Plant Science

Principle of Agronomy

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Ministry of Education, Science and Technology
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Grade 9

Technical and Vocational Stream
Learning Resource Material

Principle of Agronomy

(Grade 9)

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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for Plant Science has been developed in line with the Secondary Level Plant Science Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students and parents.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Pro.Dr. Kaniya Prasad Singh, Pro.Dr. Gyan Kumar Shrestha, Dr. Kishorchandra Dahal, Anita Bolakhe is highly acknowledged. The learning resource material is written by Rikhiram Neupane, Santosh Koirala, Niraj Belbase, Purnima Paudel, Mahesh Poudel, Dayamond Pokharel the subject matter of the materials, was edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala and language was edited by Mr. Binod Raj Bhatta. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes constructive feedback for the betterment of the material.

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Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows

or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a

given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

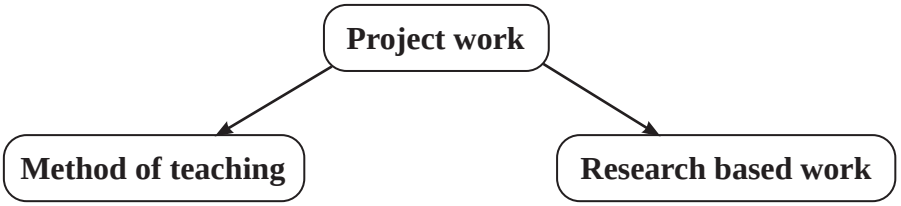
Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions.

Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other

multimedia resources that bring concepts to life and cater to auditory and visual learners.

- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.

Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.

Homework exercises: Assign tasks that provide ongoing feedback on individual progress.

Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.

Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.

Peer feedback forms: Provide structured forms for students to assess their peers.

Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.
True/False questions: Assess factual understanding with true/false questions.

Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.

Reflection statements: Ask students to write reflective statements about their work.

Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.

Performance observations: Assess practical skills through direct observation.

Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Introduction to Agronomy

Unit 1

1.1. Definition of Agriculture and Agronomy

Introduction

Nepal is an agriculture-basesd country. It is the backbone of Nepalese economy Agriculture helps to meet the basic need of humans and their civilization by providing food, cloth, shelter, medicine and recreation. Approximately 57.3% of Nepalese population depends upon agriculture (MoALD,2080/81).

Agriculture

The word agriculture comes from the Latin words ‘ager’ meaning ‘soil’ and ‘cultura’ meaning ‘cultivation’. It is a very broad term, encompassing all aspects of crop production, livestock farming, fisheries,forestry, poultry, mushroom production etc.

Agronomy

The term is derived from Greek words ‘agros’ meaning "field" and ‘nomos’, meaning ‘to manage’. Agronomy is a branch of agricultural science which deals with principles and practices of field crop production.

It can also be defined as the branch of agricultural science that deals with the methods which provide favorable environment to the for higher productivity.

1.2. Definition of Subsistence Agriculture, Commercial Agriculture

a. Subsistence Agriculture

Subsistence agriculture is defined as the type of agriculture which is concerned with the production of food by a farmer to feed themselves and their families. In other word, subsistence agriculture is a self-sufficiency farming system in which

the farmers focus on growing enough food to feed themselves and their entire families.

Advantages of Subsistence Agriculture

1. Provision of basic needs of the family like food and clothing
2. Small plot of land can be used to cultivate such as the backyard garden.
3. Little or low capital is required to carry out subsistence farming.
4. It helps keep local farming techniques, seed varieties and cultural practices alive

Disadvantages or Problems of Subsistence Agriculture

1. Low economic return is obtained from Subsistence Agriculture.
2. Many subsistence farmers lack formal training or knowledge of sustainable practices.
3. Family labor supply is unreliable because they are not paid for job done.
4. Local tools are used such as sickle, spade, hoe, rake and so on.
5. Subsistence farmers often receive little to no support from governments or NGOs.
6. Subsistence farmers rely heavily on natural weather conditions.

Commercial Agriculture

Commercial agriculture is defined as the type of agriculture which is concerned with the production of food, rearing of animals and cash crops in large quantities for sale. Commercial agriculture is generally associated with intensive farming and large production which is only done to sell and earn profit. It is carried out in large scale and mostly involves mechanized and smart farming.

Advantages of Commercial Agriculture

1. It increases yield and economic return of crops.
2. Specialization of labor is practiced because large area of farmland needs to be cultivated.

3. There is always encouragement of research work such as pest control and use of new seedlings.
4. Provision of cheap products because enough supplies are sent to the market for sale.
5. Commercial agriculture generate higher economic return then subsistence agriculture.
6. Commercial agriculture contribute in food security of the country and the globe.

Disadvantages of Commercial Agriculture

1. It is very expensive than subsistence agriculture.
2. It may increase environmental disbalance and pollution, if not done in sustainable way.
3. Over use of chemicals and heavy machineary during commercial agriculture causes land degradation.
4. Outbreak of pests and diseases.

Difference between Subsistence and Commercial Agriculture

SN	Subsistence Agriculture	Commercial Agriculture
1	Cultivation is done in small area.	Cultivation is done in large area of land is cultivated.
2	Production is mainly for family consumption	Production is mainly for economie return.
3	Crude tools and implements are used.	Complex and modern tools and implements are used.
4	Family/manual labour is usually Employed.	Paid/skilled labour is usually employed.
5	Yield or returns are low.	Yield or returns are high .
6	Pest and diseases are not controlled.	Pest and diseases are usually controlled .

1.3. Importance of Agronomy and its Role in Nepalese Context

Importance of Agronomy in Nepal

Agronomy is a synthesis of several branches like crop science, which includes plant breeding, crop physiology, Bio-chemistry and soil science, which includes soil fertilizer, manures, environmental science, metrology and crop ecology. Among all the branches of agriculture, agronomy occupies vital position and is called mother branch or primary branch. So agronomy is an important sector of agricultural science. The importance of agronomy can be described under following headings.

i. Source of Food

Agronomical crops play a vital role in food supply in Nepal. Majority of Nepalese farmers adopted the food crops for supplement of food material for daily requirement.

Agronomical crops include major food crops such as rice, wheat, maize, barley, finger millet, potato etc. Similarly larger amount of agronomical crops are also used as a source of food for animals.

ii. Source of Raw Materials

Agronomical crops are the major source of raw material for agro-based industries. A number of larger industries in the country depend upon the raw materials produced from agronomical crops. Examples: sugarcane for sugar industry, tobacco leaf for tobacco industry, paddy for rice mill etc.

iii. Employment Opportunities

Agronomy is the primary source of employment opportunities. Agronomical crops demand more labour for care in each and every aspect of cultivation, right from site selection to harvesting, processing, marketing and storage. All such factors create a great employment opportunity for the working people.

iv. Nutritional Supply

Agronomical crops are the major source food to the human being as well as animals which supply lots of nutrients including carbohydrate, protein, fat, lipids, vitamins, minerals nutrient etc. Cereals such as rice, maize, wheat, finger millet etc are good sources of carbohydrate.

Legumes crops such as lentil, chickpea, pigeon pea, etc are good sources of protein. Oilseed crops such as rapeseed, sunflower, mustard, groundnut, etc are good sources of fat and lipids as well many other agronomical crops are rich sources of mineral nutrients.

v. Food Security

Agronomy is essential for achieving stable,sustainable, and sufficient food systems for growing population. Food security prevents malnourishment that has traditionally been believed to be one of the major problems faced by the developing countries.

Agronomical crops play a vital role in food security by supplying a larger amount of food material because majority of Nepalese people can easily produce the food crops to ensure the food security in rural as well as urban areas.

Role of Agronomy in Nepal

Agronomy is the science that teaches us how to grow crops in the best way using proper techniques and tools. It plays a big role in improving Nepal's agriculture and helping farmers become more productive and self-reliant.

i. Helps in proper crop management

Agronomy teaches farmers how to grow crops properly. It guides them on when to plant, how to water, what fertilizers to use, and when to harvest. This helps farmers grow more crops in a better way.

ii. Increases crop production

By using good seeds, proper spacing, irrigation, and weeding, farmers can get higher yields.This helps in increasing food supply in Nepal.

iii. Supports food security

When farmers grow more food, people will not go hungry. Agronomy helps in producing enough food for the growing population.

iv. Encourages sustainable farming

Agronomy promotes eco-friendly methods like organic farming, use of compost, and crop rotation. This protects the soil, water, and environment for the future.

v. Supports income generation

Better farming methods increase crop yield. When farmers sell extra crops in the market, they earn more money and improve their living standard.

1.4. Agronomical Classification of Field Crops

Agronomical crops can be classified based on different aspects such as botany, climatic requirement, growing season, uses, photoperiod and soil requirement.

i. Classification Based on Botany

According to the botanical classification agronomical crops can be classified as:

Kingdom: Plantae

Division: Tracheophyta

Sub-division: Pteropsida

Class: Angiospermae

Sub-class: Monocotyledon

Order: Graminales

Family: Poaceae/Graminae

Genus: *Oryza*

Species: *sativa*

Cultivars: Radha-12

ii. Classification Based on Climatic Requirement

a) Tropical crops : The crops which is grown in warm climates with hot temperatures and abundant rainfall. Examples: Rice, sugarcane, Jowar, etc.

b) Sub- tropical crops : The crops which is grown in moderate temperatures between tropical and temperate zones. Examples: Maize, Finger millet, Lentil, etc.

c) Temperate crops : The crops which is grown in cooler climate with distinct winter and summer seasons. Examples: Wheat, Oats, Gram, Potato, etc.

iii. Classification Based on Growing Season

a) Rainy Season Crop : All rainy season crops which are mostly grown in jun-july to September-october are known as rainy season crops. Examples: rice, maize, soyabean, etc.

b) Winter Season Crop : Winter season crops which are grown in October-November to January- February are known as winter season crops. Examples: wheat, barley, mustard, etc.

c) Summer Season Crops : Summer season crops which are grown in February-March to may to June are known as summer season crops. Exemple: black gram, cowpea, sesame, etc.

iv. Classification Based on Uses

a) Cereals Crops : Grain crops may be cereals as millets cereals are the cultivated grasses grown for their edible starchy grains. Examples: rice, maize, wheat, barley, and millets, etc.

b) Pulse/legume crops : Seeds of leguminous crops plant used as food.

On splitting they produced dal which is rich in protein. Examples: green gram, black gram, soybean, pea, cowpea, etc.

c) **Oil seeds crops :** Crop seeds are rich in fatty acids, are used to extract vegetable oil to meet various requirements. Examples: Groundnut, Mustard, Sunflower, Sesamum, linseed, etc.

d) **Forage Crop :** It refers to vegetative matter fresh as preserved utilized as food for animals. Crop cultivated & used for fickler, hay, silage. Eg- sorghum, elephant grass, guinea grass, Berseem & other pulse bajara, etc.

e) **Fiber crops :** Grown for fiber yield. Fiber may be obtained from seed. Examples: Cotton, steam, jute, sun hemp, flax, etc.

f) **Sugar crops :** The two important crops are sugarcane and sugar beet cultivated for production of sugar. Examples: Sugarcane, Sugar beet, etc.

iv) Classification Based on Photoperiod

Most plants are influenced by relative length of the day & night, especially for floral initiation, the effect on plant is known as photoperiodism depending on the length of photoperiod required for floral ignition, plants are classified as:

a) **Short-day plants :** Those plants that require short day length (less than ten hours) for flower initiation are called as short day plants. Examples: rice, Jowar, green gram, black gram, etc.

b) **Long day plants :** Those plants that require long day length for flower initiation are called as long day plants. Examples: Wheat, Barley, etc.

c) **Day neutral plants :** Those plants that does not have much influence of day length for flower initiation and growth are called as day netural plants. Examples: Cotton, sunflower, etc

1.5 List of Common Agronomical Crops with Their Common Name, Scientific Name, Nepali Name and Family

a) Cereal Crops

S.N	Common Name	Nepali Name	Scientific Name	Family
1	Rice	धान	*Oryza sativa*	Poaceae
2	Maize	मकै	*Zea mays*	Poaceae
3	Wheat	गहुँ	*Triticum aestivum*	Poaceae
4	Barley	जौं	*Hordeum vulgare*	Poaceae
5	Buckwheat	फापर	*Fagopyrum esculentum*	Polygonacea
6	Finger-millet	कोदो	*Eleusine coracana*	Poaceae
7	Sorghum	जुनेलो	*Sorghum bicolor*	Poaceae

b) Oilseed crops

S.N	Common Name	Nepali Name	Scientific Name	Family
1	Mustard	रायो	*Brassica juncea*	Cruciferae
2	Rapeseed	तोरी	*Brassica compestris*	Cruciferae
3	Groundnut	बदाम	*Arachis hypogaea*	Fabaceae
4	Sunflower	सूर्यमुखी	*Helianthus annuus*	Compositae
5	Safflower	कुसुमको फुल	*Carthamus tinctorius*	Compositae
6	Sesamum	तिल	*Sesamum indicum*	Pedaliacea
7	Linseed	आलस	*Linum usitatissium*	Linaceae
8	Niger	फिलुङ्गे	*Guizotia abyssinica*	Compositae

c) Legumes Crops/pulses crops

S.N	Common Name	Nepali Name	Scientific Name	Family
1	Lentil	मुसुरो दाल	*Lens culinaris*	Fabaceae
2	Soyabean	भटमास	*Glycine max*	Fabaceae
3	Chickpea	चना	*Cicer arietinum*	Fabaceae
4	Pigeon pea	रहर दाल	*Cajanus cajan*	Fabaceae
5	Green-gram	मुङ् दाल	*Vigna radiate*	Fabaceae
6	Blackgram	कालो दाल	*Vigna mungo*	Fabaceae
7	Cowpea	बोडी	*Vigna unguiculata*	Fabaceae
8	Pea	केराउ	*Pisum sativum*	Fabaceae

d) Industrial Crops

S.N	Common Name	Nepali Name	Scientific Name	Family
1	Sugarcane	उखु	*Saccharum officinarum*	Poaceae
2	Cotton	कपास	*Gossypium herbaceum*	Malvaceae
3	Jute	सनपात	*Corchorus sp*	Tiliaceae
4	Tobacco	सुर्ती	*Nicotiana tabacum*	Solanaceae

Exercise

Choose the correct answer from the given alternatives.

1. The term of Agriculture is derived from.....
   a. Greek b. Nepal
   c. India d. Latin

2. The study of field crops production is called…
   a. Agronomy b. Horticulture
   c. soil science d. Plant protection

3. Growing of small scale of crops is called as.....
   a. Subsistence agriculture b. Commercial agriculture
   c. Crop rotation d. A and B both

4. Which is the example of tropical crops?
   a. Rice b. Buck-wheat
   c. Millet d. Lentil

5. Which crop grows in well and moderated climate?
   a. Wheat b. Jute
   c. Rice d. Sugarcane

6. An example of cereal crop is.....
   a. Mustard b. Gram
   c. Buckwheat d. All of these

Write short answer to the following questions.

1. What do you mean by agriculture?
2. Define agronomy.
3. Enlist the advantages and disadvantages of subsistence agriculture.

4. Classify the crops based on climate.
5. Write down the difference between subsistence and commercial agriculture.
6. Classify the agronomical crops based on soil requirement.

Write long answer to the following questions.

1. Explain the importance of agronomy in Nepal.
2. Define commercial agriculture. Enlist the advantages and disadvantages of commercial agriculture.
3. Classify the crop based on uses.

Project Work

1. Identify plants and seeds of common agronomic crop.
2. Diffrentation of healthy and diseased/pest attack seeds.
3. Collect the different agronomical seeds available in your locality.

Climate and Ecozones

Unit 2

2.1 Definition of Climate and Weather

Definition of Weather and Climate

Weather

Weather can be defined as the conditions in the atmosphere at a given place and at a given time. It is the short term occurrence, or daily measurement, of the fair or inclement weather. It refers to state of atmosphere over an area at any point of time. It is the total of weather conditions for limited area. Weather pertains to smaller area like village, city or even a district and smaller duration of time, i.e. part of the day or complete day and is expressed by numerical values of meteorological parameters.

Climate

Climate can be defined as the long-term weather patterns over a specified time frame for a specific area. Climate is weather conditions related to larger areas like zone, regions, country, part of continent or whole of continent and longer duration of time like month, season or year and best described as normal and average. Climate can be cold season, tropical climate or sub-tropical climate, temperate climate.

Meteorology

Meteorology is the science that deals with laws and principles as they apply to atmospheric phenomenon. It is the science of atmosphere and its attendant activities. Meteorology is also defined as a branch of physics that deals with physical process in the atmosphere that produces weather.

Agriculture Meteorology

Agriculture meteorology is the branch of applied meteorology which deals with the response of crops to the physical environment. It is the study of physical process of the atmosphere that produces weather in relation to agricultural production, and also deals with agro climatology, instrumentation and weather forecasting.

2.2. Types of Climatic Season

Nepal's climate varies with its topography. It ranges from tropical to arctic depending upon the altitude. The Terai region, which lies in the tropical southern part of the country, for instance, has a hot, humid climate. The mid-land regions are pleasant almost all year around, although winter morning and nights are cool. The northern mountain region, around an altitude above 3,353 meters has an alpine climate with a considerably lower temperature and thin air in winter as can be expected.

Nepal has four climatic seasons

i. **Spring:** March- May (Falgun- Baishak)

ii. **Summer:** June- August (Jestha- Shrawan)

iii. **Autumn:** September- November (Bhadra- Kartik)

iv. **Winter:** December- February (Mangsir- Magh)

2.3. Classification of Different Climatic Zones

Nepal's elevations ranging from less than 100 meters to over 8,000 meters and precipitation from 160 millimeters to over 5,000 millimeters the country has five climate zones from tropical to alpine zone.

1. Tropical Zone

The tropical zone lise below 750 meters above sea level (masl). The outer Terai is virtually all in the lower tropical zone. Inner Terai valleys span both tropical zones. Main crops for example rice, wheat, lentil, mustard, maize, etc. are grown successfully in this zone.

2. Sub-tropical Zone

The sub-tropical zone lise from 750 to 1500 masl. It has the most prevalent climate of the middle Hills above river valleys. Crops include rice, maize, millet, wheat, potato, and citrus.

3. Temperate Zone

The temperate zone lise from 1500 to 2100 masl. It is encountered in higher parts of the middle hills and throughout much of the mountain region.Crops include cold-tolerant rice, maize, wheat, barley, potato, apple, walnut, buckwheat, fingermillet etc.

4. Sub alpine Zone

The sub alpine zone lise from 2100 to 3,000 masl, mainly in the mountain and, Himalayan regions. It is only seasonally occupied as pasture for sheep, goats, yak and hybrid in warmer month. Crops include barley, potato, cabbage, cauliflower, buckwheat and apple. Similarly, medicinal plants are gathered.

5. Alpine Zone

The alpine zone lise from 3,000 to 4,000 masl. There are a few permanent settlements above 4,000 meters. There is virtually no plant cultivation although medicinal herbs are gathered. Sheep, goat, yaks and hybrids are pastured in warmer months.

Above 5000 meters the climate becomes nival and there is no human habitation or even seasonal use.

2.4. Effect of Climatic Factor on Crop Production

Climate is the most important dominating factor influencing the suitability of a crop to a particular region. The yield potential of the crop mainly depends on climate. More than 50 per cent of variation of crops is determined by climate. The most important climatic factors that influence growth, development and yield of crops are solar radiation, temperature and rainfall.

1. Temperature

The degree of hotness or coldness of a substance is called temperature. It is commonly expressed in degree celsius or degree Fahrenheit. This climate factor influences all plant growth, processes such as photosynthesis, respiration, transpiration, breaking of seed dormancy, seed germination, protein synthesis and translocation. At high temperatures the translocation of photosynthetic is faster so that plants tend to mature earlier.

In general, plant survive within a temperature range of 0-50° C. The favorable or optimal day and night temperature ranges for plant growth and maximum yields vary among crop species. Enzyme activity and the rate of most chemical reaction generally increase with rising temperature. Upto a certain point, there is doubling of enzymatic reaction with every 10°C temperature increase. But at excessively high temperature, denaturation of enzymes and other protein occurs.

Excessively low temperature can also cause limiting effects on plant growth and development.

2. Solar Radiation

It is the amount of radiation received directly from the sun. The radiation scattered by suspended particles is called diffused radiation. Solar radiation is a climatic factor that is essential in production of chlorophyll and in photosynthesis. It is the process by which plants manufacture food in the form of sugar. Other plant processes that are enhanced or inhibited by this climatic factor include stomatal movement, photo tropism, translocation, absorption and abscission. Three properties of this climatic factor that affect plant growth and development are light quality, light intensity and photoperiods.

3. Rainfall/Precipitation

The falling of any type of condensed moisture to the ground is called precipitation. Rainfall is precipitation in the form of liquid drops falling on the earth that are larger than 0.5 mm. Effects of precipitation or rainfall are most important among

the elements of weather and climate.

Proper moisture is essential for seed germination. Different crops have different moisture requirement for germination and complete lifecycle. Mustard requires less water absorption than jute requires Mustard requires less water absorption and jute requires more rainfall to grow. Chilli and Potato seed damages with higher rainfall.

4. Relative Humidity (RH)

The amount of water vapor that the air can hold depends on its temperature; warm air has the capacity to hold more water vapor than cold air. Relative humidity is the amount of water vapour in the air, expressed in percent. The relative humidity affects the opening and closing of the stomata which regulates loss of water from the plant through transpiration as well as photosynthesis.. . About 70-80% relative humidity is considered ideal for crop production.

$$\text{Relative humidity (RH)} = \frac{\text{Water vapour in the air}}{\text{Water vapor required for saturation}} \times 100$$

Effect of Relative Humidity on Plant

- High relative humidity reduces the saturation deficit in plants.
- High humidity increases the growth of shoots and leaves.
- It suppresses the formation of fruit and bulbs.
- Low humidity accelerates evapo- transpiration.
- It interrupts photosynthesis in plants. In extreme saturation, deficit physiological drought and killing of plants may occur.
- High relative humidity favors the growth of many fungi and other pests to the crops.

5) Wind

It is a horizontal flow or movement of air. Wind is air in horizontal motion in response to pressure gradient (rate of pressure changes with distance) in atmosphere. Wind regime influence evaporative demand to a great extent. The stronger the wind, the greater will be the crop water requirements.

Effects of Wind

Natural effects of wind can be measured as logging and breakage of plants, shattering of grains, flower drops and uprooting in cereals and other fragile crops, transport the cold and heat waves and clouds, cold waves abruptly decrease in the temperature by 4˚c and heat waves abruptly increase in temperature by 4˚c. Some of other effect causes by the wind are:

- Wind acts as vector for transportation of diseases, pests and pollutants Examples: rust and locust.
- Wind adversely affects the rate of evapo-transpiration.
- Wind helps the pollination and water uptake and metabolism in plants and to some extent regulates the temperature of plant canopy.

2.5. Introduction to Climate Change and Global Warming

Climate change is a phenomenon due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization (Upreti, 1999) resulting variations in solar energy, temperature and precipitation. It is a real threat to the lives in the world that largely affects water resources, agriculture, coastal regions, freshwater habitats, vegetation and forests, snow cover and melting and geological processes such as landslide, desertification and floods, and has long-term effects on food security as well as in human health.

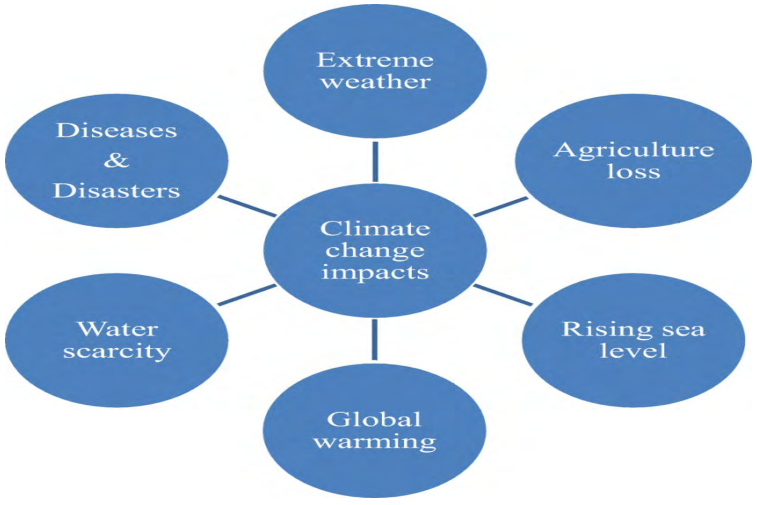


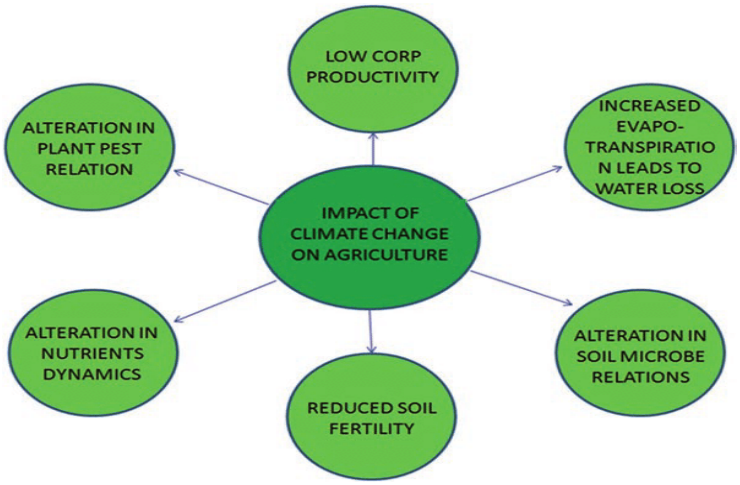
Fig: Common Impacts of climate change on the environment.

Global Warming

Global warming also referred to as climate change, is the observed century-sale rise in the average temperature of the Earth's climate system and its related effects.

- Global warming is defined as the increase in the earth's temperature due to the use of fossil fuels and other industrial processes leading to a build up greenhouse gases in the atmosphere.
- These gases include carbon dioxide, methane, nitrous oxide and chlorofluorocarbon.(Source- Slideshare ppt Global warming)

Figure- Global warming (Source-Earth jan 20, 20



Impact of climate change

(Source- Researchgate 2017)

Exercises

Choose the correct answer from the given alternatives.

1. Long term weather patterns called…

   a. Climate b. Weather

   c. Rainfall d. Humidity

2. The conditions in the atmosphere that are happening right now is called…

   a. Climate b. Weather

   c. Rainfall d. Humidity

3. Nepal has……..climatic season.

   a. 3 b. 4

   c. 5 d. 6

4. Short term weather patterns called…

   a. Climate b. Weather

   c. Rainfall d. Humidity

5. The sub-tropical zone lies from …..

   a. 1,000 to 2,000 meter b. 2,000 to 3,000 meter

   c. 1500 to 2000 meter d. None of the above

Write short answer to the following questions.

1. Define Agro-metrology.
2. What do you mean by photoperiodic effect on plant growth and development?
3. Write in brief about the effect of wind on crop production.
4. What do you mean by weather?

Write long answer to the following questions.

1. Define weather and climate. What are the differences between weather and climate?
2. Briefly explain about the different climatic zones in Nepal.
3. Write down the effects of climate on crop production.

Project Work

1. List the different agronomical crops cultivated in different climatic zones

Unit 3

Fundamental of Soil

3.1. Definition of Soil

Soil termed is derived from the Latin word Solum which means floor. Soil is the unconsolidated/loose surface materials of the earth having organic and inorganic matters that provides support to the plant, supply nutrient, water and air for their growth and has microorganisms that recycle minerals for the life. They are the dynamic natural bodies having properties derived from the combined effect of the climate and organisms on parent material over a period of time as conditioned by relief.

Uses of Soil

Soils have more uses in all living beings directly or indirectly in the earth. All living beings of the earth use soil for their shelter, food and other requirements. In agriculture, it provides support to the plant, provides nutrient to grow and provides favorable conditions to survive and reproduce. It is the source of plant nutrients. All the living beings having habitat in soil are part of the earth ecosystem and they are balancing the system and make system as one unit.

Components of Soil

Soil is composed of partly weathered, un-weathered, transformed products of rocks, rock minerals and organic matter. The mineral soil consists of four major components/phases: mineral material and organic matter (solid), water (liquid) and air (gases). The volume composition of good condition soil are 25% air, 25% water, 45% minerals and 5% Organic matter.

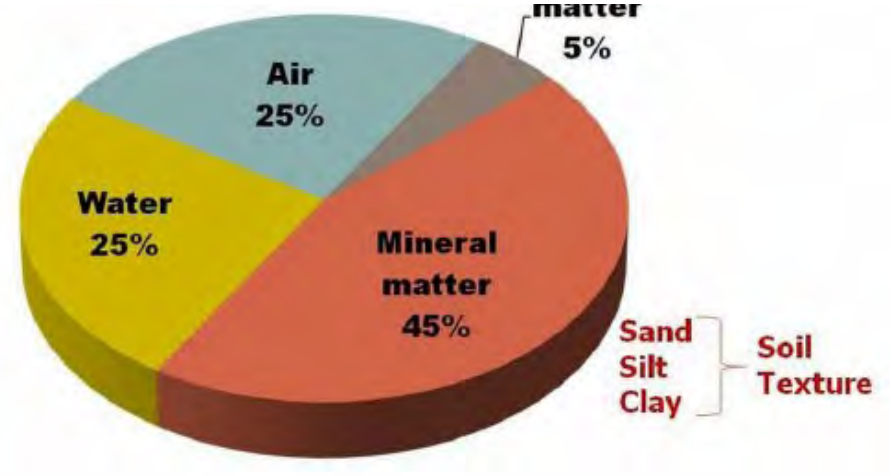


Fig- Component of soil (Source- Researchgate)

3.2. Properties of Soil

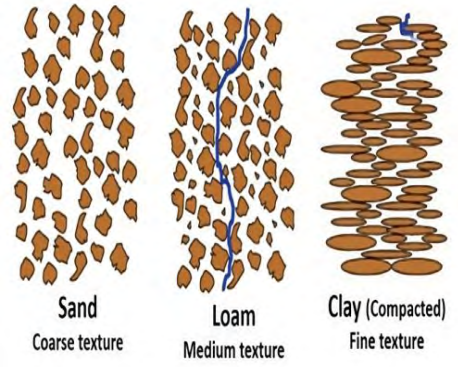
1) Physical Properties of Soil

The physical properties of a soil plays an important role in determining its suitability for crop production. These properties depend on the amount, size, shape, arrangement and mineral composition of its particles. These properties also depend on organic matter content and pore spaces. Some important physical properties of soils are soil texture, structure, density, porosity, colour, consistence and soil water.

a) Soil Texture

Soil texture is determined by the relative proportions of sand, silt, and clay in the soil. Three size classes are particularly important:

1. Sand (Largest particles, 0.05 mm to 2 mm in diameter)
2. Silt (Medium-sized particles, 0.002 mm to 0.05 mm in diameter.)
3. Clay (Smallest particles, less than 0.002 mm in diameter.)



b) Soil Structure

The term soil structure refers to the arrangement of primary and secondary particles into a certain structural pattern. The primary particles are sand, silt and clay whereas the secondary particles are the cluster of the primary particles which are called aggregates and peds. They are as follows: Structure less which includes Single grain and Massive; with structure which includes Granular, Platy, Wedge, Blocky, Prismatic, and Columnar; and Structure Destroyed which includes Puddle.

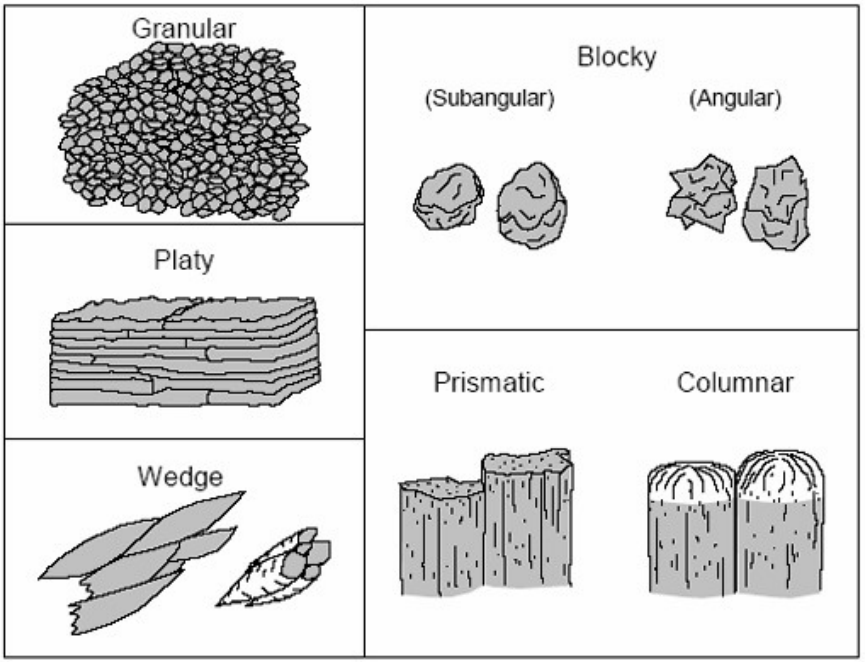


Fig.: Examples of soil structure

Bulk Density

Bulk density refers to the weight of the oven-dry soil with its natural structural arrangement. The pore space is a part of the volume of soil measured for bulk density. Bulk density is determined by dividing the weight of oven-dry soil in grams by its volume in cubic centimeters. The variation in bulk density is due largely to the difference in total pore space. Because finer textured soils have higher percentages of total pore space, it follows that finer textured soils have smaller bulk density values. Obviously then, compacted soils have lower percentages of total pore space and therefore, higher bulk densities. High and low bulk densities have great influences on engineering properties, water movement, rooting depth of plants, and many other physical limitations for soil interpretations.

$$\text{Bulk Density} = \frac{\text{Mass of dry soil}}{\text{Bulk volume of soil}}$$

Bulk Volume = Volume of solid soil + Volume of pore space

Soil Porosity

The pore space of a soil is defined as the portion of the soil volume occupied by air and water. It refers to the percentage of soil volume occupied by pore spaces. Pore-spaces directly control the amount of water and air in the soil and indirectly influence the plant growth and crop production. Size of individual pores, rather than total pore space in a soil, is more significant in its plant growth relationship. In general there are broadly two types of pores in soil.

1. Macro Pores

The diameter of these pores is larger than 0.06 mm. Macro-pores allow air and water movement readily. Sands and sandy soils have a large number of macro pores.

2. Micro or Capillary Pores

The diameter of these pores is less than 0.06 mm. The movement of air and water is restricted to some extent in micro or capillary pores. Clays and clayey soils

have a greater number of micro or capillary pores. It has got more importance in the plant growth relationship. For optimum growth of the plant, the existence of approximately equal amount of macro and micro-pores which influence aeration, permeability, drainage and water retention favorably is essential.

Soil Color

Color of soil is an important feature in recognizing different soil types, but color is also an indicator of certain physical and chemical characteristics. Color in soils is due primarily to two factors, humus content and the chemical nature of the iron compounds present in the soil. Humus has a dark brown, almost black, color. The colour of the soil is a result of the light reflected from the soil. Soil colour is an easily observable soil property and gives an immediate indication of the soil condition. Soil colour is inherited from its parent material and that is referred to as litho-chromic, Examples: red soils developed from red sandstone. Besides soil colour also develops during soil formation through different soil forming processes and that is referred to as acquired or pedo-chromic colour Examples: red soils developed from granite gneiss or schist.

Fig-Soil colour

(Source– *ZologyIn*)

2) Chemical Properties of Soil

The chemical properties of the soils indicate different reactions taking place in a soil. Soil pH is one of the important factors influencing soil chemical properties.

Soil pH

The term pH is from the French “pouvoir hydrogen” or hydrogen power. Soil pH or soil reaction is an indication of the acidity or alkalinity of soil and is measured in pH units. It is defined as the negative logarithm of hydrogen ion concentration or inverse log of the hydrogen ion concentration in a soil solution.

The pH scale goes from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases, the soil pH decreases, thus becoming more acidic. From pH 7 to 0, the soil is increasingly more acidic, and from pH 7 to 14, the soil is increasingly more alkaline or basic.

Factors Affecting Soil pH

- Parent materials
- Rainfall and leaching
- Acid rain
- Application of ammoniacal fertilizer like ammonium sulphate [$(NH_4)_2SO_4$] and urea [$CO(NH_2)_2$]
- Root and microbial respiration
- Accumulation and decomposition of huge amounts of organic matter producing organic acids.
- Application of high organic matters

Soil Acidity

Soil acidity refers to the activities of hydrogen cations in a soil solution.Soil acidity is those types of soil which have a pH below less than 7.

Cause of Soil Acidity

- Parent materials

- Rainfall and leaching
- Acid rain
- Application of ammoniacal fertilizers
- Root and microbial respiration
- Accumulation of organic matter
- Plant uptake of basic cations
- Application of high organic matters

Soil Alkalinity

Soil having a pH above the 7 is called soil alkalinity.

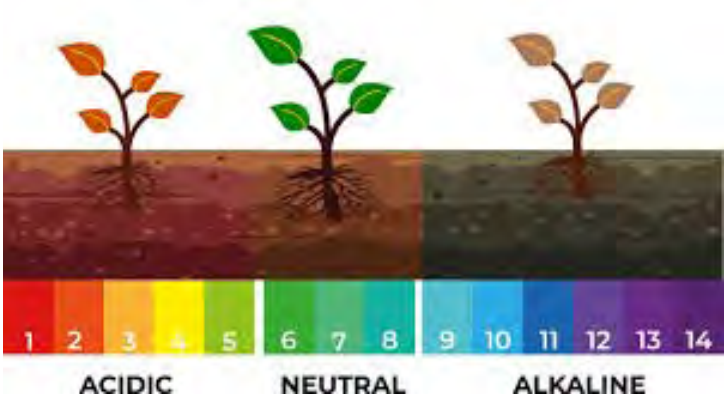


Figure- pH Scale

(Source- mantech (https://mantech-inc.com/)

Soil Colloids

Colloids are substances whose particle size is about 1 to 1000nm when they are mixed with another substance, usually air or water. Colloids are action sites for chemical reaction, microscopic, large surface area. The larger the surface area, the better they are for chemical reaction. Molecules of some compounds can come within the colloidal range but most colloids consist of aggregate of molecules. Colloids are so ubiquitous in nature and so distinctive that they have common names as fog, smoke, aerosol, foam, emulsion, soil and clay. All are small particles suspended in a fluid.

Ion Exchange in Soils

Ion exchange is a reversible process by which one types of cation or anion held on the solid phase is exchanged with another kind of cation or anion in the liquid phase. If two solid phases are in contact, exchange of ions may also take place between their surfaces. Cations and anions are two types of ions which can be exchanged in between solid or liquid surface. However, cation exchange is more important than anion exchange because anion retention capacity of most agricultural soil is much smaller than the cation retention capacity.

Cation Exchange Capacity

The CEC is the capacity of soil is defined as the capacity of soil to adsorb and exchange cations. The cation exchange capacity is the sum total of the exchangeable cations that asoil can absorb. The higher the CEC of soil the more cations it can retain. Soils differ in their capacities to hold exchangeable cations.

CEC is expressed as millie-quivalents of cations per 100 grams of soil (meq /100gsoil). After 1982, in the metric system the term equivalent is not used but moles are the accepted chemical unit. The recent unit of expression of CEC is centi moles of protons per kilo gram soil [cmol (p+) kg^{-1} soil]. One meq/100 g is equal to one cmol (p+) kg^{-1} soil.

Importance of Chemical Properties of Soil in Crop Production

The chemicals properties of soil are important physico-chemical characteristics because it influences:

- Suitability of soil for crop production
- Availability of soil nutrients to plants
- Microbial activity in the soil
- Lime and gypsum requirement of soil
- Physical properties of soil like structure, permeability etc.

3. Biological Properties of Soil

Organic Matters

Organic materials are intrinsic and essential component of all soils. Whereas the body of the soil is constituted by the inorganic materials, one may look upon the organic matter as its life. Organic matter makes the soil a living, dynamic system that supports all life on this planet. Soil Organic Matter (SOM) comprises an accumulation of

Partially disintegrated and decomposed plant and animal residues .Other organic compounds synthesized by the soil microbes upon decay. SOM is frequently said to consist of humic substances and non humic substances. The term SOM is generally used to represent the organic constituents in the soil, including un-decayed plant and animal tissues, their partial decomposition products, and the soil biomass.

Sources of Soil Organic Matter

Primary Sources

Plant, animal and microbial materials are the primary sources of organic matter. Plant tissues and microbial cells contain approximately 40 to 50 per cent carbon on dry weight basis.

Secondary Sources

On–farm Sources

Crop residues,roots,root exudates, organic manures, composts and green manure crops contribute significantly towards buildup of soil organic matter.

Off- farm Sources

Biodegradable wastes like agro-industrial wastes and municipal wastes

Soil Microorganism

All the organisms living within the soil are collectively termed soil life or soil biota. Soil organism is any organism inhabiting the soil during part or all of its life.

Soil organisms range in size from microscopic cells that digest decaying organic material to small mammals that live primarily on other soil organisms. They play an important role in maintaining fertility, structure, drainage, and aeration of soil. They also break down plant and animal tissues, releasing stored nutrients and converting them into forms usable by plants. They are the life force of soil. More living organisms occur in soil than in all other ecosystems combined. The living portion of soil is a diverse and dynamic collection of organisms, from types that you can easily see with an unaided eye down to creatures that you can observe only by using a high-powered microscope.

3.3 Essential Elements of Plant and their Major Function & Deficiency Symptom

Plant Nutrient

The plant nutrient is a "food" which is composed of certain chemical elements often referred to as 'plant nutrient' or plant food elements considered very essential for growth and development of plants.

Essential Nutrients and their Categories According to Plant Needs

An essential nutrient element is the one which is required for the normal life cycle of an organism and where functions cannot be substituted by any other chemical compound.

The elements needed by the plant without which the plant is not able to survive and complete its life cycle are called essential nutrient.

Plants absorb or utilize more than 90 nutrient elements from the soil and other sources during their growth and development and about 64 nutrients have been identified in plants by their tissue analysis. But all are not essential for their growth and development. They require only 18 elements/nutrients. These 18 have been recognized as essential elements. They are;

Elements	Chemical forms absorbed by crop plants	Elements	Chemical forms absorbed by crop plants
1. Carbon (C)	Co_2	10. Iron (Fe)	Fe^{2+}, Fe^{3+}
2. Hydrogen (H)	H_2O	11. Manganese (Mn)	Mn^{2+}
3. Oxygen (O)	Co_2, O_2, H_2O	12. Zinc(Zn)	Zn^{2+}
4. Nitrogen (N)	NO_3^-, NH_4^+	13. Copper (Cu)	Cu^{2+}
5. Phosphorous (P)	$H_2PO_4^-$, HPO_4^{2-}	14. Boron(B)	H_3BO3
6. Potassium (K)	K^+	15. Molybdenum (Mo)	$M_0O_4$2-
7. Calcium (Ca)	Ca^{2+}	16. Chlorine (Cl)	Cl^-
8. Magnesium (Mg),	Mg^{2+}	17. Nickel (Ni)	Ni^{2+}
9. Sulphur (S)	So_4		

Essential nutrients are classified into two major groups based on relative utilization or absorption by the plants. They are:

A. Macro Nutrients

B. Micro nutrients

A. Macro Nutrients

They are the nutrients utilized by the plants in relatively large amounts (quantity) for their growth and development.

Eg; C, H. O. N, P, K, Ca, Mg and S (C, H and O are abundantly present in the atmosphere and need not be applied through fertilizers).

Structural Elements

Structural elements are the essential elements that form the basic structure and body of plants. The three main structural elements are Carbon(C), Hydrogen

(H), Oxygen(O).C, H and O are abundantly present in the atmosphere and need not be applied through fertilizers.

Primary Nutrients

Primary nutrient are those nutrients required relatively in large quantities by the plants for their growth and development. These are also designated as 'fertilizer elements' because, deficiency of these elements is corrected by application through fertilizers. Eg: N, P and K

Secondary Nutrients

Secondary nutrients are those nutrients which are required by plants in moderate amounts. They are called secondary because they are unknowingly supplied through fertilizers and other amendments. However their role in nutrition is not secondary but they are given secondary importance in its supply and management. Eg: Ca, Mg and S

B. Micronutrients

The nutrients which are required by plants in relatively smaller quantities for their growth and development, but these are equally important and essential to plants as macronutrients.

They are also called as trace/rare/nano elements. These include Fe, Mn, Zn, Cu, B, Mo, Cl and Ni.

3.3.1 Function and Deficiency Symptoms of Essential Nutrient

Deficient

When an essential element is at a low concentration in plant that severely limits the plant growth and produces more or less distinct deficiency symptoms on plants. Under such conditions the yield of crop will be low / the quality of produce will be inferior.

Insufficient

When the level of an essential nutrient is below their actual content in plant

or available in an inadequate amounts that also affects the plant growth and development.

Toxic

When the concentration of an element in plants is very high this affects the plant growth severely and produces toxicity symptoms on plants.

Excessive

When the concentration of an essential nutrient is sufficiently high but not toxic. It results in a corresponding shortage of other nutrients.

Functions and Deficiency Symptoms of Essential Elements in Plants

Structural Elements (C, H, O)

C, H, and O are abundantly present in atmosphere and need not be applied through fertilizers. They form > 95% of the dry weight of plants.

Functions:

- They provide structure and give shape to plants.
- They play an important role in photosynthesis and respiration in plants.
- They are involved in the formation of organic compounds like carbohydrates starch proteins, etc.
- They provide energy for the growth and metabolism of plants.

a) Primary Nutrients

i) Nitrogen

Nitrogen plays a key role in the nutrition of plants. It is one of the principal growth promoting nutrient elements.

Functions

- It provides typical green colour to the plants.
- It helps in vigorous vegetative growth of plants.
- It is essential for cell division, reproduction, and plant growth.

- It is a constituent of metabolically active compounds like amino acids, protein, nucleic acids, enzymes and co-enzymes and alkaloids.
- It is the integral part of chlorophyll, so it is directly involved in photosynthesis.

Deficiency Symptoms

- Chlorosis of lower (older) leaves occurs.
- In severe nitrogen deficiency, the leaves will turn brown and die, which is called necrosis of leaves.
- Flowering and fruit setting are adversely affected which results in poor size and quality of the fruit.
- The plants become stunted and dwarf
- The plants mature early.
- The crop quality and yield are reduced.
- In corn, the lower leaves usually turn brown beginning at the leaf tip and progressing along the mid-rib until the entire leaf is dead and appears 'v' shape

Figure: Nitrogen deficiency in corn and soyabean)

ii) Phosphorus

Functions

- It is involved in photosynthesis, respiration, and energy storage and transfer.
- It stimulates seedling development and promotes early root formation.
- It is involved in cell division and development of meristematic tissue and thus improves better vegetative growth of plants.
- It helps in primordial development, flowering, seed formation, ripening of fruits, and germination of seeds.
- It helps in the early maturity of grain crops and promotes seed production.

Deficiency symptoms

- Plants turn dark green and appear stunted.
- Purplish discoloration of leaves is seen.
- Plants become weak and maturity is delayed.
- Leaves appear smaller than normal. They may be distorted and drop early.
- Poor quality fruits, forage, vegetables, and grain crops are produced.
- Plants develop dead necrotic areas on the leaves, petioles, or fruits.
- Poor root development occurs and weak straw of cereals is seen, which make them prone to lodging.

Figure-Deficiency symptoms of maize
(Source-https://en.wikipedia.org/wiki/Main_Page)

Potassium

Potassium is an essential plant nutrient and is required in large amounts for proper growth and development and reproduction of plants.

Functions

- Potassium regulates the opening and closing of stomata.
- It plays a role in osmoregulation of water and other salts in plant tissues and cells.
- It is essential for translocation of sugar and formation of starch.
- Potassium also facilitates protein and starch synthesis in plants.
- It activates enzymes responsible for specific functions.
- It increases plant resistance to diseases.
- It also improves the quality of seeds and fruits.

Deficiency symptoms

- Chlorosis i.e.. yellowing of leaves is seen. It starts along leaf margins towards the base, usually leaving the midrib alive and green. In severe case, the entire leaf turns yellow.
- Slow growth or poor developed roots and stems are observed.
- Straw or stalk length in cereals is reduced, so lodging problems is seen
- Disease resistance of plants is also reduced.
- The quality of fruits and vegetable also decreases.
- White spots on alfa-alfa leaf edges, small tubers in potato, poor opening of cotton bolls are seen due to the potassium deficiency.

Deficiency symptoms of potassium on maize

(Source: Purdue University http://www.purdue.edu/)

Secondary Nutrients

Calcium

Calcium is immobile in plants and it is absorbed in the form of C_a^{2+}(Calcium ion) and is abundant in leaves.

Function of calcium

- It is a major constituent of cell wall and membranes and is required for the formation of new cells.
- It is required for chromosome stability, cell wall construction, cell elongation of the shoot and root.
- It helps to provide resistance against diseases to plants.
- It plays a great role on fruit quality and increases the firmness of the fruit.
- It improves root growth as well as microbial activity.
- It increases fruit set and is essential for nut development in peanuts.

Deficiency symptoms

- The development of necrotic tissue on young leaves is observed.
- Leaves become small and malformation occurs.
- The terminal buds and root tips of plants fail to develop.

- Root growth is impaired.
- Fruit quality is reduced, sometimes rotting of fruits and susceptible to fungal disease.
- Calcium deficiency causes blackheart in celery, tip burn in lettuce, soft nose in mango, blossom end rot of tomato, cavity spot in carrots, black heart of celery, internal tip burn of cabbage, bitter pit in apple, Jonathan spot in apple, etc.

Deficiency symptoms of calcium

(Source –Rural sprouthttps://www.ruralsprout.com/)

Magnesium

Magnesium is a constituent of the chlorophyll molecule, so without which photosynthesis by plants does not occur. It is a mobile element and plant absorb as Mg^{2+} (magnesium ion)ionic form.

Function of Magnesium

- Magnesium is an essential element for chlorophyll production and photosynthesis.

- It is involved in the regulation of cellular pH, cation-anion balance and turgor regulation of cells.
- It is necessary for protein synthesis.
- It acts as an activator of enzymes in carbohydrate and ATP metabolism.
- It is required for stabilization of cell membranes.

Deficiency symptoms

- Interveinal chlorosis of lower (older) leaves occur and in extreme cases, leaves become necrotic.
- Purple or red-brown pigment may appear on older leaves along with chlorosis.
- Leaves remain small and brittle even in final stages.
- Premature dropping of leaves occurs that results in heavy loss of fruit crops.
- Twigs and stalks may be weak.

Deficiency symptoms of magnesium

(Source-https://www.hillbrothers.com/)

Sulphur

Sulphur is abundant in plant, particularly in the leaves. It is present in both organic and inorganic forms. Plant absorbs S in the form of sulphate (SO_4^{2-}).

Functions

- It is necessary element for synthesis of the S-containing amino acids like cysteine and methionine, which are important for protein synthesis.

- It helps in the synthesis of chlorophyll.
- It is a constituent of protein and volatile compounds responsible for characteristic tasteandsmell of plants in the mustard and onion families.
- It enhances oil synthesis in crops.
- It promotes nodule formation in legumes.

Deficiency Symptoms

- Initially, chlorosis occurs in younger leaves, later the entire plant turns yellow.
- Stalks become short and slender and growth is retarded.
- Fruits often do not mature fully and remain light green in colour.
- The oil content of oil seed crops such as mustard, rapeseed, peanut etc. is reduced.
- In maize plant, interveinal chlorosis is seen in young plants. When the plant matures and the deficiency becomes more severe, the entire leaf turns yellow with slightly greener veins.

Sulfur deficiency symptoms in corn

(Source- Managingnutrient https://managingnutrients.blogspot.com/)

Trace Elements

Iron

Iron is the first micronutrient to be discovered as an essential element for plant life. Plants obtain iron in the form of Fe^{2+}(ferrous ion or iron(ll) and chelated Fe form. It is an immobile element within the plant.

Functions

- It is involved in biosynthesis of chlorophyll and in the synthesis of chloroplast proteins
- It acts as an activator biochemical process such as respiration and photosynthesis.
- It brings about oxidation-reduction reactions in the plant.
- It is needed for respiration and energy transfer in plant.
- It regulates respiration, photosynthesis, reduction of nitrates and sulphates.

Deficiency Symptoms

- Interveinal chlorosis occurs with a sharp distinction between veins and chlorotic areasin the younger leaves. On severe deficiency, leaves become pale white.
- Reddish-brown necrotic spots occur along the leaf margins of young shoots in tree crops.
- In brassica, necrotic terminal buds are seen at the early seedling stage.
- Yield of citrus, soybean, corn, and vegetable crops is reduced.

Deficiency symptoms of iron

(Source-ironpowders https://ironpowders.com/)

Manganese

Manganese is absorbed by plants in the form of manganousion(Mn^{2+}) from the soil . Its availability increase with decreases with decreasing soil pH. It is a relatively immobile element.

Functions

- It is involved in oxidation-reduction reactions and electron transport in photo system.
- It assists in chloroplast formation and multiplication.
- It helps in movement of iron.
- It helps in acceleration of germination and maturity.

Deficiency Symptoms of Manganese

- Interveinal chlorosis on younger leaves occurs but no sharp distinction between veins and chlorotic areas is seen as in iron deficiency.
- The margins of expanding leaves, juvenile and adult, become pale green.
- The lateral branches of trees weep due to reduced lignifications of stem wood.
- It causes grey speck of oats, marsh spot of trees, speckled yellowing of sugar beet leaves.

Deficiency symptoms of manganese

(Source- ephytia https://ephytia.inra.fr/)

Copper

Copper minute quantities of copper are necessary for normal growth of plants. It is immobile element in plants.

Functions

- It acts as electron carriers in enzymes, which bring about oxidation-reductio reaction in plants
- It helps in utilization of iron in chlorophyll synthesis.
- It has indirect effect on nodule formation.
- It helps in the intensification of colour in apples, carrots, spinach , and wheat.
- It improves the flavor of fruits and vegetables and increases sugar content of citrus.
- It promotes the formation of vitamin-A in plants.
- It helps on pollen formation and fertilization.

Deficiency symptoms of copper

- Interveinal chlorotic mottling of leaves occurs in younger leaves,

- Chlorotic leaves may develop spots or patches of necrosis, which spread until the entire leaf is dead.
- Stunted growth, delayed maturity, lodging and in some cases melanosis (brown discoloration) occurs.
- It affects fruit formation much more than vegetative growth.
- In severe case, pollen sterility may occur.
- Poor pigmentation of fruit occurs.
- Reduction in fruit set and number of flowers is also observed.

Deficiency symptoms of copper

(Source-https://www.pthorticulture.com/en-ca)

Boron

Boron is present especially at the growing points in the conducting tissue. It is immobile element in plants.

Function

- It plays an essential role in development and growth of new cells in plant meristems.
- It is involved in proper pollination, pollen formation, pollen tube growth/ flowering and fruit or seed set.
- It helps in translocation of sugar, starch, nitrogen, and phosphorus.
- It enhances rooting of cuttings through oxidation process.

- It has role in hormone movement and action.
- It gives resistance for pest and disease infection.

Deficiency symptoms

- Young leaves are deformed and appear like a "rosette" structure.
- Premature seed or fruit drop occurs.
- Rotting of roots, tubers, and fruits occurs.
- Chlorosis of young leaves and death of terminal bud occurs.
- Leaves and stem become brittle and distorted and leaf tips tend to thicken and curl
- It causes lumpiness in papaya, cork spot in pear, corky apple, and uneven thickness of peel in citrus.

Deficiency symptoms of Boron

(Source- https://borates.today/)

Molybdenum

Molybdenum is required by plants in small quantity. The plants absorbed molybdenum in the form of MoO_4^{2-}(Molybdate).

Functions

- It plays essential role in absorption and translocation of iron in plants.
- It helps in protein synthesis and nitrogen fixation in legumes.
- It acts as a bridge in transferring electrons.

Deficiency Symptoms of molybdenum

- Symptoms resemble those of nitrogen deficiency but seen in younger leaves. A general pale green colour, stunted growth with small leaf size on the young leave is seen.
- Reddish or purplish discoloration of leaves, chlorosis, and marginal necrosis of leaves also occurs.
- Marginal scorching and rolling of leaves is seen.
- Yellow spot disease in citrus and whiptail in cauliflower is commonly seen.

Deficiency Symptoms of molybdenum
(Source- Poweraghttps://www.powerag.com/)

Chlorine

Chlorine is readily taken up by plants and its mobility is high. The plants requirement for chlorine is rather quite high as compared to other micronutrients.

Functions

- It is involved in the evolution of oxygen by chloroplasts in photo system-II.
- It is an active osmotic agent and associated with turgor production in the guard cells.
- It plays a role in opening and closing of stomata.
- It is involved in photochemical reaction in photosynthesis.

Deficiency symptoms

- Chlorosis and burning of tips and margin of leaves occur.
- Partial wilting and loose of leaf turgor in plants occurs.
- Reduction in root growth, failure to produce fruit and stunted growth are seen.

Chloride deficiency in Durum Wheat. A=No Cl, B=30 mmol Cl/pot

Fig- Deficiency symptoms of chlorine

(Source- Spectrumanalytic https://spectrumanalytic.com/)

Zinc

Zinc has limited mobility in plants and is immobile in soil.

Functions

- Zn is a constituent of several enzymes systems, which regulate various metabolic reactions in the plant.
- It influences the formation of some growth hormones in the plant like IAA, and Auxin.
- It helps in reproduction of certain plants.
- It plays a role in photosynthesis and is involved in chlorophyll synthesis and protein synthesis.
- It activates enzymes in amino acids and protein synthesis.
- It is necessary for starch formation and proper root development.

Deficiency symptoms

- Chlorotic and brown rusty spots on leaves occur.
- Drastic decrease in leaf area, leaf deformation, and stunted growth occur.
- Under severe deficiency, dieback occurs and mottled leaf is observed.
- Malformation of fruit occurs, often with little or no yield.
- It causes white bud in corn and sorghum, little leaves in cotton, dead spot on tobacco leaf, and khaira disease (bronzing) in rice.
- It also causes browning of nut trees, molted leaves in citrus and grasses, yellows walnut, and rosette of apple.

Fig- Deficiency symptoms of Zinc

(Source- Hydrobuilder https://hydrobuilder.com/)

Exercise

Choose the correct answer from the given alternatives.

1. Mineral soil consist of …… major component

   a. 4 b. 2

   c. 3 d. 5

2. Soil texture is determined by relative properties.....

   a. Sand, Silt b. Sand, silt and clay

   c. Clay, mineral and soil d. Soil, liquid and gas

3. Which is true about soil porosity?

   a. Soil, volume is occupied air and water

   b. Percentage of water volume occupied by pore

   c. Percentage of Soil volume occupied by pore

   d. Both a and b

4. Which of the following element is a part of chlorophyll?

   a. Magnesium b. Sulphur

   c. Iron d. Manganese

5. Buttoning of cauliflower is due to deficiency of:

   a. Calcium b. Phosphorous

   c. Zinc d. Boron

6. Which of the following is a structural Element?

   a. Nitrogen b. Sulphur

   c. Manganese d. Oxygen

7. Which of the following is micronutrients?

   a. Nitrogen b. Calcium

   c. Potash d. Zinc

8. Deficiency system of Nitrogen is ……..

a. Slow growth

b. Root development

c. Uniform yellowing of older leaves

d. A and b both

9. How many elements are required by the plant for its growth and development?

a. 17 b. 16

c. 18 d. 10

10. The elements/nutrients utilized by the plants in relatively large amounts for their growth & development is?

a. Micro-nutrients b. Macro-nutrients

c. Essential nutrient d. All of these

11. N, P & K are ?

a. Secondary nutrients b. Primary nutrients

c. Micro-nutrients d. None of these

12. The elements which promotes the growth of leaves and stem is?

a. Nitrogen b. Phosphorus

c. Zinc d. Cuppor

13. The elements which stimulates flowering and seed development is?

a. Nitrogen b. Phosphorus

c. Hydrogen d. Oxygen

Write short answer to the following questions.

1. Explain about the components of soil.
2. Define soil.

3. List out the components of soil.
4. What are biological properties of soil? Enlist its importance in soil.
5. What do you mean by essential nutrient? Enlist the essential plant nutrient.
6. Define soil texture. Enlist the physical properties of soil.
7. What do you mean by soil pH.

Write long answer to the following questions.

1. What are the uses of soil for different aspects?
2. Write down the importance of soil for plant growth.
3. Write down the function and deficiency symptoms of following:
   a) Nitrogen b) Phosphorous
   c) Potassium d) Calcium
4. Explain the different types of essential plant nutrient.
6. Explain the chemical properties of soil.

Project Work

- Determination of soil texture by feel method.
- Determination of soil texture by ball method.
- Determination of soil PH using by pH meter and pH paper methods.

Tillage

Unit 4

Introduction

Tillage is the mechanical manipulation of soil that brings about favorable change in soil for seed placement, growth and development of crops plants. It includes activities such as ploughing, harrowing, disking, and leveling and other various intercultural operations. Tillage operation improves the soil water holding capacity and infiltration or rain and irrigation water; maintain even distribution of soil constitutions, soil particles, organic matter, microorganism, moisture and air throughout the field.

Tillage

Tillage may be defined as mechanical manipulation of soil that brings about favorable change in soil for seed placement, growth and development of crops plants. It includes activities such as ploughing, harrowing, discing, and leveling and other various intercultural operations.

It can also be defined as manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops. Tillage may be defined as mechanical manipulation of soil for the purpose of crop production

Purpose of Tillage

Tillage means the act of preparing land for growing crops. The main purposes of tillage are as follows:

- For preparation of suitable seed bed.
- To incorporate crop residues, green manures, compost, organic materials, chemicals fertilizer and other agrochemicals.

- To remove weeds, unnecessary crop stubbles, root stocks, stumps etc.
- To control soil- borne pests, insects, pathogens and rodents.
- To enable better anchorage of crop plants and space for underground crops.
- To create soil surface condition suitable for necessary field operation such as irrigation, drainage, planting, harvesting so that these operations could be done quickly, smoothly and uniformly.
- To destroy hard pan and lump size.
- To increase moisture infiltration.
- To improve soil temperature.
- For soil and water conservation. Examples: erosion control
- For adequate seed-soil contact.
- To increase water availability such as water retention at surface, surface runoff, soil water evaporation.

Importance of Tillage

- It improves the soil water holding capacity and infiltration of rain and irrigation water.
- It helps to maintain even distribution of soil constituents, soil particles, organic matter, microorganism, moisture and air throughout the field.
- It helps to check the soil erosion by increasing infiltration and checking run off.
- It improves the availability of plant nutrients by enhancing the decomposition of organic matter and mineralization.
- It helps to improve the growth and proliferation of root system by reducing penetration resistance of soil and promote roots respiration and provides accessibility of roots to the moist zone in soil.
- It provides an optimum environment encouraging early and uniform emergence and establishment of seedlings.
- It encourages the growth and activities of soil inhabiting beneficial fauna

and flora including symbiotic bacteria and earthworms.

- It provides conditions suitable for prolonged periods of growth and yields of crop plants.

Factors Influencing Tillage Operation

The factors that influence tillage operation are as follows:

i) The Crop

Hardy crops like sorghum and other millets are not sensitive about tilth. Small seeded or delicate crops like tobacco, chili, coriander, sesame, mustard etc requires a fine soil for which land is repeatedly cultivated to get required fine tilth. Sugarcane and other roots crops require deep cultivation of land to lose the soil to the required depth.

ii) Type of Soil

A clayey soil is willing to cultivation only within a narrow range of moisture. Too wet or too dry soils are difficult to cultivate. The lighter soils can be worked under a wide range of moisture and the draught required for their manipulation is much less. Loamy soils are easily brought to good tilth with little cultivation and expenditure of energy.

iii) Climate

Climate influences the moisture content in the soil, for example, in scarcity areas the rainfall is low and the moisture in the soil prior to sowing does not ordinarily permit deep cultivation which tends to dry up soil to a great depth and eventually reduces moisture available to the crops. Sowing cannot be done till depth of cultivated soil is properly moistened.

iv) Types of Farming

Under irrigated farming intensive farming is followed which includes cultivation of more than two crops. Dry land farming depends entirely on rains and in such areas only one crop is taken in a year.

Types of Tillage

Tillage includes use of different kinds of implements at different times. Tillage operations are broadly grouped into two types based on the time.

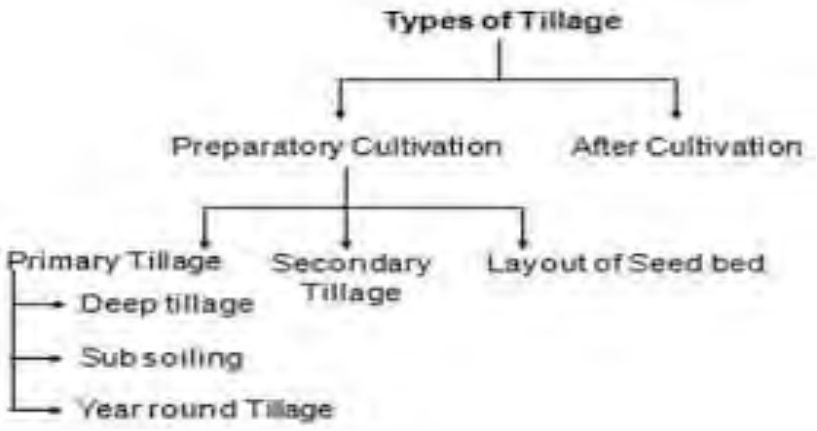


Fig- Types of tillage

1) Primary Tillage

Primary tillage is the ploughing operation which opens the compact soil with the help of different ploughs. Ploughing is done to open the hard soil, separate the top soil from lower layers, invert the soil whenever necessary, and uproot the weeds and stubbles.

Primary tillage is the first soil tillage after the last harvest. It is normally conducted when the soil is wet enough to allow plowing and strong enough to give reasonable levels of traction. Mainly heavy equipment should be used.

The objective of primary tillage is to attain a reasonable depth of soft soil, incorporate crop residues, kill weeds, and to aerate the soil. Using implements MB plough, rotary tiller, disc plough depending upon the purpose or necessity, different types of tillage are carried out. They are deep ploughing, sub- soiling and year-round tillage.

Fig- Primary Tillage

(Source-https://en.wikipedia.org/wiki/Tillage)

2) Secondary Tillage

Lighter or finer operations performed on the soil after primary tillage is known as secondary tillage. After ploughing, the fields are left with large clods with some weeds and stubbles partially uprooted. Harrowing is done to a shallow depth to crush the clods and to uproot the remaining weeds and stubbles.

Disc harrows, cultivators, blade harrows etc., are used for this purpose. Planking is done to crush the hard clods to smoothen the soil surface and to compact the soil lightly. Thus the field is prepared for sowing after ploughing by harrowing and planking.

Generally sowing operations are also included in secondary tillage.It includes harrowing, leveling, preparing irrigation layouts such as basins, borders, ridges and furrows using handtools or implements like harrow, rollers plank, rider, etc.

Figure:Secondary tillage seedbed preparation.

3) Minimum Tillage

Minimum tillage denotes the reduction of number of operation by planting crops directly after harrowing without any other intervening cultivation, which usually ensures a fine seed bed. It involves considerable soil disturbance, though to a much lesser extent than that associated with conventional tillage. Minimum tillage is aimed at reducing tillage to the minimum necessary for ensuring a good seedbed, rapid germination, satisfactory stand and favorable growing conditions.

Objectives of Minimum Tillage

- Reducing energy input and labour required.
- Conserving soil moisture and reducing erosion.
- Increasing organic carbon, improving structure of soil, and increasing hydraulic conductivity of soil, increasing infiltration of water.
- Providing optimum seedbed rather than homogenizing the entire soil surface.
- Keeping the field compaction to minimum.

Advantages of Minimum Tillage

- Improved soil conditions due to the decomposition of plant residues in *situ;* Higher infiltration caused by the vegetation present on the soil and channels formed by the decomposition of dead roots;
- Less resistance to root growth due to improved structure;
- Less soil compaction by the reduced movement of heavy tillage vehicles and less soil erosion compared to conventional tillage.

(Note: These advantages are evident on coarse and medium textured soils and appear after two to three years of practicing minimum tillage.)

Disadvantages of Minimum Tillage

- Seed germination is lower with minimum tillage.
- In minimum tillage, more nitrogen has to be added as the rate of decomposition of organic matters is slow.
- Nodulation is affected in some leguminous crops like peas and broad beans. Sowing operations are difficult with ordinary equipment.
- Continuous use of herbicides leads to pollution problems and dominanceof problematic perennial weeds.

Fig- Minimum Tillage(Source- Summer manufacturing)

(4) Conventional Tillage

Conventional tillage is the traditionalmethod of farming in which soil is prepared for planting by completely inverting it with a tractor. Pulled plough, followed by

subsequent additional tillage to smooth the soil surface for crop cultivation. In contrast, conservation tillage is a tillage system that conserves soil, water and energy resources through the reduction of tillage intensity and retention of crop residue. Conservation tillage involves the planting, growing and harvesting of crops with limited disturbance to the soil surface.

5) Zero Tillage

Zero tillage refers to tillage system in which soil disturbance is reduced to sowing generals and traffic only and where weed country must be achieved by a genital nears.It can be considered as an extreme form of minimum tillage. Primary tillage is commonly avoided and secondary tillage restricted to Seedbed Corporation in the row zone only. It is also known no till and is resorted to who soil are subjected to wind and water erosion zero tilled soil are homogenous in structure with high population earthworms.

Zero tillage will be useful concept where:

- Soils are subject to wind and water erosion Examples: Sloppy bare compacted soils with high gilt fine sand.
- Timing of tillage operation is too difficult.
- Conventional tillage to not yield more.
- Requirement of energy and labor too high.
- In medium to fine textured soils use of heavy implements can result in formation of hard puncturing wet conditions.

Advantages of Zero Tillage

- Soils are homogenous in structure with more number of earthworms.
- Organic matter content increase due to less mineralization.
- Surface run-off is reduced due to presence of mulch. Several operations are performed by using only one implement. In this weeds are controlled by spraying of herbicides.

Disadvantage of Zero Tillage

- More Nitrogen has to be applied due to slower mineralization of organic matter.
- Perennial weeds emerge as problems.
- More pests are built up.

Figure:Zerotillage

Exercises

Choose the correct answer from the given alternatives.

1. Zero tillage also known as ….

a. Primary tillage
b. Minimum tillage
c. Deep tilt
d. No till (Farming)

2. The purpose of tillage is.....

a. To improve soil aeration
b. To prevent soil erosion
c. To add fertility to soil
d. All are correct

3. Which equipment is commonly used for primary tillage?

a. MB plough
b. Harrow
c. Harvester
d. None of these

4. Which equipment is commonly used for secondary tillage?

a. MB plough
b. Harrow
c. Harvester
d. None of these

5. The first soil tillage after the last harvest is known as…

a.]Minimum tillage
b. Conservation tillage
c. Secondary tillage
d. none of the above

6. What is the objective of secondary tillage?

a. To break clods
b. To leveling the land
c. To pulverize the soil
d. b and c both

Write short answer to the following questions.

1. Define tillage. List out the purpose of tillage?
2. Enlist the tillage equipments.
3. Write down the difference between primary and secondary tillage.

4. What do you mean by primary tillage? Write its advantages and disadvantages.

Write long answer to the following questions.

1. Define minimum tillage. Write its advantages and disadvantage of minimum tillage.
2. What do you mean by tillage? Explain the types of tillage

Project Work

1. Identification of various tools and equipment which is used in tillage operations.
2. Practice of different tillage operations in field.

Unit 5

Manure and Fertilizer

5.1. Importance and Nutrient Contents of Organic Manures

Nutrition

The supply and absorption of chemical compounds needed for growth and metabolism of an organism.

Nutrient

Nutrients are substances required by an organism for their normal growth and reproduction**.**

Plant Nutrient

The plant nutrient is a "food" which is composed of certain chemical elements often referred to as 'plant nutrient' or plant food elements considered very essential for growth and development of plants.

A) Source of Nutrients

1. Organic Source

Soil is an important source of plant nutrients. Atmospheric carbon dioxide serves as the main source of carbon. Organic sources of plant nutrients are plant or animal wastes, by products of cattle or poultry manure, composted rice straw or other crop residues, sewage sludge, oil cakes, green manures, etc. There are mainly two organic sources and they are.

a) Plant Source

Various parts of plants or plant as a whole serve as organic source of various nutrients. The leaves, herbaceous stems are used to make compost that provides N P. K and other elements. In addition, seeds of various plants like mustard. sunflower, neem, etc. can be used as seed meals that provide various nutrients

for plants. Plants like Berseem, Dhaincha, etc. are used as green manure. The leguminous plants also serve as a great source of nitrogen in available form for the next season in the field.

b) Animal Source

Mostly feces of livestock animals are used as an organic source to provide various plant nutrients. Cow dung, feces of Buffalo, and other livestock animals poultry, pig, etc. are used for preparing Farm Yard Manure (FYM) that is nick source of N, P, and K along with other nutrients. Similarly, the feces are used prepare compost as well. The organic materials also include animal wastes, bio-mass spent slurry, microbial preparations, vermi- compost, sewage sludge, ete.

Advantages

- Organic fertilizer provides all the nutrients that are required for plants but in limited quantities.
- It helps in maintaining C:N ratio in the soil and also increases the fertility & productivity of the soil.
- It improves the physical, chemical, and biological properties of soil.
- It improves both the structure and texture of soils.
- It increases the water holding capacity of soil.
- It acts as mulch, thereby minimizing the evaporation losses of moisture from soil.
- Organic manures are cheaper than fertilizer and can be made easily by the farmers as farm manure.
- The organic manure helps to maintain soil pH by buffering ability.

Disadvantages

- It may contain primary nutrients like nitrogen, phosphorous or potassium only.
- They cannot provide all the nutrients and in sufficient amount required by plants.

- Nutrients release slowly, so immediate benefit cannot be obtained.

b) Inorganic Source

Inorganic (or mineral) fertilizers are fertilizers mined from mineral deposits. (Examples: lime, potash, phosphate rock, etc.), or industrially manufactured through chemical processes (Examples:Urea, DAP, etc.). Inorganic fertilizers vary in appearance depending on the process of manufacture. The particles can be of many different sizes and shapes (crystals, pellets, granules, or dust). Inorganic fertilizer could be classified into three based on the nutrient composition as follows:

1. Straight Fertilizers

These are fertilizers which contain and supply only one nutrient element. They could be nitrogenous, phosphotic or potassic fertilizers supplying nitrogen, phosphorus or potassium, respectively.

2. Complex/Compound Fertilizers

These are fertilizers which contain two or more nutrient elements usually. Combined in a homogeneous mixture by chemical interaction. Complex NPK fertilizers have the advantage of having each nutrient in each granule.

3. Fertilizer Blends or Mixed Fertilizers

These are fertilizers formed by physically blending mineral fertilizers to obtain desired nutrient ratios. Two or more then two fertilizer carriers or straight fertilizers are mixed to obtain the desired nutrient ratios. Examples are NPK 15 15-15, NPK 20-10-10, etc.

Advantages

- They adsorb into plants much more quickly than organic fertilizers. Hence, show quick results.
- They provide the necessary nutrients for healthy plant growth and development.

- They can be used in poor soil to make it fertile immediately.
- They add a sufficient amount of nutrients needed by the plant.
- They are cheaper and easy to use.
- Chemical fertilizers are predictable and reliable.

Disadvantages

- They are more expensive than the organic manures.
- There is a danger of over fertilization as the nutrients are readily available. This only can kills the plants but also upsets the entire ecosystem.
- Chemical fertilizers tend to leach, or filter away from the plants, require additional applications.
- Repeated applications may result in a toxic buildup of chemicals that can eventually make their way into the fruits and vegetables.
- Long-term use of chemical fertilizer can change the soil pH, upset benefice microbial ecosystems, increase pests, and even contribute to the release of green house gases.

Organic Manure

Concept

Organic manure is bulky in nature and supply nutrients in small quantities and organic matter in large quantities.

Importance and Scope

- Organic manure provides all the nutrients that are required by plants but in limited quantities.
- It helps in maintaining C:N ratio in the soil and also increases the fertility and productivity of the soil.
- It improves the physical, chemical and biological properties of the soil.
- It improves both the structure and texture of the soils.
- It increases the water holding capacity of the soil.

- Due to increase in the biological activity, the nutrients that are in the lower depths are made available to the plants.
- It acts as much, thereby minimizing the evaporation losses of moisture from the soil.

Types Organic Manure

Organic manures are categorized into two types which can be discussed below.

1. Bulky Organic Manure

- This consists of the slow acting organic manures with large quantities of organic matter. Examples are cattle, sheep, poultry, pig, goat, horse manures, compost, green manures, and sewage, sludge.
- Bulky organic manures generally contain fewer amounts of plant nutrients as compared to concentrated organic manures. The bulky organic manures include

a. Farm Yard Manure (FYM)

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well-decomposed farmyard manure contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O. One ton of FYM contains approximately 5-6 kg nitrogen, 1.2-2.0 kg phosphorus, and 5-6 kg potash However, the quantity and quality of FYM depend upon the type (draught, milch) and age of the animals, method of preparation, and the care taken to collect and store the material.

Advantages

- FYM is easily available.
- It is easy to prepare and locally available resources can be used.
- It is an inexpensive organic source of nutrients.
- It also attracts the worms to the soil.

Disadvantages

- FYM application can acidify soil.
- The anaerobic decomposition causes foul and unpleasant smell.
- The nutrient composition is not certainly known.
- It is difficult to transport to the field from the preparation site.

b. Compost

Compost is the product of organic residues, or mixture of organic residues and soil that have been piled, moistened and allowed to undergo biological decomposition.

Composting is a biological process in which microorganisms, both aerobic and anaerobic decompose organic matter resulting in a final product of well-rotted compost.

In composting, organic wastes of almost all kinds are reduced and converted to humus by the activity of microorganisms. The final product is brown to black colored humified material, which in addition to soil replenishes plant nutrients, maintains soil organic matter content, and helps in improving the physical, chemical, and biological conditions of the soil.

Compost commonly contains about 2% nitrogen, 0.5-1% phosphorus, and about 2% potassium. In addition, compost contains micronutrients and trace minerals such as Sulfur, Carbon, Magnesium, Calcium, Boron, Copper, Iron, Iodine, Zinc, and Manganese.

Method of Composting

There are two methods of composting in farm scale. They are described below in brief

a) Pit Method

It is the simplest form of compost making. The compost will be ready for use after 1-2 months. Turning can also be done. The steps involved in the method

are given below:

- Dig a pit of size 2m×2m×1m.
- Fill the pit about 30 cm deep with plant materials. The plant materials if dry, wet them so that it contains about 50-70% moisture.
- Components such as animal manure, beddings and urine (or I par livestock manure to 10-part water) should be applied in thin layer every 30 cm. A handful amount of lime and some surface soil previously prepared compost should be applied in each layer.
- Repeat the steps 2 and 3 until the pit is filled 50 cm or more above the surface of the soil.
- Plaster the rounded heap with cow-dung mud slurry.
- After 3 months remove the materials from the pit, place it in a heap, and plaster again as above.

b) Heap Method

Heap method of composting is preferred during monsoon season because the pits are easily water logged. Composting is done by piling the materials above ground in a heap. The size of the heap should be determined by the amount of materials available for composting. In any case, the amount should not be less than 1 m^3 and the height of the heap should not exceed 2m. In this method, the compost is ready for use after 3 months. The steps involved in this method are given below:

1. Pile the compost materials on the top of the wood, old branches or rocks to ensure good aeration to a height of about 30 cm.
2. Apply a thin layer of about 5 cm of starter materials consisting of cow-dung and urine water slurry, some superphosphate, or lime, some surface soil or plant ash etc.
3. Repeat steps 1 and 2 until the height of the heap is about 2m. Insert bamboo

poles along the heap to serve as air vents and then enclose the heap with a thin cow-dung mud plaster. Remove poles after 1 to 2 days when the temperature in the heap is risen (60-70^{0}C).

4. After about 2 weeks, open the heap, turn and reseal. Add water, if required, at this point.

Advantages

- Compost contains high amount of nutrients compared to FYM.
- It is also easier to transport.
- It is very useful organic source of nutrient in organic and commercial farming.
- It also kills the seeds of weeds.
- It does not give unpleasant odor when spread in the field.

Disadvantages

- There is loss of about half the available nitrogen.
- It releases greenhouse gases.
- It requires composting area, so reduces the field size for cultivation.
- It is difficult to compost with liquid manures.
- The nutrient composition is not certainly known. It depends on the composting materials.

Vermi Composting

Vermi composting is a simple technology for converting biodegradable waste into organic manure with the help of earthworms (the red worm Eisenia foetida).

- This method entails no smell and fast production of compost.
- The earthworms are bred in a mix of cow dung, soil, and agricultural residues or pre-decomposed leaf-litter.
- The whole mass is converted into casts or vermi compost, which can be used in all types of plants in vegetable beds.

- Vermi compost contains water-soluble nutrients and it is an excellent, nutrient-rich organic fertilizer and soil conditioner.
- Worm castings contain five times more nitrogen, seven times more phosphorus, and 11 times more potassium than ordinary soil, the main minerals needed for plant growth.

2. Concentrated Organic Manure

This consists of the quick acting organic manures with small quantity of organic matter. Examples are groundnut cake, castor cake, bone meal, blood meal, horn meal, wood ash, cotton and linseed Meal.

Table 5.1: Nutrient Content of Organic Manure

Organic Manure	Nitrogen	P_2O_5	K_2O
FYM	0.5	0.25	0.6
Compost	0.89	0.51	3.05
Night soil	5.50	4	2
Sewage and sludge	3.0 -6.0	2	1
Poultry Manure	3.03	2.63	1.4
Bird Guano	7 -8	11 – 14	2 – 3
Blood meal	13 – 20		
Raw boan meal	3- 4	20 – 25	
Fish manure	4-10	3- 9	3-1.5

3. Bio Fertilizer

Bio fertilizers are cultures of microorganisms (bacteria, fungi, algae). Their use benefits the soil and plants growth by providing N & P and also brings about the rapid mineralization of organic materials in soils. They are capable fixing N, solubilizing and mobilizing the phosphorus and mineralizing organic matter in soil. Their incorporation improves the physical and biological properties of soils.Examples: Azotobacter, Blue Green Algae, Rhizobium, Azospirillum, Azolla, etc.

The term "bio-fertilizers" includes selective microorganisms like bacteria, fungi, and algae which are capable of fixing atmospheric N or convert insoluble phosphate in the soil into forms available to plants. Bio-fertilizers are cost effective, eco-friendly and renewable sources of plant nutrients to supplement chemical fertilizers Bio-fertilizers also play a vital role in maintaining long fertility and sustainability.

Groups of Bio-Fertilizers

Nitrogen fixing organisms are either free living or having symbiotic association with plants. They directly or indirectly contribute nutrition to crop plants.

Free Living

This group includes numerous species of blue green algae and certain bacteria such as Azotobacter.

Symbiotic Association

The bacteria, Rhizobium, live symbiotically on the roots of legumesfern, fixes atmospheric N in symbiotic association with blue-green algae (BGA), Anabaena azollae in rice ecosystem.

Associative Symbiotic

One of the species of Azospirillum , A. lipoferum has associative symbiosis with higher plant systems.

Based on the type of microorganisms, the bio-fertilizers can also be classified as follows:

1. **Bacterial Bio-Fertilizers:** Examples: Rhizobium, Azotobacter, Phosphobacteria.
2. **Fungal bio-fertilizers :** Examples: Mycorrhiza, Azospirillum,
3. **Algal bio-fertilizers:** Examples: Blue Green Algae (BGA) and Azolla.
4. **Actinomycetes Biofertilizers:** Examples: Frankia.

Bio-fertilizers are mostly cultured and multiplied in the laboratory. However, bluegreen algae and azolla can be mass-multiplied in the field.

Importance and Benefits of Bio-Fertilizers

Importance

- The increase in the productivity during the green revolution period is accompanied by an exponential increase in consumption of non-renewable sources of energy.
- In view of the fast diminishing energy sources combined with their escaling cast.

Benefits/Advantages of Bio- Fertilizers

- Germination increase up to 20 percent.
- Improved seedling emergence and growth.
- Increase yield from 10 to 40 percent.
- Improve the quality of fruit and keeping quality.
- Saving of 25 to 35 percent inorganic fertilizers.
- Increase the availability and up take of N and P in plants.
- Improve the status of soil fertility maintain good soil health and crop productivity.

Limitations

- They require special care for long-term storage because they are alive.
- Bio-fertilizers are soil specific. There is loss of effectiveness if the soil is too dry or hot.
- Soil must contain adequate nutrients for bio fertilizer organisms to thrive and work.
- The release of nutrients is also slow.
- They are also crop specific and strain specific.
- They are less efficient than the synthetic fertilizers.

- They provide much lower nutrient density, however, crops require in large amount for optimum growth and development.

5.2. Define Green Manuring Crops with its Importance and Nutrient Contents

Green Manuring

Green manuring is a practice of ploughing or turning into the soil under composed green plant material for improving the physical conditions of the soil or for adding nutrients.

- Any crop or plant (generally leguminous) grown and ploughed in situ is called a 'green manure'. Examples: dhaincha, sesbania, sunnhemp, wild indigo and pillipesara.
- A leguminous crop producing 10-25 tonnes of green matter per ha will add about 60 to 90 kg N.
- 'Green leaf manure' refer to turning under of green leaves and tender green twigs collected shrubs and trees grown on the bunds, wastelands and nearby fore areas.
- Common shrubs and trees useful for this purpose are karanj glyricidia, neem, subabul, etc.
- There are two types of green manuring and they are:

(a) In-situ Green Manuring

In this system, green manure crops are grown and incorporated into the soil of the same field that is to be green manured, either as a pure crop or as an intercrop with the main crop. Common green manure crops in this system are sun hemp, dhaincha, guar, etc.

(b) Ex-situ Green Manuring

In this system, green leaves and tender green twigs are collected from outside the field to be green manured and turned into the soil. The common green manure crops are Glyricidia, Karanja etc.

Table5.2 Nutrient Content of Green Manure

S.N.	Greens Manures	Percentage Content		
		Nitrogen(N)	Phosphorus (P2O5)	Potassium (K2O)
Green manures when Fresh				
1	*Vigna unguiculata* (Cowpea)	0.71	0.15	0.58
2	*Sesbania aculeate* (Dhaincha)	0.62	-	-
3	*Cyamopsis tetragonoloba* (Cluster-bean)	0.34	-	-
4	*Dolichos biflorus* (Horse-gram)	0.33	-	-
5	*Vigna mungo* (Blackgram)	0.85	0.18	0.53
6	*Crotalaria juncea* (Sun hemp)	0.75	0.12	0.51
Nutrient content % on dry weight basis				
7	*Sesbania aculeate* (Dhaincha)	3.3	0.7	1.3
8	*Crotalaria juncea* (Sun hemp)	2.6	0.6	2.0
9	*Sesbania speciosa*	2.7	0.5	2.2
10	*Tephrosia purpurea* (Wild indigo)	2.4	0.3	0.8
11	*Phaseolus trilobus* (Pillipesara)	2.1	0.5	-

5.3. Explain the Different Types of Green Manuring Crops used in Crop Production

A) Dhaincha *(Sesbania aculeata)*

It is suitable for loamy and clayey soils. Dhaincha is an ideal green- manure crop for rice based cropping system. It is fairly resistant to drought as well as stagnation of water. The green manure grows well even in alkaline soils and corrects alkalinity if grown repeatedly for 4- 5 years. The roots have plenty of nodules. It yields about 10-15 tonnes of green manure per ha and requires a seed rate of 30-40 kg/ha.

b) *Sesbania speciosa*

It is a valuable green manure for wetlands and can be grown in a wide range of soils. Seed production is prolific; however, pods are frequently attacked by insects. The green manure can be raised on the field borders along the bunds. Sesbania seedling (21 days) can be planted in a single line at 5-10 cm apart in the borders of the fields close to the bunds. In about 90 days it produces about 2-4 tonnes of green manure per ha.

c) Sunnhemp *(Crotalaria juncea)*

It is a quick growing green manure crop and gets ready for incorporation in about 45 days after sowing. It does not withstand heavy irrigation leading to flooding. The crop is at times subject to complete damage by leaf eating caterpillars. The crop can produce about 8-12 tonnes of green biomass per ha. The seed requirement is 30 kg/ha.

d) Indigo *(Indigofera tinctoria)*

It resembles wild indigo and is a long duration crop with more leafy growth. It comes up well in clayey soils with one or two irrigations.

e) Green Leaf Manure Crops

A number of leguminous and non-leguminous plants are grown on bunds or wastelands with the prime objective of utilizing their foliage as green manure.

f) Karanj *(Pongamia glabra)*

It is a leguminous tree grown in wastelands. On an average, a tree can yield 100-120 kg of green matter. The leaves contain about 3.7% N (on dry weight basis).

g) Neem *(Azadirachta iridica)*

It is an indigenous tree with wide range of adaptability. Almost all parts of the tree have been used for several millennia for preparation of medicine and its leaves and leaf-extracts to repeal insect pests of crops and stored grains. The leaves are pruned at the time of planting rice and incorporated as green leaf manure.

5.4. Define Chemical Fertilizers with its Importance and Nutrient Contents

Chemical Fertilizers

Concept and Importance

Fertilizers are defined as materials having definite chemical composition with a high analytical value that supply essential plant nutrients in available form. There are usually manufactured by industries and sold with a trade name. They are commonly synthetic in nature and also called as chemical fertilizers/ inorganic fertilizers/commercial fertilizers other than lime and gypsum. Presently fertilizers have become an integral part of agricultural economy as they increase the fertility of soils and enable them to support high yields. About 50% of the increase in crop production during recent times has been attributed to fertilizer use; though the fertilizer use efficiency is very poor.

Types of Chemical Fertilizer

a) Nitrogenous Fertilizers

Nitrogen is the first fertilizer element of the macronutrients usually applied in commercial fertilizers. Nitrogen is a very important nutrient for plants and it seems to have the quickest and most pronounced effect. In the case of nitrogenous fertilizers, nitrogen may be in the ammoniacal, nitrate (or a combination thereof) or amide form.

Table 5.3 Nitrogenous Fertilizer - Source of Nitrogen

Name of fertilizers	Percentage Nitrogen
Ammonium Sulphate	21
Urea	46
Ammonium Chloride	25
Ammonium Nitrate	32-34
Ammonium Sulphate Nitrate	2.6

b) Phosphatic Fertilizers

Phosphorus is the second fertilizer element after N and it is an essential constituent of every living cell and for the nutrition of plant and animal. It takes an active part in all types of metabolism of plant. Phosphate present in phosphatic fertilizers may be in the water soluble form or citrate soluble form. That portion of phosphate which is soluble in water is called water soluble phosphate and that which is not soluble in water but in 2 per cent neutral ammonium citrate solution is called citrate soluble phosphate. The sum of water soluble and citrate soluble values is termed as available phosphates.

Table 5.4Phosphatic Fertilizer – Source of Phosphorous

Name of fertilizers	Percentage of P_2O5
Single Superphosphate	16
Double Superphosphate	32
Triple Superphosphate	48

C) Potassic Fertilizers

Potassium is the third fertilizer element. Potassium acts as a chemical traffic policeman, root booster, stalk strengthener, food former, sugar and starch transporter, protein builder, breathing regulator, water stretcher and as a disease retarder but it is not effective without its co-nutrients such as nitrogen and phosphorus.

Potassic Fertilizer – Source of Potassium

Name of fertilizers	Percentage of K20
Murate of potash	60.0

Nutrient content of Chemical Fertilizer

Name of the Fertilizer	Nutrient contains (in percentage)				
	Nitrogen	Phosphorus	Potash	Zinc	Sulfur
Urea	46	-	-	-	-
Ammonium sulphate	21	-	-	-	20-25
Complesal	20	20	20	-	-
Complete	19	19	10	-	-
D.A.P(Di- ammonium Phosphate	18	46	-	-	-
Single super Phosphate(SSP)	-	16	-	-	-
Double super Phosphate	-	32	-	-	-
Triple Super Phosphate	-	48	-	-	-
Murate of potash	-	-	60	-	-
Zinc Sulphate	-	-	22-35	-	

(Source- MoALD 2081)

Exercise

Choose the correct answer from the given alternatives.

1. The fertilizers containing nitrogen in amide form is.....

   a. Urea b. CAN

   c. Ammonium sulphate d. Ammonium phosphate

2. Urea has ……..% of nitrogen.

   a. 36% b. 40% c. 46% d. 50%

3. ……is a simple technology for converting biodegradable waste into organic manure with the help of earthworms.

   a. Vermi composting b. Farm Yard Manure

   c. Green manure d. Compost

4. Compost contains …….% of NPK .

   a. 0.89 : 0.51 : 3.05 b. 4-10: 3- 9: 3-1.5

   c. 0.5: 0.25: 0.6 d. 1: 3: 4

5. Advantage of FYM is…

   a. FYM is easily available.

   b. It is easy to prepare

   c. Locally available resources can be used

   d. All of these

6. The two methods of composting in farm scale are…

   a. Pit method b. Peat method

   c. Heap method d. b and c both

7. The different types of green manuring crops used in crop production are**…….**

   a. Dhaincha (Sesbania aculeata) b. Sesbania speciosa

   c. Green leaf manure crops d. All of these

8. Example of Fungal bio-fertilizersare.....

a. Azospirillum b. Azolla

c. Azotobacter d. Frankia

9. MOP contains …….% of potash.

a. 46% b. 60% c. 50% d. 65%

Write short answer to the following questions.

1. What do you mean by organic manure? Also discuss the advantages and disadvantages of organic manure.
2. Define the concept of nutrition and nutrient.
3. Define Bio- fertilizer. What are the benefits of using bio-fertilizer?
4. What are the diferrent types of sources of nutrients? Explain in brief.
5. List out the advantages and disadvantages of chemical fertilizer.

Write long answer to the following questions.

1. Explain the method of preparation of compost.
2. Define green manure. Explain the different types of green manuring crops used in crop production.
3. How FYM is prepared. Explan

Project Work

1 Guide students to prepare compost in your home utilizing local resources available in the surrounding and assign students to present the work in classroom.

Cropping Systems

Unit 6

6.1. Definition of Cropping System and Cropping Pattern

Cropping System

Cropping system is a complete method of farming. It includes not only the type of crops but also how the farmer uses land, water, fertilizer, and other resources. For example, growing rice and wheat in rotation along with proper irrigation and manure is a cropping system. It can also include animals, like using cow dung as fertilizer or keeping buffaloes for milk. In Nepal, integrated farming systems are popular in hilly areas where farmers grow vegetables, keep livestock, and use compost from animal waste to grow crops. A good cropping system helps to increase production and protect the environment.

Cropping Pattern

Cropping pattern means the way farmers grow crops on their land. It tells us which crops are grown and in what order during a year. For example, a farmer may grow rice in the rainy season and wheat in the winter. There are different types of cropping patterns such as monocropping, intercropping, and mixed cropping. In Nepal, many farmers follow the pattern of growing rice in the monsoon and then wheat or mustard in the winter season.

Difference between Cropping System and Cropping Pattern

Cropping pattern and cropping system are two important concepts in agriculture. Although they are closely related, they differ in scope, focus, and components. Below are three key differences between cropping pattern and cropping system along with examples for better understanding.

Cropping Pattern	Cropping System
It refers to the type and sequence of crops grown on a particular piece of land over time. Example: Growing rice followed by wheat on the same land in a year.	It includes the cropping pattern plus all associated farm practices like input use, resource management, etc. Example: A rice-wheat system that also includes irrigation scheduling, fertilizer use, and weed control.
Focuses mainly on which crops are grown and in what sequence. Example: Mixed cropping of maize and beans.	Focuses on the overall farming approach including crop-livestock integration, pest management, etc. Example: Integrated farming system with rice, vegetables, and poultry.
Has a narrower scope and deals with crop arrangement only. Example: Intercropping of sugarcane with mustard.	Has a broader scope involving ecological, technological, and management factors. Example: Sustainable agriculture system that uses crop rotation, organic inputs, and conservation tillage.

There are different types of cropping system. They are follows:

6.2. Mono-cropping/Monoculture

Mono-cropping is the agriculture practice of growing the single crop year after year in the same field; this practice is better described as continuous cropping, or continuous mono-cropping. Principles of Mono-cropping are most frequently practiced in industrialized countries agricultural system. Maize (corn), soybean and wheat are three common crops often grown using mono-cropping techniques.

Advantages of Mono-cropping

- It allows a farmer to specialize in a particular crop, which means that he or she can invest in machinery designed specifically for that crop, along with high yield seeds which will generate a large volume of the crop at harvest.

- With stable crops like rice, maize, wheat, corn and soybean farmers can also be confident that the crop will produce a high income, although this scheme can go wrong.
- If demand declines radically, a farmer's mono crop may be at stake.

Disadvantages of Mono-Cropping

- Mono- cropping is highly chemical and energy intensive.
- It often leads to depletion of the nutrients of the soil and problems with weeds and pesticides (being dependent on pesticides and artificial fertilizers).
- It also makes the crop more susceptible to disease as genetic similarity between plants makes them equally vulnerable.
- An example of this would be the potato famine of Ireland in 1845-1849.

Figure-Mono-cropping (Source- Gardening https://www.gardeningknowhow.com/)

6.3. Mixed & Relay Cropping

Mixed Cropping

It is a system of raising two or more crops together on a piece of land during a specified period of time by using the mixed seeds of various crops. The seeds may be sown in lines or broadcasted. . This type of cropping leads to an improvement in the fertility of the soil and used as an insurance against crop failure due to

abnormal weather condition.

In mixed cropping, we can plant crops in lines-one crop in one line and another crop in another line- so that both crops can grow well. In one line we can plant a leguminous crop andin another line a non-leguminous one.

Figure- Mixed-cropping (Source- Prepp https://prepp.in/)

Advantage of Mixed Cropping

- All the crops do not fail under adverse climatic condition Examples: frost kills only legume, flood kills only dicot plants and drought kills the monocots. Thus, farmers can get some crop instead of losing the entire crops.
- An epidemic attack of any insect pest or diseases kills only need crop without affecting the rest of the crops.
- The farmers grow different crops which fulfill their daily need or demand for cereals, pulses and oilseeds.
- Mixed cropping checks soil erosion, weeds, etc.
- It improves or maintains the soil fertility.
- Family labor and cattle are employed throughout year.
- Legumes and non- legumes mixture improves both the quality and quantity of the fodder.
- It reduces the cost of cultivation.

Relay Cropping

Relay cropping is analogous in a relay race where a crop hands over a land to the next crop in quick succession. This practice is common in both upland and low land culture. The best example of relay cropping is given below:

Under rain fed or partial by irrigated conditions:

- Paddy- lentil
- Paddy - Lucern
- Paddy - Berseem
- Cotton – Berseem
- Maize – Potato
- Maize – Tomato
- Maize - Millet

The seed of lentil lathyrus, Berseem or lucern are broadcasted in standing paddy or cotton crop just before they are ready for harvesting. Thus the field is never fallow or there is no gap at all between two successive crops.

Under Irrigated Conditions

- Maize- Early potato- Late potato- Cucurbit
- Maize- Potato-Onion- Okra

Figure- Modified Relay intercropping (Source- ohioline https://ohioline.osu.edu/)

6.4. Intercropping

Intercropping

Intercropping means growing two or more crops simultaneously in different rows in the same field. Intercropped plants/crops do not necessarily have the same time for harvest. The main objective of the intercropping is to utilize the wide space left between two subsequent rows of slow growing main crops during early growth period.

Examples: vegetables in fruit orchard, cowpea in maize, etc.

Intercropping was originally practiced as an insurance against crop failure under rain fed conditions. At present, the main objective of intercropping is higher productivity per unit area in addition to stability in production.

Figure-Intercropping (Source-prepp)

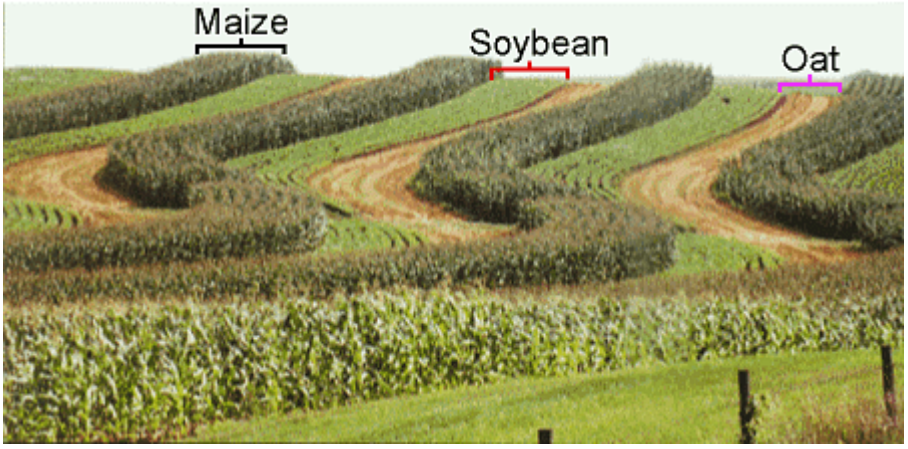
Multiple Cropping

Multiple cropping is the agriculture practice of growing two or more crops on the same piece of land within a single year or season.

Advantages of Multiple Cropping

- With multiple cropping the risk of total loss from drought, pests and disease is reduced.
- Some of the crops can survive and produce a yield.

- It gives maximum production from small plots. This can help farmers cope with land shortages.
- Including legumes in the cropping pattern helps maintain soil fertility by fixing nitrogen in soil.
- Different types of crops can be produced simultaneously thereby providing a balanced diet for family.



Multiple Cropping System of Maize, Soybean and Oats

(Source-Prepp https://prepp.in/)

6.5. Cropping Scheme and Crop Rotation

Cropping Scheme

A cropping scheme is a detailed plan or arrangement of crops to be grown on a particular piece of land over a specific period, usually for one year. It includes what crops will be planted, in which season, on which field, and in what sequence. In simple words, it is like a calendar or schedule for farming, helping farmers decide when and where to grow different crops based on climate, soil type, and available resources.

For example:

Monsoon (June–September): Rice

Winter (October–February): Wheat

Spring (March–May): Mung bean

Objectives of Cropping Scheme

Cropping scheme provides an idea beforehand about the following:

i. What crop is to be cultivated in a farm?

ii. What amount of area is allotted for a particular crop?

iii. The relative claim for acreage of the competitive crop.

iv. Selection of crops as per the facilities available for power, irrigation, inputs, labour transport etc.

v. Utilization of inputs and other resources available on the farm without wastage. Preparation of budget for each crop.

Principle or Characteristics of a Good Cropping Scheme

i) Area under Individual plots

The areas of individual plot for each crop should be approximately same year after year,unless price variation.

ii) Number of Plots

The number of plots should be equal to the duration or multiple of it. When the total duration of rotation in cropping scheme is 4, then the number of plots may be 4 or minimum of it. i.e. 8, 12, 16 and so on.

iii) Selection of crops

Cropping Scheme is related to the profitable use of productive resources and management.

iv) Profitable crops

The rotation should be planned around most profitable crops.

v) Meet the requirement

The cropping scheme should be so planned as to provide maintainance of soil fertility and other physical-chemical properties.

Crop Rotation

Crop rotation is one of the oldest and most effective cultural control strategies. It means the planned order of crop species planted on the same field. It also means that the succeeding crop belongs to a different family than the previous one. The planned rotation may from 2 or 3 year or longer period.

Some insect pests and disease causing organisms are host specific. For example, rice stem borer feeds mostly on rice. If you don't rotate rice with other crops belonging to a different family, problems continue as food is always available to the pest. However, if you plant legumes as the next crop, like corn, beans, bulbs, the insect pests will escape due to food.

Principles of Crop Rotation

The principles of crop rotation are as follows:

i) The crop with tap root, should be followed by those which have a fibrous root system. This helps in proper and uniform use of nutrients from different depth of the soil.

ii) The leguminous crops should be grown after non-leguminous crops because legume fixes atmospheric nitrogen and adds more nitrogen and organic matter to the soil

iii) Selection of the crop should be demand based.

iv) The crop of same family should not be grown in succession because they act like alternate hosts for insect pests and diseases.

v) An ideal crop rotation is one which provides maximum employment to the family and farm labour. In this the machines and equipments are efficiently used and all the agricultural operations are done timely, simultaneously maintaining soil productivity.

vi) On slop lands which are prone to erosion, erosion promoting and erosion resisting crops like legumes should be planted alternately.

vii) Under dry farming the only crops that can tolerate drought should be selected.

viii) The selection of crop should suit the farmer's financial conditions.

ix) The crop selected should also suit the soil and climatic conditions.

Advantages of Crop Rotation

- Reduces soil erosion.
- Reduces the pests and disease problems..
- Increases crop yield and quantity.
- Helps control weeds.
- It improves soil fertility.
- Improves soil texture and structure.

6.6. Cropping intensity

Cropping Intensity

Cropping intensity is the ratio of total cropped area to net cultivated area which is multiplied by 100 and represented in percentage.

$$\text{Cropping Intensity (CI)} = \frac{\text{Net cultivated area}}{\text{Total cropped area}} \times 100\%$$

Cropping Index

The number of express the relative yield of the crops on a particular area with the average yield over an entire region being taken as 100.(Ref- Merriam webter)

$$\text{Cropping index} = \frac{\text{Cropping Index and Harvesting Index}}{\text{The number of crops grown per annum on a given area of land}} \times 100\%$$

Exercise

Choose the correct answer from the given alternatives.

1. Mixed cropping is the raising of …….. in a specified period of time .

   a. Only one type of crop b. Two type of crop

   c. Two or more type of crops d. None of the above

2. Realy cropping is alos called

   a. Overlapping b. Paira

   c. Utera d. All of the above

3. Intercropping is the process of growing…….

   a. Only one crop in same rows in the field

   b. Two or more crop in different rows in the same field

   c. Two or more crop in same rows in the same field

   d. Only one crop in differnt rows in the field

4. Advantages of crop retation is.....

   a. Maintain and reduces soil erosion

   b. Increase soil depletion

   c. Increase insect pest

   d. Helps in increasing weeds

5. Mono cropping refers to.....

   a. Presence of a single crop in field

   b. Presence of double crop in field

   c. Presence of tripple crop in field

   d. Presence of a single crop in field

Write short answer to the following questions.

1. Write short notes on**:**
   a. Mixed cropping
   b. Inter-cropping
   c. Relay cropping
2. List out the importance of intercropping.
3. Define cropping intensity and cropping index.

Write long answer to the following questions.

1. Define mono- cropping. Enlist its advantages and disadvantages of mono-cropping.
2. What do you mean by crop rotation? Explain the Principles of Crop Rotation.

Project Work

1. Arrange a field visit to the local farm to study the cropping pattern and system. Assign students to prepare a report of that visit.

Water and Weed Management

Unit 7

7.1. Irrigation

Irrigation is generally defined as the artificial application of water to soil for the purpose of supplying soil moisture essential for plant growth. However, in broader sense, irrigation is the application of water to the soil for the following purposes.

- To add water to soil to supply the moisture essential for plant growth.
- To provide crop insurance against short duration drought.
- To cool the soil and atmosphere, thereby making more favorable environment for plant growth.
- To soften soil crust, thereby making tillage operations easier.
- To leach and wash out salts from the soil for reclaiming it.
- To reduce the hazard of soil piping.
- To reduce the hazard of frost.
- To delay bud formation by evaporation cooling.

7.1.1. Importance of Water in Crop Life

Water plays an important role in raising crops. The main functions of water are listed below**:**

- It is the principal medium in which all process of plants occurs.
- Water is a constituent of protoplasm.
- Water is used as transpiration carrier of nutrients from the soil to green plant tissues.
- Water serves as for medium the transportation of ions to and from the cells.

- They are used for photosynthesis and the end product is also conveyed through water to various plant parts.
- Water is essential in hydraulic process in the plant. It helps in the conversion of starch to sugar.
- By weight over half of all plants life is made up of water.
- Water neutralizes unfavorable temperature variations in plants and thus maintains the uniform temperature.
- Water in the form of hydrogen, an essential element of all organic molecules, is absorbed and assimilated in the course of photosynthesis.

7.1.2. Different Irrigation Systems in Crops Production

There are several methods of irrigation which can be used on flat or slopping land depending upon the soil, water supply, crops to be grown etc. Four general methods of soil irrigation are:

A) Surface Irrigation

Surface irrigation is the method of irrigation in which water is applied directly over the field and the soil acts as the reservoir for moisture. This method is utilized in arid and semi-arid region where topography is level. It is less expensive and invite more water loss due to evaporation. But since the system depends on gravity flow, it is inefficient in distribution because more water is supplied to the area closest to the source. Another serious objection is the harmful effect on soil structure. Heavy soil becomes puddle, which results in a loss of soil aeration followed by clodding and cracking when the soil dries out.

The different methods of surface irrigation are as follows.

a) Wild or Uncontrolled Flooding

This is most primitive and wasteful method of irrigation.This method is followed in areas where unlimited water is available and a vast area like pasture is to be irrigated. The water is let into the field from a higher gradient and spread slowly all over the cropped area depending upon the slope. Thus the depth of irrigation

varies from place to place due to varied topography. It has many disadvantages like greater loss of water and nutrients, more soil erosion, uneven distribution of water and wetting of soil, greater percolation in certain pockets and salinity at higher spots. This method is rarely adopted.

Rice irrigated with wild flooding method

(Source- Agrivi https://www.agrivi.com/)

b) Controlled Flooding

The field to be irrigated is divided into several plots of convenient sizes of more or less even surface. The water is let into the field through main and sub channels for irrigating plots one after another. The method needs less volume of total water. There is uniform wetting, no soil erosion and it also leads to lesser loss of water and nutrients. This can be done in following ways:

c) Check Basin Method

This is also called as check flooding method or bed method. The method is practiced in areas where small stream of water is available, ground is properly leveled and the crop needs a careful distribution of water. Rectangular or square beds of 10 to 100 square meter area are prepared in this method.The water is conveyed through main channel and branch channels which used to connect two consecutive parallel rows of beds or basins.

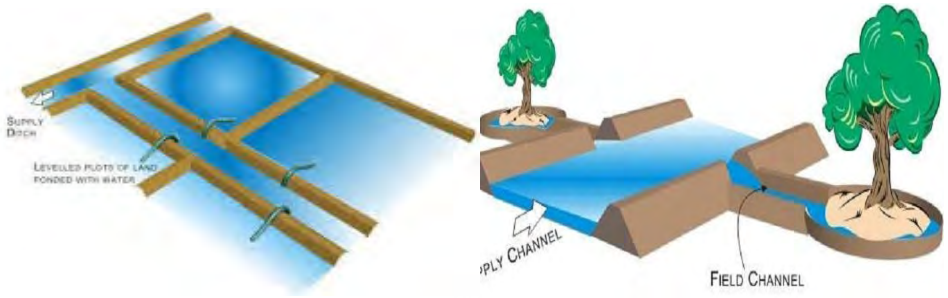


Figure- Check- basin

d) Border Strip Method

This method is suitable in areas having a slope of 0.5 to 1%. Where close growing crops are to be grown and the soil has shallow to medium depth. In this method the fields are divided into strips of 3 to 15 meters width and 50 to 300 meters length depending upon the type of soil and the extent of slope above 1% and the contour borders are prepared. The area remains prone to erosion in cases of semi-graded, graded and contour borders, therefore, it requires higher degree of skill in applying irrigation.

e) Ring basin method

This method is most suited to the widely spaced crops where a limited stream of water is available for irrigation. A ring is prepared around each plant and each row of pockets or rings are connected with the other through main channel which is prepared at the end of the row of rings.

Fig.: Border Strip Flooding Method

(Source- Surface irrtigation methods https://eopcw.com/find/downloadLectureNote/823)

f) Furrow Method

This method is used for root and tuber crops which are sensitive to saturated soil condition at the root zone. The crop is sown on the ridges and the irrigation water is applied in the furrows so that most of the roots remain above the saturation zone and there is no soil compaction. In this method, the field is divided into ridges and furrows along or across the slope and the furrows are connected with main channels. The depth of furrow is decided based on the length of the roots of the crop to be grown and the infiltration rate of the soil. Optimum length of furrows depends upon several factors like slope, infiltration rate, rainfall or water application intensity and furrow spacing etc.

Figure- Furrow Irrigation

(Source-Irrigation Methods Jan 11, 2022,https://www.slideshare.net/LeemaMargret1)

g) Sprinkler Irrigation

In this system, water conveyed through pipes is distributed under pressure. Pressure to operate sprinklers can be supplied by gravity or pump. Sprinkler may be used for frost protection, heat control, as well as for irrigation. Three common types of sprinklers are fixed head, perforated pipe and rotating head. The most

commonly used type is the rotating head. It applies water to circular area. The sprinkler should be so designed as to apply water uniformly at a rate that will not cause run-off with the help of pump and water supply capacity depends on irrigation needs according to climate and crop.

Sprinklers are adapted to a wide range of soil types and various topography and slopes. They are especially useful on rolling land that cannot be leveled or on steep slopes with erodible and shallow soils. It has proved practical as a means of providing supplemental water in the humid climates. In arid climate, evaporation may be higher with sprinkler irrigation than with surface irrigation. Though this system requires less labor and water, the serious limitation of sprinkler irrigation lies in the high initial cost. The power requirement is also very high compared to other irrigation methods. Sprinkler cannot be operated where wind velocity is high as it disturbs the sprinkler pattern and results in uneven distribution of water.

Figure- Sprinkler Irrigation

(Source- indiamart https://www.indiamart.com/)

h) Drip System of Irrigation

In this system, water is delivered to each plant at its root zone, through a network of tubing. Under medium to low pressure, a required quantity of water is given

daily so that plants may not suffer from water stress. Crops like cotton, maize, sugarcane, banana, tomato, tobacco and plantation crops like orange, apples, etc. are irrigated by this system. The lateral pipes are laid at uniform intervals according to the spacing of the crops. This is expensive and sometimes clogging of equipment makes it ineffective but it has several advantages like water saving to the extent of 30-50%, reduced weed growth, reduced labour cost, constant water supply, early maturity and superior quality of crop produce.

Figure-Drip irrigation(Source- Aquahub https://www.aquahubkenya.co.ke/)

B) Sub-Surface Irrigation

In this method, the root zone is made wet by running underground porous tile tubes or perforated pipes. The water is passed through tile or perforated pipes. The water is passed through tile or perforated pipes which oozes out through the holes and wets the root zone of the soil. The method needs least labour but is expensive and even a slight negligence in applying water may lead to water logging in root zone, Therefore a careful and controlled water supply along with provisions for proper drainage is essential.

Figure –Subsurface Irrigation (Source- Civildigital https://civildigital.com/)

7.1.4. Critical Stages of Moisture Requirement of Major Agronomical Crops

There are certain growth stages in crops. They require assured supply of irrigation water at these stages. These are referred to as critical stage (periods) for crops. If water is not supplied at critical stages, yield is badly reduced. For herbaceous crop, germination is the critical stage. Varying from crop to crop initial tillering and flowering period in rice, crown root initiation, tillering, jointing, etc in wheat, flowering and cob development in maize, pod development for legumes etc are the critical water requirement stages of crop development. Critical stages of moisture requirement for major agronomical crop are as follows:

Critical Stage of Moisture Requirement for Major Agronomical Crop

Crops	Critical Stages
Rice	Transplating, initial tillering, flowering
Maize	Early vegetative, knee-high, tasselling and silking stage
Wheat	Most critical stage crown root initiation, tillering, jointing, booting, flowering, milk and dough stage
Pulses	Pre-flowering, flowering and podding.
Barley	Tillering,Heading and Milking.
Sorghum	Pre flowering, flowering, grain formation.

7.2. Drainage

7.2.1. Concept, Objective and Importance of Drainage and Drainage System in Crop Production

Definition of Drainage

Drainage means the process of removing water from the soil that is in excess for crop plants. It is a process of driving out excess water from agriculture field or land. The excess water may get accumulated due to precipitation, snow melt, seepage from canals, bunds, irrigation waste etc. Drainage is the removal of excess gravitational water from the soil by artificial means to enhance crop production. A soil may need artificial drainage for one or two reasons.

1. When there is a high water table that should be lowered or
2. When excess surface water cannot move downward through the soil or even the surface of the soil fast enough to prevent the plant roots from suffocating.

Drainage System

There are two methods of drainage to remove excess water from the field. They are:

i) Surface Drainage

It refers to the removal of surface water by developing the slope of the land. Drainage canal may be shallow and broad to permit the controlled removal of water from the soil before it infiltrates the soil. It may consist of open ditches that are laid out by eye judgment, leading from one wet spot to another and finally into a nala or river. This is often called natural system.

ii) Open Ditch Drains

The pattern of ditches is regular. The method is adopted to land that has uniform slope.

iii) Field Ditches

Field ditches for surface drains may be either narrow with nearly vertical sides, or V shaped with flat side slopes. V-shaped ditches can be easily crossed with large machinery.

iv) Narrow Ditches

Narrow ditches are most common where large farm machinery is not used. In level areas, a collecting ditch necessary at one side of the field and shallow ditches are constructed to discharge water into the collecting ditch.

v) Sub- Surface or Underground Drainage

A sub surface or underground drainage will remove excess soil water that percolates into themselves, just like open drains. These underground drains afford the great advantages that the surface of the field is not cut off, no wastage of land and do not interfere with farm operations. On the other hand, they are costly to lie and are not effective in slowly permeable clay soils.

Underground Drains May be Classified as:

i) Tile Drain

It consists of digging a narrow trench, placing short section of tiles at the bottom and covering the tiles with earth. The loose joints between two sections of the tiles serve as a place where drain water may enter into the drainage system. Water moves by gravity into the joints between tiles and through tile walls.

ii) Box Drains

Instead of pipes, underground drains may be made in V shaped cuts or trench as sides of which are reverted with soil, restoring the surface of the field. Depth may be 90 cm below the ground surface.

iii) Rubble Drains

A substitute for tile drains is made by cutting narrow V shaped or rectangular drains, as for box drains, filling them up with rough stones large and small and then covering the hole upto soil level with surface field soil. Depth may be 90 cm.

iv) Mole Drains

They are often used in clay, clay loam soils. A moling machine is one that draws a bullet nosed cylinder;which is used to make a cylindrical drain of 10-15 cm in diameter. A mole drain should be at least 75 cm below the surface to prevent closing of the holes by compaction from farming operations. Mole drains are commonly used in Europe.

v) Use of Pumps for Drainage

The pumps are used in U.S.A. and many other countries for drainage. River bottoms, lakes and costal plains, peat lands and irrigated lands are the main types of lands reclaimed by pump drainage. The subsequent must be sufficiently permeable for the ground water to move to the pipes enough for effective pumping.

Objectives and Importance of Drainage in Crop Production Objectives

The objectives of agriculture drainage systems are to:

i) To reclaim and conserve land for agriculture.

ii) To increase crop yields.

iii) To permit the cultivation of more valuable crops.

iv) To allow the cultivation of more than one crop a year, and/or to reduce the costs of crop production in otherwise waterlogged land.

Importance of Drainage

The field-scale importance of drainage are as follows:

i) Drainage promotes beneficial soil bacteria activity and improves soil tilth.

ii) There is less surface runoff and soil erosion on drained land.

iii) Improved field machine traffic ability reduces soil structural damage. Soil compaction is reduced and less energy is requiredfor field machine operations. Drainage also allows for more timely field operations. Consequently, the growing season can be lengthened and crops can achieve full maturity.

iv) Crop yields are increased because of improved water management and uptake of plant nutrients.

v) High value crops can be planted, and there is flexibility to introduce new and improved cropping systems.

vi) In general, land value and productivity are increased.

vii) Farm income is increased and income variability reduced.

viii) Drainage maintains favorable salt and air environments in the crop root zone.

7.2.2. Water Logging in Crop Production

The crops become stunted with yellowing of leaves when the soil is saturated. In excess water, the plants usually die because of root damage caused by reduced supply of oxygen and accumulation of carbon dioxide with the related effects on the soil plant relationship. The adverse effects are not from direct presence of excess water, because crops will not suffer even in total from direct presence of excess water, because crops will not suffer even in total water culture, if they can get air. The root growth in such cases is also poor due to lack of aeration and they tend to remain largely near the surface and are subject to wilting when the surface becomes dry in spite of the moisture underneath.

7.2.3. Rain Water Harvesting and its Technique

Rain water is the biggest and ultimate source of fresh water on the earth. The distribution of annual precipitation varies from less than 50 mm to more than 2000 mm in low to high rainfall areas. Hence, it is necessary to develop suitable techniques for its storage and efficient use. It is all about recharging ground

water by capturing the abundant rain water harvesting signals, a paradigm shift from the present dependence on river and groundwater to meet the domestic irrigation and industrial requirement of water.

Rainwater Harvesting Techniques

There are mainly two methods of harvesting rainwater techniques like Rooftop collection and Surface runoff harvesting.

A) Rooftop Rainwater Harvesting

In rooftop rainwater harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building. It can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly helps in augmenting the ground water level of the area.

Steps of Rooftop Rainwater Harvesting

- Collect water from the rooftop
- Draw it down from pipes.
- Filter the water.
- Store in a sump or tank for later use.
- Charge the groundwater through a soak pit.
- Lead the water into a well to increase ground water content.

B) Surface Runoff Harvesting

Harvesting of surface runoff and storage of the same into reservoirs such as water pans makes it available for use when required. In this method of collecting rainwater for irrigation, water flowing along the ground during the rains will be collected to a tank below the surface of the ground.

Fig-Sruface Runoff harvesting

(Source-Surface runoff - Wikipedia)

7.3. Weed Management

7.3.1. Definition of Weed

Weeds are those plants which are grown without human interest. In other word a weed is a plant which considered as undesirable in a particular situation. For example commonly available unwanted plants in farm fields, lawns, garden, parks etc. Britain farmer Jethro Tull (known as father of weed science) was the First person who have defined weed in 1731. According to Jethro Tull, Wed is defined as, "the unwanted and harmful plants which interfere with agriculture operations, increase labour, add to the cost of cultivation and reduce yield of crop".

7.3.2. Losses and Benefits of Weeds

Weeds are competitive and adaptable to all adverse environments. It has been estimated that in general weeds cause 5% loss in agricultural production in most developed countries, 10% loss in developing countries and 25% loss in under developed countries.

In developing countries like Nepal and India, yield losses due to weeds are more than those from pest and diseases. Yield losses due to weeds vary with the crops.

In wheat, direct yield losses due to weeds have been estimated to range from 10 to 82%. This depends on the cultivar, weed species and density, cropping season, plant spacing, fertility and moisture.

Besides reduction yield, weeds remove large amount of plant nutrients from the soil. An estimate shows that weeds can, deprive the crops 47% N, 42% P, 50% K, 39% Ca and 24% Mg of their nutrient uptake. Weeds indirectly reduce the yield potential by serving as alternate host to a number of crop pests.

Aquatic weeds reduce the flow of water in irrigation and drainage channels, canals and streams. They indirectly increase water levels in the system which results in seepage, breakage of canal banks, flooding and siltation besides reducing aesthetic value of water bodies and inadequate delivery of irrigation water to farms.

Benefits of Weeds

Weeds provide ground cover, which helps prevent soil erosion by wind and water. Weeds offer food and shelter for insects, birds, and other small animals, helping maintain biodiversity. Many weeds like dandelion, nettle, and plantain have traditional medicinal properties and are used in herbal remedies. Some fast-growing weeds can be used as temporary cover crops to protect bare land and improve soil. In times of shortage, some weeds can serve as emergency fodder for livestock.

7.3.3. Managements of Weeds: Prevention and Control

Weed Management

Weed management is the process of keeping or reducing the weed population and their enlargement below the level of economic injury to the crop with lowest environment pollution. The common methods used to manage weeds include prevention and cultural, mechanical, biological, and chemical means.

Prevention

Preventative methods are used to stop the spread of weeds. Preventative practices

include cleaning tillage and harvesting equipment of weed seeds and vegetative structures; planting certified, weed-free crop seed; and controlling weeds in barnyards, around structures, and along fencerows, roadways, and ditch banks.

7.3.4. Physical, Cultural, Biological and Chemical Methods of Weed Control with their Relative Advantages and Disadvantages.

Management of Weeds

1. Cultural Management

Cultural and crop management techniques provide a healthy crop to best compete with weeds. Crop competition can be an inexpensive and effective aid to weed management if used to its fullest advantage. Examples of cultural techniques include:-

- Soil test recommendations for fertilizer and lime
- Selecting the best crop varieties
- Planting dense crop populations at the proper timing
- Scouting fields regularly for weeds, insects, and diseases and controlling them when necessary
- Crop rotations etc.

2. Mechanical Management

Mechanical or physical techniques either destroy weeds or make the environment less favorable for seed germination and weed survival. These techniques include hand pulling, hoeing, mowing, plowing, disking, cultivating, and digging. Mulching (straw, wood chips, gravel, plastic, etc.) can also be considered a mechanical control means since it uses a physical barrier to block light and impede weed growth.

3. Biological management

Biological weed control involves the use of other living organisms, such as insects, diseases, or livestock, for the management of certain weeds. Herbivores

such as sheep and goats can provide successful control of some common pasture weeds.

7.4. Chemical management

Herbicides can be defined as crop- protecting chemicals used to kill weedy plants or interrupt normal plant growth. Herbicides provide a convenient, economical, and effective way to help manage weeds. They allow fields to be planted with less tillage, allow earlier planting dates, and provide additional time to perform the other tasks that farm or personal life require. Without herbicide use, no-till agriculture becomes impossible. However, herbicideuse also carries risks that include environmental, ecological, and human health effects. It is important to understand both the benefits and disadvantages associated with chemical weed control before selecting the appropriate control. Examples of herbicides are glyphosate, butachlor, 2,4-D (2,4-dichlorophenoxyacetic acid), atrazine, pendimethalin, etc.

Exercise

Choose the correct answer from the given alternatives.

1. Artificial application of water is called…

   a. Rainfall b. Irrigation

   c. Wind d. Humidity

2. By weight ……of all plants life is made up of water.

   a. One half b. Full

   c. Third half d. None of these

3. Method of irrigation in which water is applied directly over the field is known as ……..

   a. Surface irrigation b. Sub- Surface irrigation

   c. Drainage d. None of these

4. The critical stage of moisture requirement for wheat is …..

   a. Tasselling and silking stage. b. Jointing

   c. Booting d. podding.

5. The removal of excess gravitational water from the soil is called…….

   a. Irrigation b. Drainage

   c. A and B both d. Sub surface irrigation.

6. Culture management of weed include …..

   a. Scouting fields regularly for weeds

   b. Crop rotation

   c. Use chemical herbicide

   d. A and B both

7. The plants which are grown without human interest is called….

a. Plant
b. Weeds
c. Moth
d. None of these

8. Which is the types of drainage…..

a. Mole drain
b. Ditch drain
c. Box drain
d. All of these

9. Which chemical method is commonly used to control weeds in field?

a. Insecticide
b. Fungicide
c. Herbicide
d. Fertilizer

10. The advantages of drip irrigation system is …

a. Water saving
b. Reduced weed growth
c. Reduced labour cost
d. All of these

Write short answer to the following questions.

1. Define irrigation.
2. Write the critical stages of water requirement in rice, maize and wheat?
3. What do you mean by drainage?
4. Write down the objective of drainage.

Write long answer to the following questions.

1. What is irrigation? Write down the different types of irrigation system practiced in Nepal.
2. Why is water important to the crop life? Write down the critical water requirement of major field crops.
3. Define drainage. Write down the different drainage systems practiced in field.

Project Work

1. Exercise the practice of surface irrigation.
2. Get familiar with the practices of erosion control methods.
3. Identify the important weeds of agronomic crops.
4. Practice the application of herbicides.

Farm Mechanization

Unit 8

8.1. Concept and Usage of Farm Mechanization

Farm mechanization refers to the development and use of machines that can take the place of human and animal power in agricultural processes. The mechanization of agriculture that took place during the 20th century led to major changes in how farmers plant, irrigate and harvest crops. Combines, tractors, harvesters and other machinery have enabled farmers to increase their production while relying less upon an extended labor force.

Agricultural mechanization has been defined in a number of ways by different people. The most appropriate definition is that it is the process of improving farm labor productivity through the use of agricultural machinery, implements and tools. It involves the provision and use of all forms of power sources and mechanical assistance to agriculture, from simple hand tools, to animal draught power (DAP), and to mechanical power technologies. The choice depends on local circumstances. Human, animal and machine power can complement each other in the same household, farm and village (FAO, 2005).

Usage and Advantages of Farm Mechanization

i) Increases Production

Mechanization increases the rapidity and speed of work with which farming operations can be performed.

ii) Increases Efficiency and Per Man Productivity

Mechanization raises the efficiency of labor and enhances the farm production per worker. By its nature it reduces the quantum of labor needed to produce a unit of output.

iii) Increases the Yield of Land Per Unit of Area

Increase in the yield of crops, due to mechanization of farms, has been traced from 40 to 50 per cent in the case of maize; 15 to 20 per cent in pearl millet/bajra and paddy; 30 to 40 per cent in sorghum/Junelo/Jowar, groundnut and wheat.

iv) Reduces Labour Cost

It has been accepted by all that one of the methods of reducing unit cost is to enlarge the size of work on the farms and go in for more intensive farming.

v) Contracts the Demand for Work Animals for Ploughing, Water Lifting, Harvesting, Transport, etc.

vi) Brings in other Improvements in Agricultural Technique

Ploughing by tractor reclaims more land and thereby extends the cultivated area as the tractors smoothens hillocks, fills in depressions and gullies and eradicate deep rooted weeds. It also prevents soil erosion. Besides mechanical fertilization, contour bounding and terracing are done by mechanical methods with the help of self-propelled graders and terraces.

vii) Modifies Social Structure in Rural Areas

It results in a significant modification of the social structure in rural areas. It frees the farmers from much of the laborious, tedious, hard work on the farms. The pressure on land decreases and the status of the farmers improves.

viii) Leads to Commercial Agriculture

Mechanization results in a shift from 'subsistence farming' to 'commercial agriculture. This shift occurs mainly due to the need for more land and capital to be associated with farmer in order to reap the full technological benefits.

ix) Solves the Problem of Labor Shortage

In countries where human labor falls short of requirements in agriculture, use of machines can replace human and animal power.

x) Releases Manpower for Non-agricultural Purposes

Since the mechanization of agriculture results in the employment of lesser number of persons on farms, surplus manpower may be available for other economic activities.

xi) Results in Better use of Land

Use of machine energy leads to good agricultural production, to the trade of many crops or saleable animal products in short, to an exchange economy and a system of land utilization.

xii) Increases Farm Income

With the introduction of mechanization the farm income as well as the individual income goes up. It creates much of the capital surplus on which modern economic progress is largely based.

xiii) Reduces Fodder Area and Enlarges Food Area

With the introduction of mechanization in agriculture the surplus animal power would be reduced so that large areas of land required for producing fodder for it can be utilized for producing food for human consumption.

8.2. Tractor and Farm Machines with their Advantages and Disadvantages.

Farm Machine

A farm machine is a tool or equipment used to help farmers do their work more easily and quickly. These machines save time, reduce hard labor, and increase the amount of crops produced. Farm machines are used in many different activities like plowing, planting, watering, harvesting, and storing crops. Some common examples of farm machines are tractors, plows, seed drills, harvesters, and threshers. A tractor is one of the most important machines. It pulls other tools and carries heavy loads. A plow is used to turn the soil before planting. A harvester cuts and collects crops like wheat or rice, while a thresher separates grains from the stalks. Modern farm machines run on fuel or electricity and are

very powerful. They are especially helpful on large farms where doing all the work by hand is difficult. Farm machines have made farming easier and more productive.

1) Based on power source

Equipments need power to operate. The different types of power available can be classified as:

a) Human Power

The decline in number of laborers employed for agriculture is likely to increase in future resulting a greater investment in labor saving devices and mechanical power. Labor is one of the most important sources of farm power in regions where traditional system of agriculture is practiced. On small farms, high proportion of labor is supplied by the farmer and his family. Having very little spare capital to buy appropriate type of hand tools and animal drawn equipment, both labor use efficiency and productivity are very low.

Advantages

Easily available and used for all types of work.

Disadvantages

Costliest power compared to all other farms of power, very low efficiency, requires full maintenance when not in use and affected by weather condition and seasons

b) Animal Power

Animal power is the most important source of power on the farm all over the world particularly in developing countries. It is estimated that nearly 80% of the total draft power used in agriculture throughout the world is still provided by animals. Different animal sources are:

A bullock-can pull of about 15% of its weight. The average force a bullock can exert is nearly equal to one tenth of its body weight. But for a very short period,

it can exert many more times the average force. Generally a medium size bullock can develop between 0.50 to 0.75 hp.

A donkey: can pull 80 % of its weight for a short period and 1015% of its weight for sustainable period. Buffaloes, Camels, Horses, Mules and elephants

c) Mechanical Power

The third important source of farm power is mechanical power that is available through tractors and stationary engines. The engine is a highly efficient device for converting fuel into useful work.

Advantages

Easily available, used for all types of work, low initial investment, supplies manure to the field and fuels to farmers and Live on farm produce.

Disadvantages

Not very efficient, Seasons and weather affect the efficiency, Cannot work at a stretch, Require full maintenance when there is no farm work, Creates unhealthy and dirty atmosphere near the residence and Very slow in doing work.

d) Electrical Power

Nowadays, electricity has become a very important source of power on farms in various countries. It is steadily becoming more and more available with the increase of various river valley projects and thermal stations. The largest use of electric power in the rural areas is for irrigation and domestic water supply. Besides this, the use of electric power in dairy industry, cold storage, fruit processing and cattle feed grinding has tremendously increased.

Advantages

Very cheap form of power; high efficiency; can work at a stretch; maintenance and operating cost is very low and not affected by weather conditions.

Disadvantages

Initial capital investment is high; require good amount of technical knowledge and it causes great danger, if handled without care.

e) Wind Power

The availability of wind power for farm work is quite limited. Where the wind velocity is more than 32 km/h, wind mills can be used for lifting water. The most important reason of its low use is its uncertainty. Thus the average capacity of a wind mill would be about 0.50 hp. It is one of the cheapest sources of farm power available.

This source could not become attractive due to the following limitations of the system :

- Initial investment is high,
- Repair facilities are not available in rural areas,
- Even the matching pump sets and electric generators are not readily available in the country,
- It not suitable for all situations in the country. For the present, the wind mills have limited scope of the use in the country.

Equipments

Hand Equipments

Hand equipment's are those machineries that are to be operated by hand. These equipments require hand power. They can be further classified as:

i. **Hand tools:** spades, shovels, pickaxes, secateurs, steel baskets, rakes, hoes, weeders/mowers, sickles and garden tools

ii. **Hand-operated machinery:** Hand pumps, dusters, sprayers, maize shellers, foot-operated threshers, seed treaters, chaff cutters Some of the common hand equipments with brief descriptions are given below:

2. Based on Farm Operation

Based on type of farm operation farm machineries may be classified as :

a) Tillage machinery

b) Seeding and sowing machine

c) Plant protection machine

d) Intercultural machinery

e) Irrigation machinery

f) Harvesting and threshing Machine

g) Grading and seed processing machine

Some of the common hand equipments with brief descriptions are given below:

a) Secateurs

Garden tool that has two short sharp blade sandis used for cutting plant stems

b) Watering can/Hajari

A vessel usually with a spout used to sprinkle or pourwater especially on plants, also called watering pot.

c) Mowers

Machines that cutor slash grass or other cover crops.. The result is a good cover, because the greater part of the biomass remains intact after cutting.

d) Sprinkler

A device perforated with small holes that is attached to a gardenhose or watering can and used to spray plants, lawns with water

e) Trowel

Any of various tools having a flat blade with a handle, used for depositing and sworking mortar, plaster soil plaster, soil.

f) Barrow

A flat, rectangular frame usedfor carrying a load, especially such aframe with projecting shafts at each end for handles

g) Sprayers

A sprayer is a piece of equipment that is used to apply herbicides, pesticides, and fertilizer so agricultural crops. Spray ersrange in different sizes and shapes from man-portable units (typically backpacks with spray guns) to trailed sprayers.

Figure3:Different types of hand equipments

Power Drawn/Power Operated Machines

These are the machines which require power to operate. The power here is not the hand power or any other animal power. It refers to the power generated from other sources of energy. Some of these machines are ploughs, harrows, rotavators, seed- cum-fertlizer drills, Inclined plate planters, self-propelled paddy tranplanters, multicrop threshers, reapers, mini dal mill, mini rice mill, etc.

Tractor

Tractor is a self-propelled power unit having wheels or tracks for operating agricultural implements and machines including trailers. Tractor engine is used as a prime mover for active tools and stationary farm machinery through power

take-off shaft (PTO) or belt pulley. The most common use of the term "Tractor" is for the vehicles used on farms. The farm tractor is used for pulling or pushing agricultural machinery or trailers , for plowing , tilling, disking, harrowing, planting and similar tasks. A farm tractors used to power a pump for irrigation a plot of land.

Figure- Tractor (Source- Sawraj)

Advantages

1. Increased Productivity

Tractors allow farmers to complete field operations more quickly, enabling higher yields and the ability to manage larger areas of land.

2. Versatility

They can be equipped with various attachments for different tasks, such as plowing, planting, and harvesting, making them multifunctional.

3. Labor Savings

Tractors reduce the need for manual labor, which can be scarce and expensive, especially during peak farming seasons.

4. Efficient Soil Management

Tractors enable more precise and controlled tillage, improving soil health and crop production.

Disadvantages

1. High Initial Costs

The purchase price and maintenance costs of tractors can be a significant financial burden, particularly for small-scale farmers.

2. Soil Compaction

Heavy tractors can lead to soil compaction, which negatively affects soil health and may reduce crop yields over time.

3. Dependence on Fossil Fuels

Most tractors run on diesel or gasoline, contributing to environmental concerns and increasing operational costs.

4. Skill Requirements

Operating tractors requires training and expertise, which may not be readily available in all farming communities.

Power Tiller

It is a prime mover in which the direction of travel and its control for field operation is performed by the operator walking behind it. It is also known as hand tractor or walking type tractor. Power tiller was first introduced in Nepal in the year 1963. Power tiller is a walking type tractor. The operator walks behind the power tiller, holding the two handles of power tiller in his own hands. Power tiller may be called a single axle walking type tractor, though a riding seat is provided in certain designs.

Uses of Power Tiller

a. For puddling operation in paddy fields- using rotary tines.

b. For cutting and pulverizing the soil in dry lands and in garden lands.

c. For cutting and pulverizing the stubbles of sugarcane, maize and cotton.

d. For sowing and inter-cultivation works.

e. For spraying of orchard trees.

Fig- Powertiller (Source-Linked In Powertiller)

Minitiller

The mini-tiller is a mechanized plow used to prepare land for agricultural production. In Nepal, in one hour the mini-tiller ploughs 1 to l.5 ropanis compared bullock-drawn plow, which takes one day to plow 3 to 4 ropani. The mini-tiller is similar purpose to the power-tiller, but is more compact, making it easier to operate on narrow plots terraced land typically found in Nepal's mid-hill region. Both diesel- and petrol fueled tillers have been imported, running on a v-belt or shaft. Petrol-fueled mini-tillers are prefer by farmers because they are lighter than diesel-fueled mini-tillers, Mini-tillers typically use starts; however, some use a hand start and others self-start with an electric button, although self-start model is significantly more expensive. The mini-tiller is also designed to utilize various attachments for agricultural production, processing, and transport including adjustable ridgers, seeders, reapers, threshers, water pumps, and load carriers among others.

Fig- Minitiller (Source-Dkam MicrosystemsMinitiller | Dkam)

8.3. Seed Drill, Seed Cum Fertilizer Drill Machine

Seed Drill

A seed drill is a device that sows the seeds for crops by metering out the individual seeds, positioning them in the soil, and covering them to a certain average depth. The seed drill sows the seeds at equal distances and proper depth, ensuring that the seeds get covered with soil and are saved from being eaten by birds. Before the introduction of the seed drill, a common practice was to plant seeds by hand. Besides being wasteful, planting was usually imprecise and led to a poor distribution of seeds, leading to low productivity. The use of a seed drill can improve the ratio of crop yield (seeds harvested per seed planted) by as much as nine times.

Function of Seed Drill

Seed drill performs the following functions:

i. To carry the seeds

ii. To open furrow to an uniform depth

iii. To meter the seeds

iv. To place the seeds in furrows in an acceptable pattern

v. To cover the seeds and compact the soil around the seed

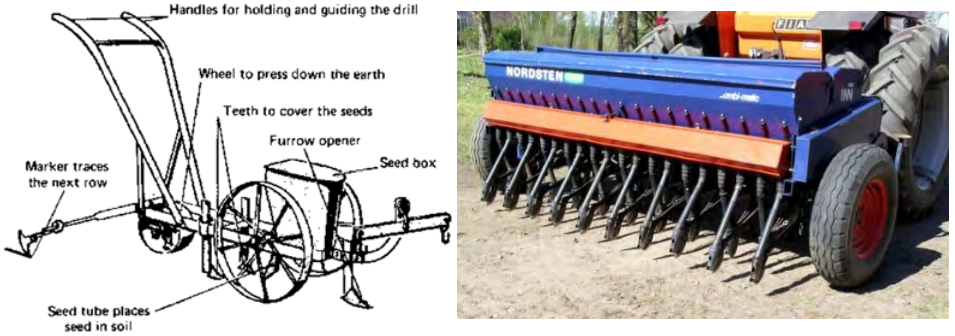


Fig- Seed Drill

Seed Cum Fertilizer Drill Machine

The farming seed-cum-fertilizer drill is used for simultaneous activating of seeding and fertilization process in a single operation. It can be retrofitted to a tractor of 35 HP and above. It drills seeds and fertilizer together but delivers them separately in a single drive. Seeds and fertilizer are drilled at different depths which improves germination. The machine has separate containers for seed and fertilizer.

Figure- Seedcum fertilizer drill

Functions of a Seed Cum Fertilizer Drill : Seed cum fertilizer drill performs the following functions

1. To carry the seeds and fertilizer in separate compartments.
2. To open furrows at uniform depths

3. To meter the seeds and fertilizers
4. To deposit the seed and fertilizer in the furrows in an acceptable pattern

8.4. Tools and Machine use in Tillage Operations

(Types of Plough Machine are as Follows)

Implements for Primary Tillage

The implements used for primary tillage are called as primary tillage implements. They include many animals drawn and tractor drawn implements. Animal drawn implements mostly include indigenous ploughs and mould-board ploughs. Tractor drawn implements include mould-boar ploughs, disc ploughs, heavy duty disk harrows, subsoil ploughs, chisel ploughs and other similar implements.

Plough

The main implement used for primary tillage is a plough. Ploughing essentially consists of opening the upper crust of the soil, breaking the clods and making the soil suitable for sowing seeds.

Classification of ploughs according to power used

a. Bullock drawn ploughs-indigenous types
b. Tractor drawn ploughs

Indigenous Types

It is an animal drawn plough. It penetrates into the soil and breaks it open. It forms V shaped furrows with 15-20 cm top width and 12-15 cm depth. It can be used for ploughing in dry land, garden land and wetlands. The size of the plough is represented by the width of the body and the field capacity is around 0.4 ha per day of 8 hours. The functional components include share, body, shoe, handle and beam. Except share all other parts are made up of wood. In villages local artisans make the plough and supply to the farmers. These ploughs are also called as country ploughs.

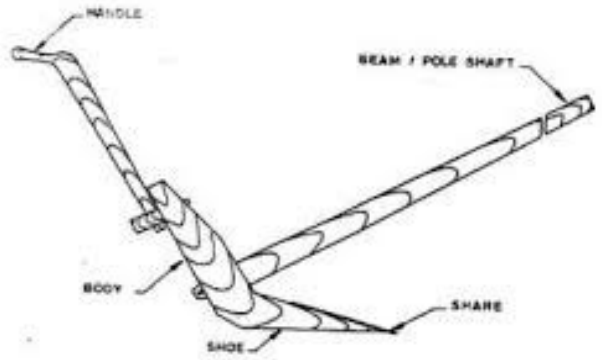


Figure- Indigenous plough

(Source- SNS Courcewarehttps://snscourseware.org/snsctnew/files/1691664785.pdf)

Mould Board Plough (M.B. Plough)

A mould board plough is very common implement used for primary tillage operations. Mould board ploughs are available for animals, power tiller and tractor operation/While working. a mould board plough does four jobs namely

a) cutting the furrow slice
b) lifting the furrow slice
c) inverting the furrow slice and
d) pulverizing the furrow slice.

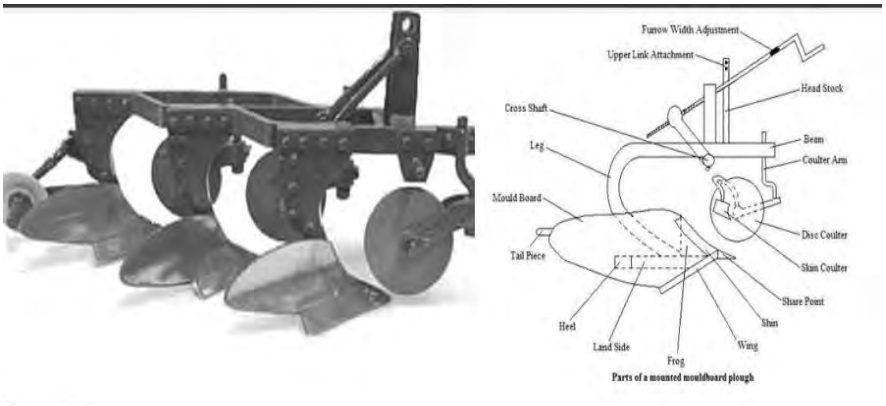


Figure- MB plough

Disc Plough

An action of a disc plough is similar to the mould board plough. Disc plough cuts, turns in some cases breaks furrow slices by means of separately mounted large steel concave dises. A Disc plough is designed with view to reduce friction by making a rolling plough bottom instead of sliding plough bottom as in the case of moldboard plough. A disc plough works in the conditions where moldboard plough does not work satisfactorily.

Figure- Disc Plough (Source- Fieldking)

Chisel Plough

Chisel ploughs are used to break through and shatter compacted or otherwise impermeable soil layers. Deep tillage shatters compacted sub soil layers and aids in better infiltration and storage of rainwater in the crop root zone. The improved soil structure also results in better development of root system and the yield of crops and their drought tolerance is also improved. The functional component of the unit includes reversible share, tyne (chisel), beam, cross shaft and top link connection. Chisel plough consists of heavy chisel type tyne which is pulled through the soil normally at a depth greater than that at which conventional ploughing would be done and bursting up the underlying layers of soil without bringing the sub-soil to the surface. -Hitch bracket

Figure- Chisel plough (Source-*Agrotech*)

Sub-Soil Plough

The function of the sub-soiler is to penetrate deeper than the conventional cultivation machinery and break up the layers of the soil, which have become compacted due to the movement of heavy machinery or as a result of continuous ploughing at a constant depth. These compacted areas prevent the natural drainage of the soil and also inhibit the passage of air and nutrients through the soil structure. The sub-soiler consists of heavier tyne than the chisel plough to break through impervious layer shattering thesub-soil to a depth of 45 to 75 cm and requires 60 to 100 hp to operate it.

Implements for Secondary Tillage

Tillage operation are primary tillage which are performed to create proper soil tilth for seeding and planting are secondary tillage. These are lighter and finer operations, performed on the soil after primary tillage operations. Secondary tillage consists of conditioning the soil to meet the different tillage objectives of the farm. They include different types of harrow, cultivators, sweeps, clod crushers, levelers, bund formers, ridge ploughs ete.

a) Harrow

Harrow is a secondary tillage implement that cuts the soil to a shallow depth for smoothening and pulverizing the soil as well as to cut the weeds and to mix the materials with the soil. There are several types of harrow used in Nepal such as

disc harrow, spike tooth harrow, spring tooth harrow, acme harrow, triangular harrow, bade harrow and reciprocating power harrow.

Puddler

Puddler is an implement for churning the soil with water. It is used to prepare paddy fields with standing water after initial ploughing with country plough. It breaks up the clods and churns the soil. The main purpose of puddling is to reduce leaching of water or decrease percolation of water, to kill the weeds by decomposition and to facilitate transplantation of paddy seedlings by making soil softer. Puddling is done in standing water of 5-10 cm depth. A common puddler has puddling units each having four straight blades or paddies or fan type blades or squirrel type blade mounted on an axle. The weight of the puddler is 30-40 kg

Leveler

Land leveling is expected to bring permanent improvement in the value of land. Leveling work is carried out to modify the existing contours of land so as to achieve certain objectives desired for efficient agricultural production system. These objectives include

(1) efficient application of irrigation water

(2) improved surface drainage

(3) minimum soil erosion

(4) increased conservation of rain waterspecially on dry lands and

(5) provision of an adequate field size and even topography for efficient mechanization

Cultivators

It is an implement for inter cultivation with laterally adjustable tines or discs to work between crop rows. The cultivator stirs the soil, and breaks the clods. The tines fitted on the frame of the cultivator comb the soil deeply in the field. A cultivator performs functions intermediate between those of plough and

the harrow. Destruction of weeds is the primary function of a cultivator. The following are a few important functions performed by a cultivator.

1. Inter cultural the fields.
2. Destroy the weeds in the field.
3. Aerate the soil for proper growth of crops.
4. Conserve moisture by preparing mulch on the surface.
5. To sow seeds when it is provided with sowing attachments.
6. To prevent surface evaporation and encourage rapid infiltration of rain water into the soil.

8.5. Harvester

- A harvester is a machine which is used for harvesting.
- The designs and functions of harvesters vary widely according to crops.
- Harvesting is process of collecting the mature rice crop from the field.
- Harvesting of crops includes cutting, stacking, handling, threshing, cleaning and hauling.
- The goal of the good harvesting methods is to maximize grain yield and to minimize grain damage and quality deterioration.
- Some of the popular harvesters are:

a) Forage Harvester

A forage harvester (also known as a silage harvester, forager or chopper) is a farm implement that harvests forage plants to make silage. Silage is Grass, com or other plant that has been chopped into small pieces, and compacted together in a storage silo, silage bunker, or in silage bags. The silage is then fermented to provide feed for livestock. Haylage is a similar process to silage but using grass which has dried.

Figure- Forage Harvester

b) Fruit Harvester-

The following are the suitable tools and equipment used for harvesting fruits:

Figure-Fruit harvesting tools

c) Combine Harvester

The combine harvester is a machine that harvests grain crops. The name derives from its combining three separate operations comprising harvesting-reaping, threshing, and winnowing-into a single process. Among the crops harvested with a combine are wheat, oats, rye, barley, corn (maize), sorghum, soybeans, flax (linseed), sunflowers, etc. The waste straw left behind on the field is the remaining dried stems and leaves of the crop with limited nutrients which is either chopped and spread on the field or baled for feed and bedding for livestock.

Exercise

Choose the correct answer from the given alternatives.

1. The size of M.B. plough is expressed in terms of its ……

   a. Width of cut b. Depth of cut

   c. Length of share d. None of these

2. The disc angle of plough influences.....

   a. Depth of cut b. Width of cut

   c. Both a and b d. None of the above

3. The application engineering and technology is agricultural operations to do a better way to improve productivity.....

   a. Custom hiring b. Farm mechanization

   c. Farm machinery d. All of the above

4. ……. is a machine which is used for harvesting.

   a. Harvester b. Seed drill

   c. a and b both d. None of the above

5. A device that sows the seeds for crops by metering out the individual seeds is known as….

   a. Harvester b. Seed drill

   c. a and b both d. None of the above

Write short answer to the following questions.

1. What are the advantages of farm mechanization?
2. How combine harvester is use for harvesting grain crops.
3. What are the disadvantages of MB plough?
4. Define seed drill. Enlist the function of seed drill.
5. Write short notes about

a. Disc plough

b. Indigenous plough

Write long answer to the following questions.

1. Define farm mechanization and write its importance on agricultural production in Nepal.
2. Write down the status of farm mechanization in Nepal.
3. Lists out the tools and machinery used in agriculture and describe three among them with figures.
4. Define tractor. Write down the advantages and disadvantages of tractor.

Prject Work

1. Identification of hand tools and implements used in tillage
2. Land and seed bed preparation.
3. Identification of tractor and their parts.
4. Practice harvesting method of Rice.

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