhizobium and it requires certain host plants, for example, microbes that live harmoniously with soybean cannot live with alfalfa. There is a certain classification of Rhizobium leguminosarum association such as Rhizobium meliloti which can live on alfalfa while Rhizobium trifolii on clover, Rhizobium leguminosarum on peas.

• Legumes can form a symbiotic relationship with nitrogen-fixing soil bacteria called rhizobia. The result of this symbiosis is to form nodules on the plant root within which the bacteria can convert atmospheric nitrogen into ammonia that can be used by the plant.

• Azolla is a unique freshwater fern that is one of the fastest-growing plants due to its symbiotic relationship with a cyanobacterium ('blue-green alga') called Anabaena. It is a floating pteridophyte that is used as a biofertilizer in the rice fields. It is incorporated into the soil before the rice plantation or planted as a dual plantation along with the rice plants. Azolla–Anabaena can fix almost three times more atmospheric nitrogen than legumes. Typical rates for legumes are 400 kg. of nitrogen per hectare per year. Those for Azolla-Anabaena are 1100 kg. of nitrogen per hectare per year. At present several Azolla species are under cultivation in India, e.g., Azolla filiculoides and Azolla rubra in cold areas of India, while A. Mexicana, A. microphylla, A. nilotica, and A. pinnata grow under tropical conditions as they are tolerant to high temperature.

• Azospirillum is known for its nitrogen-fixing and phytohormone production ability. It is one of well-studied plant growth-promoting rhizobacteria from lab to field. None of its species or strains is a human or plant pathogen. It is considered as the safest bacteria that can be used as a biofertilizer at the commercial level for several crops, especially cereals and grasses including wheat and rice. Some of its species are reported for phosphate-solubilizing ability and high salt tolerance. Azospirillum is recommended for rice millets, maize, wheat sorghum, etc., and it fixes 20-40 kg. N/hectare.

• Azotobacter- These are the microbes that are aerobic and free-living in soil, which has an important contribution to the nitrogen cycle. Azotobacter works with the atmospheric nitrogen and converts in the form of ammonium ions and released into the soil. This is the nitrogen fixation of the inaccessible form of atmospheric nitrogen. There are some biologically active substances consist phytohormones, which stimulated plant growth such as auxins, are synthesized by Azotobacter. Azotobacter helps in the bioremediation of soil from heavy metals like cadmium, mercury, and lead. Azotobacter can biodegrade 2,4,6-trichlorophenol, which is chlorine contained aromatic compound. 2, 4, 6-triclorophenol used as insecticide, herbicide, and fungicide but some mutagenic and carcinogenic effects were also found.

• Blue-green algae are photoautotrophic and prokaryotic algae. They are free-living creatures and are also known as Cyanobacteria. They fix the atmospheric nitrogen in moist soils. Blue Green Algae (BGA) find a favorable abode in the waterlogged conditions of rice fields and provide cheap nitrogen to plants, besides increasing crop yield by making the soil vital, fertile and productive. BGA biofertilizer in rice, popularly known as “Algalization”, helps in creating an environmentally safe agro-ecosystem that ensures economic viability in paddy cultivation while saving energy-intensive inputs.

• Mycorrhiza is another function that is used as a biofertilizer. It is called vesicular Arbiscular mycorrhiza. Arbuscular Mycorrhizal Fungi (AMF) constitute a group of root obligate biotrophs that exchange mutual benefits with about 80% plants. They are considered natural biofertilizers since they provide the host with water, nutrients and pathogen protection in exchange for photosynthetic products.

**Methods of Fertilizer Application**

The proper method of application of fertilization is important as fertilizers needs are different with different types of methods of application.

• Nitrogen and potash are required to apply as a broadcasting and bund placement.

• Water-soluble phosphorus fertilizer is required to apply as a bund placement in neutral and alkaline soil.

• Citrate soluble phosphorus fertilizer is applied in a broadcast method in acidic soil.

• Bisulfate forms of sulphate fertilizer are required to apply in broadcasting or band placement.

• Sulphur element is required to apply in broadcasting method.

• Certain micronutrients can be applied in small quantities as a foliar spray.

• Water-soluble fertilizers are applied with the help of fertigation.

The time of application of fertilizers also depends on the physiology of the crop. There are different types of applications of fertilizers for various crops like plain crops are applied 2 splits of fertilizers at the seeding stage and 3-5 weeks after the first dose, while in the case of flooded rice, 3 splits are important at the transplanting stage when there is a 3 and 6 week after the first dose. Considering nutrient interrelationship is important because there is certain antagonistic nature of fertilizers. Some of the fertilizer applications in excess can cause the loss of yield and quality of crops.

There are a number of essential elements required for the crop growth which are broadly classified into five categories. They are based on the relative quantity that is normally present in the plant, chemical nature, general function and mobility. Based on the relative quantity which is normally present in the plants, it is divided into three categories, viz., macronutrients, secondary nutrients and micronutrients.

• Macronutrients are the major nutrients or primary nutrients such as carbon, hydrogen, oxygen, nitrogen, phosphorus and potassium.

• Secondary nutrients are calcium, magnesium and sulphur, while micronutrients are iron, magnesium, zinc, copper, molybdenum, boron, sodium and Iodine.

Choice of the method as well as the time of application depends on the form as well as the number of fertilizers, convenience of the farmers, and efficiency and safety of fertilizer application. Fertilizers are of various forms such as solid and liquid. In the case of solid form, some methods are more established like broadcasting, while for the liquid form the common application methods include fertigation.

• In the case of the solid form of fertilizers, broadcasting is one of the important methods where manure and fertilizers are scattered uniformly in the field before planting the crop and it can be incorporated by tilling or cultivation practices.

• In the case of drilling and placement, fertilizers can be placed in the soil. It can be done by plough sole placement, deep placement and subsoil application.

• In plough sole placement method the fertilizer is applied or dropped in the plough sole which is covered by the plough during the opening of the adjacent furrow. In deep placement method the fertilizer and manure are placed at the bottom of the topsoil at a depth of 10 to 12 cm., especially in the puddle rice soil. In subsoil application the fertilizers are applied to it, especially for three crops or in the case of orchard plants at a depth above 15 cm.

• In case of location or spot application, the fertilizers are placed in the root zones or the spot which is near the roots. From the roots, fertilizers can be absorbed easily. It can be done by five methods, i.e.,

- contact of drill placement,
- band placement,
- pocket placement, м side dressing and
- pellet application.

In the case of liquid fertilizer, application on the foliage of the plant for quick recovery from the deficiency is done either from the nitrogen or the sulphur deficiency. There are three methods for the apploation of liquid fertilizer:

• Fertigation, that is, the fertilizer is dissolved in the irrigation water either in the open or closed system and it is sprinkled or trickled.

• Another method is starter solution where the solutions of a fertilizer prepared in low concentration are used for soaking seeds.

• Liquid fertilizers can be applied directly to the soil with special injecting equipment as liquid manure, urine, sewage water and cattle shed washings are directly let into the field.

**To Do Activity**

1. What are the bio-fertilisers and micro-organisms which are applied in the crops of
your region?
2. Discuss the effective methods of fertiliser application.
3. Discuss the use of organic manures/compost over the fertilisers.

## 4. AGRICULTURE IN UKRAINE DURING THE WAR

The agricultural sector was a major driver of Ukraine's economy prior to the full-scale war and will continue to be important during the reconstruction process. Although many officials and producers [1] expect production will return to pre-war levels, post-war reconstruction needs to align with Ukraine's EU accession ambitions, which will require the adoption of relevant EU requirements and regulations. Moreover, the 'build back better' principle foresees that reconstruction will address the key environmental challenges that jeopardise the sustainability of food production, such as soil degradation, water and air quality pollution, and the biodiversity and climate crises. Post-war development in the sector should be seen in the wider scope of the sustainable rural development of Ukraine and should proceed in a participatory and inclusive way. In short, recovery of the sector should be based not only on production growth goals, but also on ensuring long-term sustainability for Ukraine on its path to EU membership.

### Losses and reconstruction needs

The World Bank Rapid Damage and Needs Assessment report [2] concluded that during the first year after the full-scale invasion (February 2022 to February 2023), direct damage to assets in the agricultural sector (USD 8.7 billion) and indirect losses due to reduced production opportunities (USD 31.5 billion) totalled USD 40.2 billion. The demining costs are estimated at USD 37.6 billion. Separately, the assessment evaluates damages and losses for the irrigation and drainage sector at USD 380.5 and USD 282.5 million, respectively. As of February 2023, irrigation reconstruction costs were USD 8.9 billion. According to the assessment, the reconstruction and recovery needs for agricultural production in Ukraine are estimated to be USD 29.7 billion from 2024 to 2033, including USD 600 million in 2023, mostly for the immediate recovery of production.

The Rapid Damage and Needs Assessment has, however, limitations when it comes to calculating the long-term indirect losses to the sector, such as those arising due to issues like soil cover degradation and pollution caused by military actions. The cost of the destruction of the Kakhovka dam in June 2023 is also not included in the assessment.

### Agricultural production during the full-scale war in Ukraine

Damage and occupation of the means of production, infrastructure and logistics disruptions, rocketing prices for agrichemicals and fuels, and the lack of human resources are having tremendous impacts on the country's capacity to produce food. This is especially the case for grain production: during the spring campaign of 2022, on average 21 per cent fewer fields were sown, and 41 per cent fewer winter crop fields were sown in the autumn. Twenty-five per cent of Ukraine's vegetable production areas are under occupation. Numbers for animal products also fell, especially in regions that were or still are under occupation. After a sharp drop in March 2022, the export of animal products recovered later in the year, especially for chicken meat.[3]

In 2022, agricultural export revenues formed 52 per cent of all export revenues, compared to 41 per cent in 2021. This can be attributed to the loss of other major export products like metals, ores and machinery. In absolute numbers, the revenues from agriculture were smaller: USD 21 billion in 2022 versus USD 27 billion in 2021.[4] These imbalances in the Ukrainian food system have caused systemic consequences for supply chains both in Ukraine and globally.[5] In this context, the system, which is based on large-scale monoculture production and centralised logistics and processing, lacks resilience and is therefore extremely vulnerable to external attacks.

Following the blockade of Ukraine's ports and the European Commission's suspension of all duties on imports from Ukraine,[6] exports of agricultural products to the EU skyrocketed from 27.7 per cent in 2021 to a gigantic 55.2 per cent in 2022Local producers in Bulgaria, Hungary, Poland, Romania and Slovakia have pushed governments to enforce exceptional and temporary preventive measures on imports of wheat, maize, rapeseed and sunflower seed from Ukraine.[7] This backlash from EU farmers stems from various concerns, including production costs and environmental standards in Ukraine, which were used as arguments in favour of preventing these imports.

As Ukraine has the ambition to become a full member of the EU, international investors such as the European Bank for Reconstruction and Development (EBRD) must create stronger incentives for their clients to implement the EU's green agenda for agriculture in future investments. This will mean accelerating the integration of EU requirements into Ukraine's production, namely: Good Agricultural Practices[8] and Best Available Techniques[9] to reduce and prevent environmental pollution from the sector.

**The role of the EBRD and other international financial institutions in agricultural developments in Ukraine**

Since 1996, the European Bank for Reconstruction and Development (EBRD) has invested in over 70 agricultural projects in Ukraine,[10] helping to develop the capacity of large enterprises that have become some of the world's major producers. Since the full-scale war, another three loans have been provided to two companies: two loans of EUR 24 million[11] and 90 million to the MHP Group[12] and one loan of EUR 10 million to Slobozhanschyna Agro.[13] Totalling EUR 124 million, these investments are aimed at recovering production of grain and oil seeds for export.

The new investments provided to the EBRD's longstanding client MHP were made with limited environmental and social due diligence during martial law, and in the full knowledge that the compliance[14] of previous investments in MHP Group projects remained unresolved. Moreover, chicken meat exports from Ukraine to the EU jumped by 54 per cent immediately after the export quota was lifted in 2022. This has caused great alarm among European producers, given that a single company, MHP, is now responsible for almost all of Ukraine's chicken exports.[15]

In 2022, the EBRD also provided loans to intermediary banks under the Food Security Guarantee (FSG) and the Resilience and Livelihoods Guarantee (RLG) with the aim of providing access to financing for small and medium-sized enterprises, including farming and other agriculture-related activities.[16] In 2022, under the FSG and RLG, 10 projects were provided with a total sum of EUR 105.5 million. Another four projects are being discussed, with a total amount of EUR 112.5 million earmarked for ProCreditBank,[17] OTP,[18] KredoBank[19] and PrivatBank.[20] The common goal, according to the EBRD's Project Summary Document, is 'to finance long term capital investments of micro-, small-, and medium sized enterprises (MSME) to upgrade their technologies and equipment to EU standards, including investments in sustainable and green technologies, thereby enhancing businesses' competitiveness'.

Financial support from international financial institutions is vital to address short- and medium-term issues such as the recovery of the agricultural sector and reconstruction of its assets, the strengthening of public institutions, guaranteeing liquidity for smaller farms and banks, and more sustainable investment. Additionally, it is strategically important to develop policies and measures that address underestimated issues such as soil degradation, water infrastructure restoration and development, and sectoral weaknesses such as lack of transparency and the distortion of competition caused by the dominance of large enterprises. The EBRD, as both a financier and an active supporter of policy development, must consider these issues as Ukraine moves toward EU accession.

Priorities for the reconstruction and recovery of agriculture

The Rapid Damage and Needs Assessment lists the following mid- and long-term goals for agricultural recovery:[21] provide direct financial support to farmers by diversifying agricultural production and creating a food-energy nexus; incentivise the environmental and social sustainability of food systems in Ukraine in line with the European Green Deal; develop the capacity of institutions so that they can deliver climate-resilient recovery; and help farmers use EU pre-accession funds wisely to integrate Ukraine‘s agriculture sector into the EU system.

The New Agrarian Policy,[22] which forms part of Ukraine's Recovery Plan, sets out priority areas for recovery until 2032 along with details on anticipated financing sources. The draft document specifies the expectations for the involvement of international financial institutions in projects such as green growth for the agrifood sector, territory mapping and infrastructure development for geospatial data, and spatial planning for community territories.

Agriculture was the sector with the sharpest upward trend in the growth of greenhouse gas emissions during the last decade in Ukraine, increasing by almost 30 per cent over 10 years.[23] At the same time, the escalating effects of climate change have left agricultural production vulnerable,[24] especially in central and southern Ukraine, with higher temperatures, less water and soil moisture, and more frequent extreme weather events. The harvest volatility (unpredictability) rate for winter wheat in the steppe zone of Ukraine is among the highest in the world.[25] Given the increasing severity of these impacts, climate change mitigation and adaptation measures are urgently required.

The development of irrigation systems in southern Ukraine has been widely promoted as a necessary climate change adaptation measure. For decades, irrigation systems in the region have languished in poor condition. Since Russia's invasion in

2022, these systems have become targets of military aggression, resulting in further destruction. Most recently, the destruction of the Kakhovka dam on 6 June 2023 caused untold damage to the country's largest freshwater reservoir. Besides the immediate immense harm and transformation of the landscape, the event will have medium- and long-term consequences for the region's water supply, including irrigation. Although there has been discussion as to whether it is even possible to restore the blown-up facilities, some officials have put forth the projected cost and timeline of such a reconstruction: at least EUR 800 million and five years.[26] Economically and timewise, reasonable alternatives are needed to secure the future of these lands in the form of decentralised, climate-smart irrigation solutions.[27]

Soil degradation is another long-term consequence of the war that will shape the future of agriculture in Ukraine. Demining is an expensive and time-consuming process that will take up to 10 years to conduct. However, the chemical pollution of the soil at former mine sites will have negative consequences for agriculture, the environment and people for generations to come.[28] For these reasons, mine clearance must proceed in conjunction with extensive testing and monitoring of soil pollution. Science-based recultivation on less polluted lands and fair land conservation on the most polluted lands are also crucial – for farmers, who may otherwise lose their means of production; for local communities and consumers, who should have access to healthy food; and for the environment, whose distorted ecosystems must be restored. The involvement of civil society and local communities in assessing the severity of the pollution and planning joint clean-up efforts will be paramount, as will the selection of best practices for land recovery.[29]

Small and medium-sized farms are the backbone of rural communities. They provide workplaces, budgetary support, social security, a greater potential for achieving ecological balance, and food for settlements. Their importance was ably demonstrated during the invasion of Ukraine. Supporting and promoting the decentralisation of food systems by empowering small farmers and ensuring their cooperation is a vital element for the further sustainable reconstruction of Ukraine and the vitality of its rural areas. Therefore, efforts toward ensuring sustainable reconstruction and recovery of the agricultural sector must include support for small and medium-sized enterprises and cooperation development.

Ensuring transparency of the land market is another important consideration. Plans to postpone the second phase[30] of enrolments for land market reform until the end of martial law are currently being discussed. During 2022, the land market was still operational, with almost 42,000 land deals representing a total area of more than 77,600 hectares concluded over the year. In the first months of 2023, another 13,000 agreements representing a total area of 26,000 hectares were concluded.[31] But evaluating the efficiency of land concentration control by the State Service of Ukraine for Geodesy, Cartography and Cadastre, also known as the State Geocadaster,[32] is a difficult task. The State Geocadaster collects, summarises and analyses information on land deals and acts as the central body responsible for overseeing and administering the concentration of agricultural land. However, due to martial law, the access of civil society to information on land is limited, which in turn restricts independent monitoring of land concentration, planning and decision-making. Therefore, it is crucial to ensure effective control and transparency of data in the second phase of the land market reform, which will begin in 2024. This is particularly important for the recovery of the agricultural sector.

Recommendations

Investments must be used strategically, not only to help reach pre-war levels of production, but also to achieve a deeper qualitative transformation of a sector that has ambitions to become an equal part of the EU family. EU institutions, public investors and civil society must come together to explore ways of rebuilding and reorienting the country's farming system. Putting small farmers, transparency and sustainability at the heart of these efforts should be at the top of any agenda. Decarbonised and decentralised production that can adapt to climate change would be less vulnerable and more resilient, both for Ukraine and for global food security.

As an investor in the agricultural sector, the EBRD should:

- Prepare its Ukrainian clients for further implementation of the EU's ambitious Green Deal and Farm to Fork strategies as a means of achieving carbon-neutral, socially fair, environmentally friendly and healthy production;
- Ensure the viability of small and medium-sized farmers and help them cooperate across diverse and decentralised agrifood systems designed to benefit the revival and development of rural areas;
- Increase the transparency of the roles of financial intermediaries.

To prioritise and coordinate policy developments, donors must:

- Accelerate the integration of EU requirements in Ukraine's production, namely: Good Agricultural Practices and Best Available Techniques to reduce and prevent environmental pollution from the sector;
- Reduce greenhouse gas emissions and adapt to the ongoing climate crisis, help to develop resilient agrifood systems and enhance ecosystem services in rural areas;
- Develop sustainable alternatives to large-scale irrigation projects, such as through soil moisture retention measures to protect and restore nature, nexus projects combining irrigation and nutrient needs with the development of wastewater treatment facilities in communities, and other climate-smart technologies for irrigation;
- Incorporate restoration measures for damaged land into the agricultural revival of de-occupied territories in Ukraine by comprehensively assessing soil contamination and conservation in the most polluted areas;
- Give the public access to information on the land market, including on efficient control and prevention of land concentration risks and extend favourable conditions to small and medium-sized enterprises for the purchase of land as a basic requirement for their sustainable development.

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ІНОЗЕМНА МОВА

Методичні вказівки до практичних занять для здобувачів освіти першого (бакалаврського) рівня, спеціальність 201 “Агрономія” – ЦНТУ, 2023, – 30 с.