ISBN: 978-93-95847-73-5

A PRACTICAL MANUAL ON FUNDAMENTALS OF AGRONOMY

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Bhumi Publishing

Bhumi Publishing, India
First Edition: January 2025

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Published by:

BHUMI PUBLISHING

Nigave Khalasa, Tal – Karveer, Dist – Kolhapur, Maharashtra, INDIA 416 207

E-mail: bhumipublishing@gmail.com

FOREWORD

The field of Agronomy focuses on the principles and methods of crop cultivation and soil management. It is becoming increasingly clear that students studying Agriculture must possess a strong understanding of the practical elements of Agronomy.

The manual for Fundamentals of Agronomy emphasizes perspectives from both academics and students, with extensive coverage of topics including crop identification, seed analysis, weed control, fertilizer application, plant protection chemicals, weed management, water quality assessment, and measurement techniques. The authors have revamped the experiments, following the recommendations of the Sixth Dean Committee, to enhance the learning experience whenever possible. This book is seen as meeting a longstanding need among students.

PREFACE

This practical manual serves as a textbook for undergraduate students in the field of Agriculture and is also beneficial to research scholars and professionals involved in agriculture development and management, particularly within the teaching domain. Introductory Agronomy encompasses essential subjects such as agronomy, soil and water management, farm machinery, engineering, soil science, plant breeding, and genetics. It is imperative for undergraduate students to acquire knowledge in all these areas for comprehensive agriculture development and management. The manual aims to offer students a holistic perspective on these subjects.

A foundational understanding of crop identification, seed analysis, weed control, fertilizers, plant protection chemicals, water quality assessment, and measurement is crucial for effective crop planning in diverse scenarios. Hence, the manual is designed to address topics relevant to the field of agronomy. It acts as a valuable resource for agriculture students and teachers seeking information on agronomy from various perspectives. The content of this manual is a compilation from different sources, with due credit given to the original authors, books, manuals, and online resources used in its preparation.

The authors express their gratitude to Honorable Vice Chancellor Prof. Deepa Sharma and thank Dr. Ajay Singh and other colleagues for their valuable input in enhancing the quality during the creation of the first edition of Fundamentals of Agronomy. They extend their appreciation to all well-wishers for their support. The authors welcome constructive feedback from readers for further enhancements and refinements to the text. References are provided at the end of the book and within footnotes to acknowledge the sources of the materials used.

- Authors

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EXPERIMENT 1: IDENTIFICATION OF CROPS, SEEDS, FERTILIZERS AND PESTICIDES

Aim: To study the identification of crops, seeds, fertilizers, and pesticides

MATERIALS REQUIRED:

1. Crops (Cereals, pulses, and millets)
2. Seeds (Rice, wheat, and Maize)
3. Fertilizers:
- Urea
- DAP (Diammonium Phosphate)
- MOP (Muriate of Potash)
4. Weedicides:
- Atrazine
- Glyphosate

THEORY:

Identification of crops:

Cereals:

- Cereals are herbaceous plants belonging to the Grass family (Gramineae or Poaceae).
- They have round, hollow internodes.
- Cereals have narrow leaves and flowers in inflorescence form (spikes, earhead, and panicles).
- They are generally monocots.
- Cereals are used to make flours that have been consumed since ancient times.

Pulses:

- Pulses belong to the Leguminaceae or Fabaceae family.
- They are generally dicots with broad leaves that bear pods.
- Pulses enrich our diet with protein and fix atmospheric nitrogen into the soil.
- Rich in essential amino acids like lysine and methionine.

Millets:

- Millets belong to the Grass family (Gramineae or Poaceae).
- They produce small edible seeds.
- Millets have narrow leaves and flowers in inflorescence form (spikes, ear head, and panicles).
- Used as forage crops and food cereals.

Identification of seeds:

Rice:

- Rice seeds are oval or round in shape.

- Straw yellow in colour.
- Rice seeds possess the following features:
- Water: 68.44 g
- Protein: 2.69 g
- Energy: 130 kcal

Wheat:

- Wheat seeds are generally oval in shape.
- Straw yellow in colour.

Maize:

- Seeds of maize are bold in appearance.
- Pale yellow/bright yellow in colour.
- Seeds are narrow at the end and wider at the top.

Identification of fertilizers:

Urea:

- Extensively used as a nitrogenous fertilizer supplying 46% nitrogen to the soil.
- Granules of urea are crystalline white.
- It is an organic fertilizer.

DAP (Diammonium Phosphate):

- Extensively used as fertilizer supplying 46% phosphorus and 18% nitrogen to the soil.
- Greyish in colour.

MOP (Muriate of Potash):

- Extensively used as a fertilizer supplying 60% potassium to the soil.
- Reddish in colour.

Identification of Weedicides:

Atrazine:

- A selective weedicide that kills weeds soon after emergence.
- Used in weed management of crops like maize and sugarcane.

Glyphosate:

- Glyphosate (N-(phosphonomethyl)glycine) is a broad-spectrum systemic herbicide and crop desiccant.
- An organophosphorus compound, specifically a phosphonate.
- Used to eliminate weeds, especially annual broadleaf weeds and grasses competing with crops.

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EXPERIMENT 2: IDENTIFICATION OF TILLAGE IMPLEMENTS

Aim: To identify different types of tillage implements

Materials Required:

1. **Primary tillage implements:**
   a. Wooden plough
   b. Mouldboard plough
   c. Disc plough
   d. Chisel plough
   e. Rotary hoe
2. **Secondary tillage implements**
   a. Cultivator
   b. Harrow
   c. Guntaka
3. **Implements for seeding:**
   a. Seed drill
   b. Ferti-cum-seed drill

Theory:

Tillage: The physical manipulation of soil using tools and implements to create suitable conditions for crop germination and growth is known as tillage.

Primary Tillage:

The initial soil cultivation process involving the use of ploughs is referred to as primary tillage.

Secondary Tillage:

The subsequent finer operations done on the soil after primary tillage are classified as secondary tillage.

Primary Tillage Implements:

Ploughs are primarily used for primary tillage to open and loosen the soil. Ploughs come in three main types: wooden ploughs, iron or inversion ploughs, and special purpose ploughs.

1. **Wooden Plough or Indigenous Plough:**

An indigenous plough is made of wood with an iron share point and includes a body, shaft, pole, share, and handle. It cuts a "V" shaped furrow without inverting the soil completely. Cross ploughing is sometimes necessary to reduce unploughed areas.

2. **Moldboard Plough:**

This type of plough cleanly cuts and inverts furrow slices to one side, ensuring thorough soil pulverization. It is typically drawn by animals or tractors. Please review the following text and let me know if it aligns with your expectations:

- **Mouldboard Ploughs:** It ploughs to a depth of 15 cm, while larger mouldboard ploughs attached to tractors can plough to depths of 25 to 30 cm. Mouldboard ploughs are utilized when soil inversion is required. The Victory plough is a short-shaft animal-drawn mouldboard plough.
- **Disc Plough:** The disc plough differs significantly from the traditional mouldboard plough, as it turns the furrow slice to the side with a scooping action. This type of plough is suitable for land with substantial fibrous weed growth since the disc cuts and incorporates the weeds.
- **Chisel Plough:** Primarily employed for breaking hardpans and deep ploughing (60-70 cm) with minimal disruption to the top layers.
- **Rotary Hoe:** This implement cuts and pulverizes the soil using blades or Tynes and is ideal for light soils.
- **Secondary Tillage Implements:** Cultivators, harrows, planks, and rollers are among the different types of implements used for secondary tillage.
- **Tractor Drawn Cultivator:** Also known as a tiller or tooth harrow, this tool is used to further loosen previously ploughed land before sowing and to eliminate weeds that sprout after ploughing.
- **Harrow:** These tools are utilized for shallow cultivation tasks like seedbed preparation, seed covering, and weed seedling destruction. There are two main types of harrows: disc harrows and blade harrows.
- **Disc Harrow:** The disc harrow is composed of multiple concave discs ranging from 45 to 55 cm in diameter. These discs are smaller than those on a disc plough, but a greater quantity of discs is mounted on a frame. They slice through the soil, effectively breaking up clods.
- **Blade Harrow:** Blade harrows serve various purposes such as weed and stubble removal, clod crushing, shallow soil cultivation, seed covering, intercultivation, and groundnut harvesting.

- **Indigenous Blade Harrows:** The typical design of an indigenous blade harrow, known as guntaka, includes a beam with two attached pegs at the ends. A blade is fixed to these pegs, with two shaft poles and a handle completing the gun taka.
- **Guntaka:** Guntaka, or blade harrow, is utilized for weed and stubble removal and for seeding crops. It is operated by a pair of cattle.

Implements for Sowing:

1. Seed Drill:

A farming implement used to sow seeds evenly at the correct depth and spacing, ensuring optimal germination and crop growth.

2. Ferti-cum-Seed Drill:

Fertilizers are positioned at a depth of 5 cm and 5 cm away from seed rows for efficient fertilizer utilization. The ferti-cum-seed drill allows for simultaneous drilling of seeds and fertilizers, similar to a seed drill but with additional tynes and a hopper specifically for drilling fertilizers.

EXPERIMENT 3: IDENTIFICATION OF WEEDS

Aim: To identify weeds

A basic illustrated glossary of weed identification

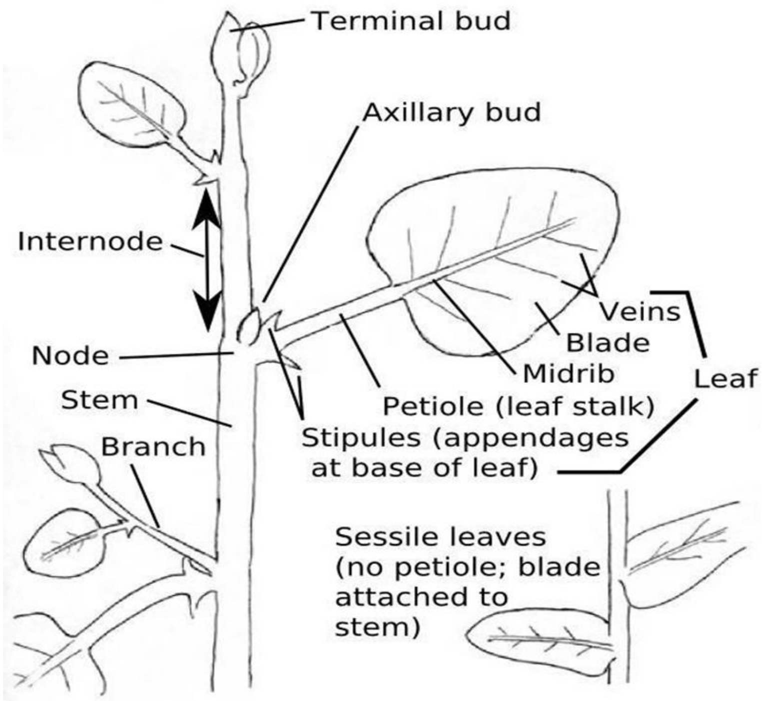

Figure 1: Structures on a broadleaf weed or crop

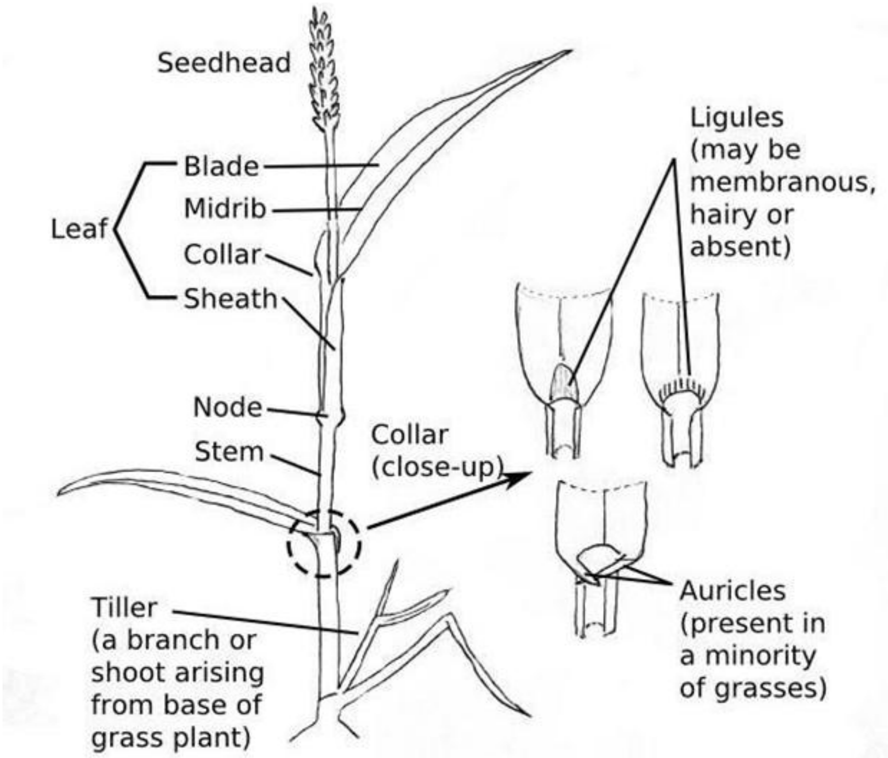

Figure 2: Structures on a grass weed or crop

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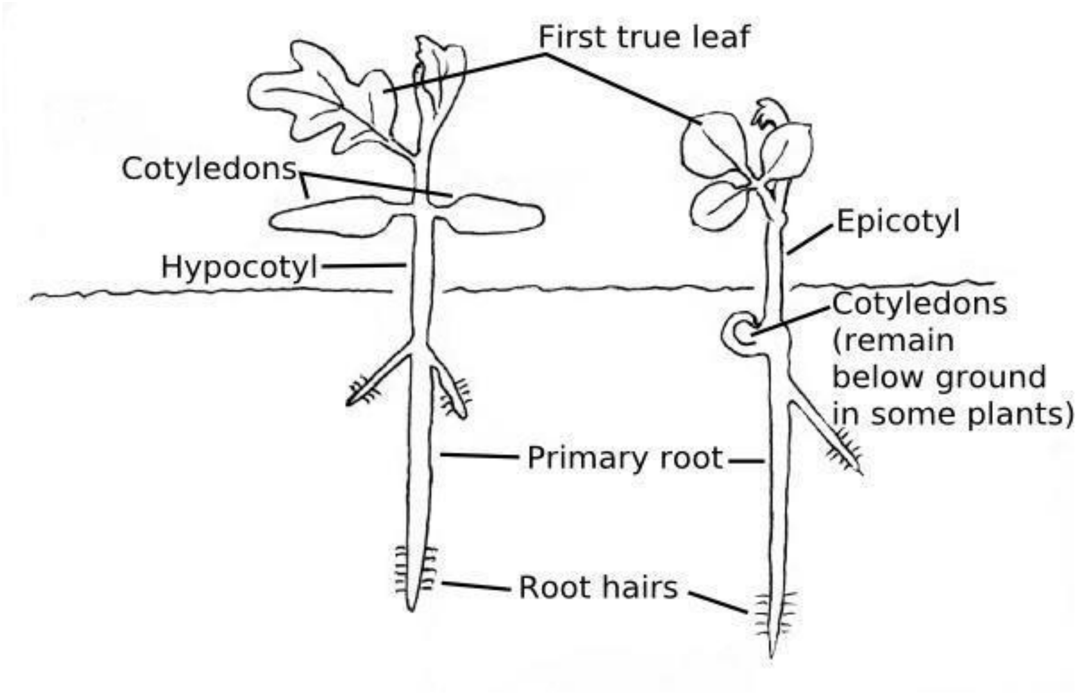

Figure 3: Broadleaf seedlings

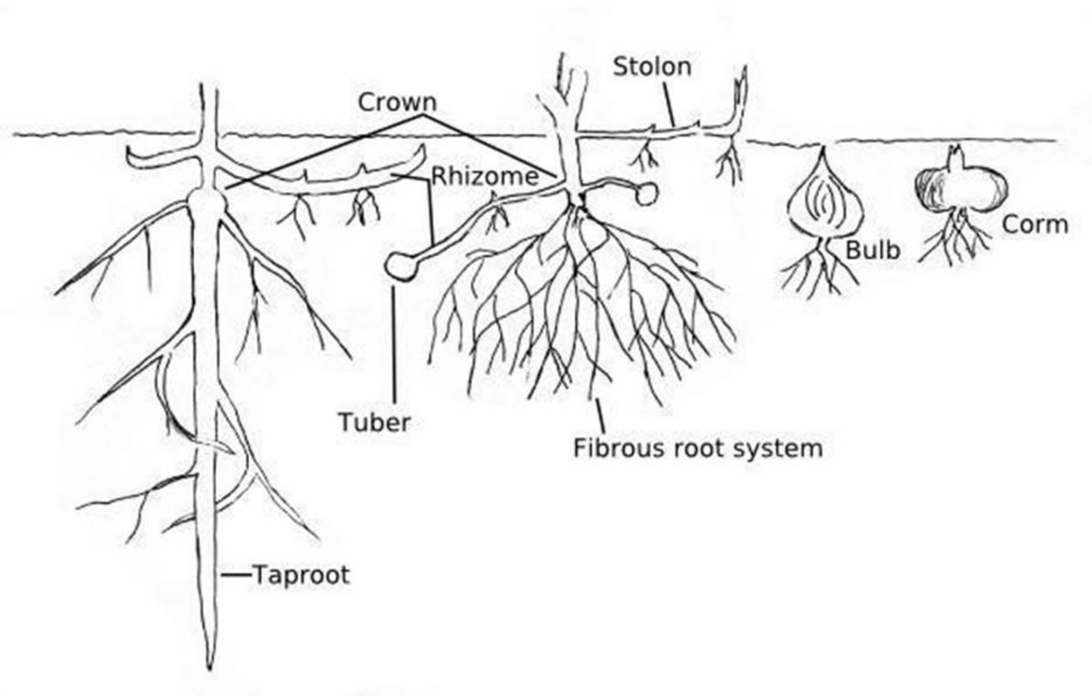

Figure 4: Roots and other underground structures

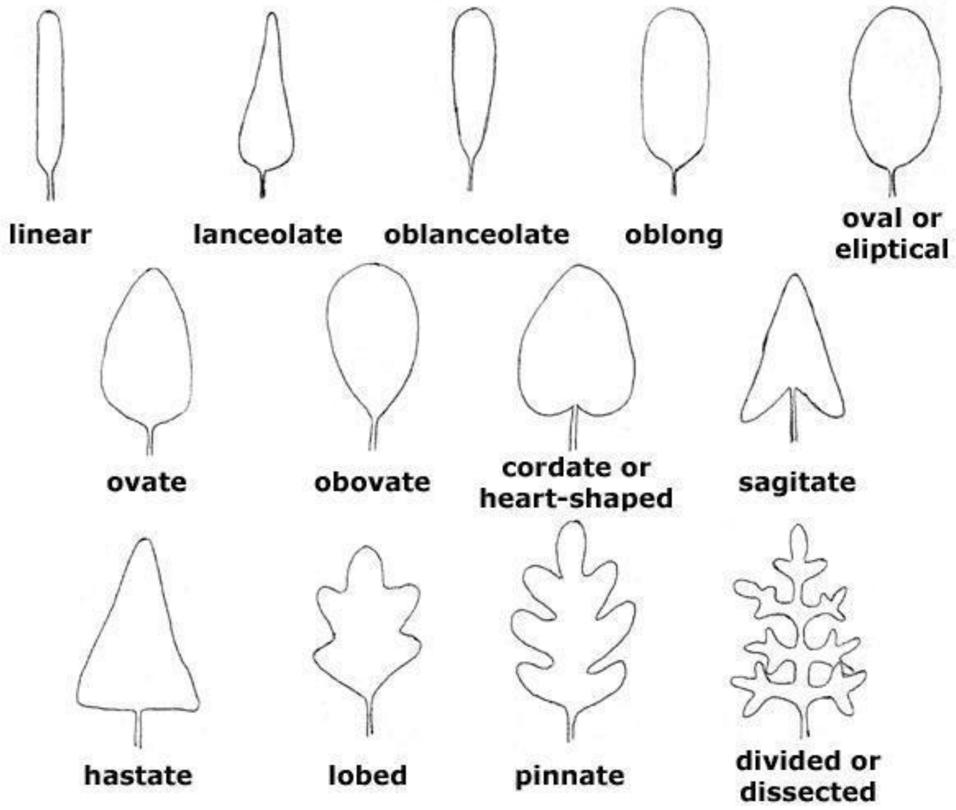

Figure 5: Leaf shapes

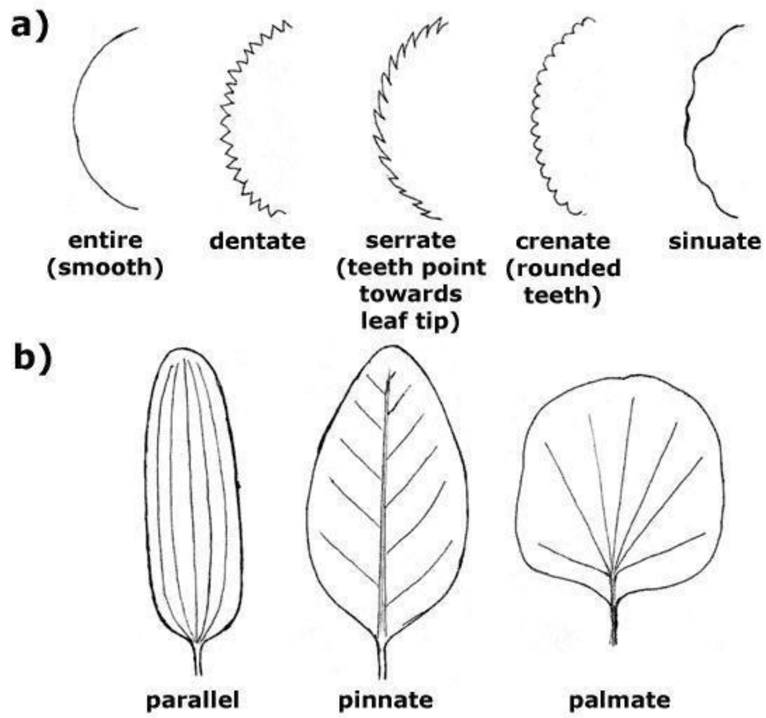

Figure 6: (a) Leaf margins (b) Leaf venation

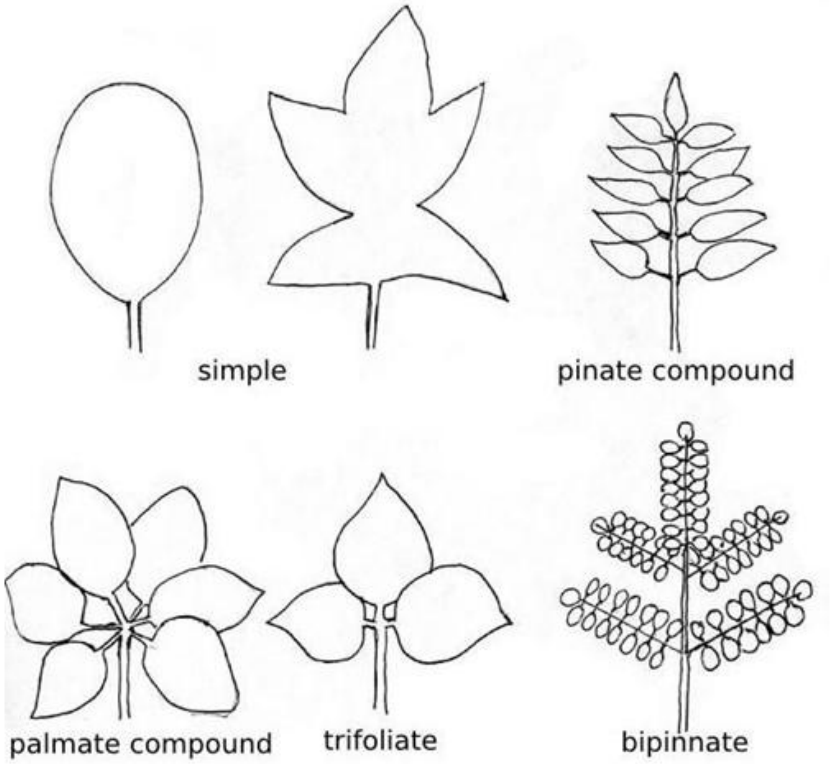

Figure 7: Leaf structures

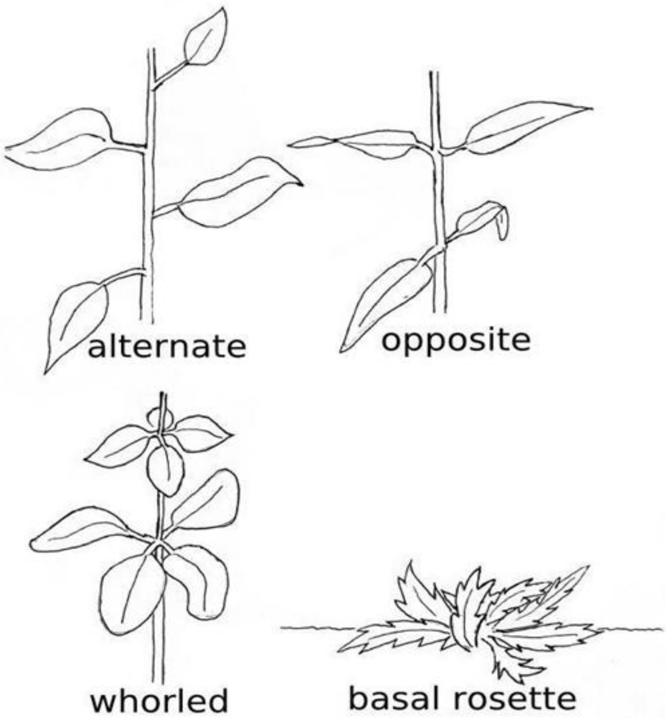

Figure 8: Arrangement of leaves

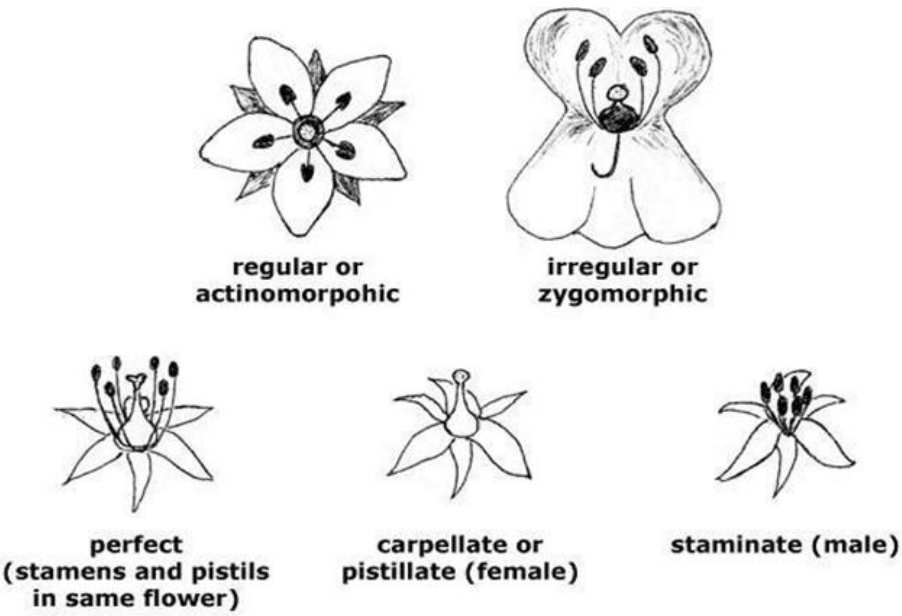

Figure 9: Type of flower

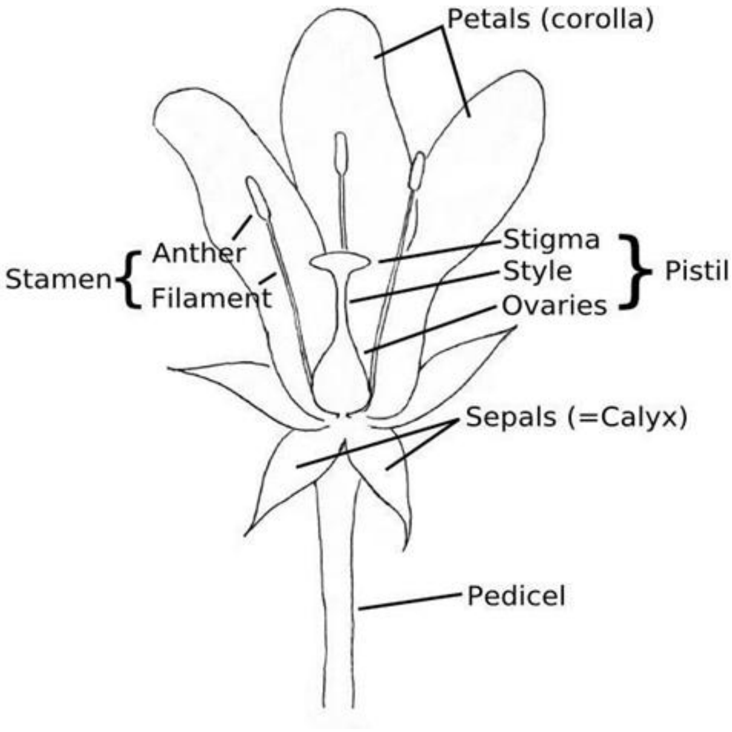

Figure 10: Flower structures

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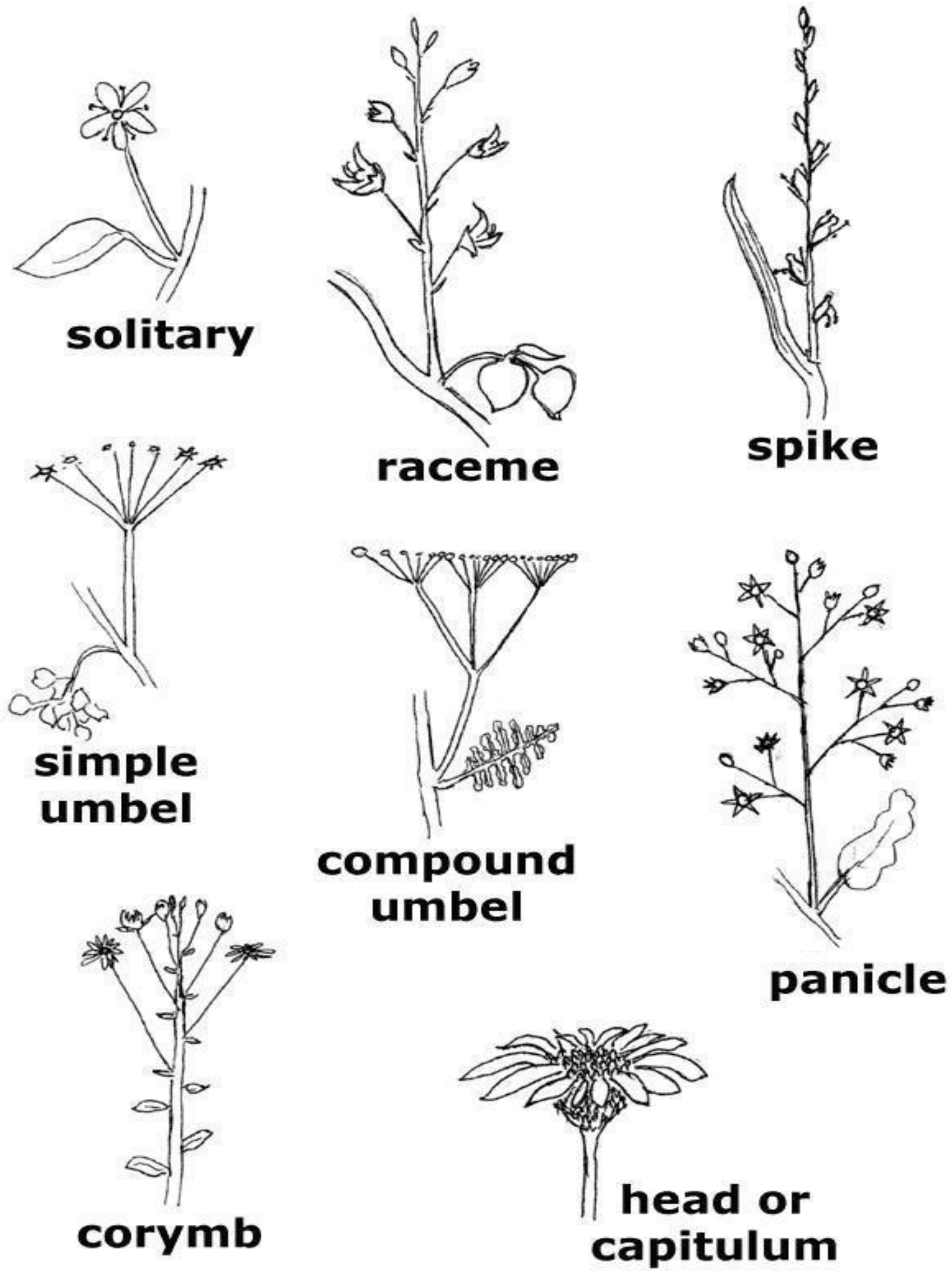

Figure 11: Inflorescences (arrangement of flowers in clusters)

Commelina benghalensis

Boerhavia erecta

Chenopodium album

Sonchus arvensis

Phleum pratense

Sorghum halapense

Cynodon dactylon

Convolvulus arvensis

Cyperus rotundus

Ammania baccifera

Eclipta alba

Trianthema portulacastrum

Digera arvensis

Tribulus terrestris

Argemone mexicana

Prosopis juliflora

Leucas aspera

Lantana camara

Spergula arvensis

Gynandropsis pentaphylla

Calotropis gigantea

Parthenium hysterophorus

Acanthospermum hispidum

Phalaris minor

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Indigofera enneaphylla

Cynodon dactylon

Cyperus rotundus

Tridax procumbens

Echinochloa colona

Crotalaria verucosa

Rumex acetosella

Taraxacum sp.

Datura metal

Croton sparsiflorus

Amaranthus viridis

Cuscuta chinensis

Loranthus longiflorus

***Orabanche cernua* on Tobacco**

***Striga lutea* on sorghum**

Echinocholoa

Eichhornia crassipes

Salvinia sp.

Typha sp.

Polygonum sp.

EXPERIMENT 4: AGRO-CLIMATIC ZONES OF INDIA

Aim: Investigate the Classification of Agro-Climatic Zones in India by the Planning Commission

In 1989, the Planning Commission of India sought to categorize the nation into distinct Agro-climatic regions characterized by similarities in rainfall, temperature, topography, cropping patterns, farming systems, and water resources. India is segmented into 15 Agro-climatic regions.

Agro-climatic Zones

Sl. No.	Agro-Climatic Zones	Area
1	Western Himalayan Region	J&K, HP, UP, Utranchal
2	Eastern Himalayan Region	Assam Sikkim, West Bengal & North-Eastern states
3	Lower Gangetic Plains Region	West Bengal
4	Middle Gangetic Plains Region	UP, Bihar
5	Upper Gangetic Plains Region	UP
6	Trans-Gangetic Plains Region	Punjab, Haryana, Delhi & Rajasthan
7	Eastern Plateau and Hills Region	Maharastra, UP, Orissa & West Bengal
8	Central Plateau and Hills Region	MP, Rajasthan, UP
9	Western Plateau and Hills Region	Maharastra, MP & Rajasthan
10	Southern Plateau and Hills Region	AP, Karnataka, Tamil Nadu
11	East Coast Plains and Hills Region	Orissa, AP, TN, & Pondichery
12	West Coast Plains and Ghat Region	TN, Kerala, Goa, Karnataka, Maharastra
13	Gujarat Plains and Hills Region	Gujarat
14	Western Dry Region	Rajasthan
15	The Islands Region	Andman & Nicaobar, Lakshya Deep

Western Himalayan Region

The region features steep slopes in undulating terrain. The soils predominantly consist of silt loams, which are susceptible to erosion hazards.

Western Plateau and Hills Zone

The zone experiences an average rainfall of 904 mm. The net sown area covers 65% of the total area, while forests occupy 11%. Only 12.4% of the area is irrigated, mainly through canals.

Southern Plateau and Hills Zone

This zone is typically semi-arid, with dryland farming practiced in 81% of the area. The cropping intensity is 111%.

East Coast Plains and Hills Zone

The soils in this zone are mainly alluvial and coastal sands. Irrigation is primarily through canals and tanks.

West Coast Plains and Ghats Zone

Encompassing the west coast of Tamil Nadu, Kerala, Karnataka, Maharashtra, and Goa, this zone exhibits a variety of crop patterns, rainfall, and soil types.

Gujarat Plains and Hills Zone

Characterized by arid conditions and low rainfall, only 32.5% of the area is irrigated, predominantly through wells and tube wells.

Western Dry Zone

This zone is characterized by a hot sandy desert, erratic rainfall, high evaporation, and scanty vegetation. Groundwater is deep and often brackish, with frequent occurrences of famine and drought.

Islands Zone

Encompassing the island territories of Andaman and Nicobar and Lakshadweep, this zone has an equatorial climate with an average rainfall of 3000 mm spread over eight to nine months. It is predominantly covered by forests with undulated lands.

Classification by ICAR

Under the National Agricultural Research Project (NARP) by ICAR, State Agricultural Universities were advised to divide each state into sub-zones. Based on factors like rainfall and cropping patterns, 127 Agro-Climatic zones are classified.

State	No. of Zones
Andhra Pradesh	7
Assam	6
Bihar	6
Gujarat	8
Haryana	2
Himachal Pradesh	4
Jammu and Kashmir	4
Karnataka	10
Kerala	8
Madhya Pradesh	12
Rajasthan	9
Maharashtra	9
North Eastern Hill region	6
Orissa	9
Punjab	5
Tamil Nadu	7
Uttar Pradesh	10
West Bengal	6

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EXPERIMENT 5: METHODS OF HERBICIDE APPLICATION

Aim: To explore the techniques used for applying herbicides

Various methods used for applying these herbicides are listed in the table below

Soil application	Foliar application
Surface	Blanket spray
Sub-Surface	Directed spray
Band	Protected spray
Fumigation	Spot treatment
Herbigation	Herbicide + irrigation

Soil Herbicide Application

Soil active herbicides are applied evenly on the soil surface through spraying or broadcasting. The herbicides can either be left undisturbed or mixed into the soil to prevent volatilization and photo-decomposition.

Eg. Fluchoralin – Left undisturbed under irrigated conditions

- Incorporated under rainfed conditions

Subsurface Application

This method involves applying herbicides in a concentrated band approximately 7-10 cm below the soil surface to control perennial weeds. A special nozzle is used to introduce the herbicides below the soil while being covered by a sweep hood.

Eg. Carbamate herbicides to control Cyperus rotundus, Nitralin herbicides to control Convolvulus arvensis

Band Application

Herbicides are applied in a limited band along the crop rows, leaving untreated areas in between. The inter-rows are later cultivated to remove weeds, allowing for cost savings. For instance, applying a 30 cm wide band of herbicide over crop rows spaced 90 cm apart saves two-thirds of the cost.

Fumigation

Fumigation involves applying volatile chemicals into confined spaces or the soil to generate gas that destroys weed seeds. Herbicides used for fumigation are referred to as fumigants. This method is effective for killing perennial weeds and eliminating weed seeds, such as Methyl bromide and Metham.

Herbigation

Herbigation is the application of herbicides with irrigation water using surface or sprinkler systems. In India, farmers commonly apply fluchloralin for chillies and tomatoes, while EPTC is widely used with sprinkler irrigation water in western countries for Lucerne crops.

Foliar Herbicide Application - Blanket Spray

This method involves uniformly applying herbicides to standing crops without considering the specific location of the crop. Highly selective herbicides are utilized here. For example, spraying 2,4-Ethyl Ester on rice three weeks after transplanting.

Directed Spray

Herbicides are applied only on weeds between crop rows by directly targeting the spray on the weeds while avoiding the crop. This can be achieved through the use of protective shields or hoods. For example, spraying glyphosate between tapioca rows using a hood to control Cyperus rotundus.

Protected Spray

This method involves applying non-selective herbicides on weeds by covering widely spaced crops with materials like polyethylene covers. It is expensive and labour-intensive but is used by farmers for spraying glyphosate to control weeds in jasmine, cassava, and banana fields

Spot Treatment

This method is employed on small areas with severe weed infestation to eradicate and prevent its spread. Tools like rope wick applicators and herbicide gloves are useful for spot treatments.

EXPERIMENT 6: METHODS OF FERTILIZER APPLICATION

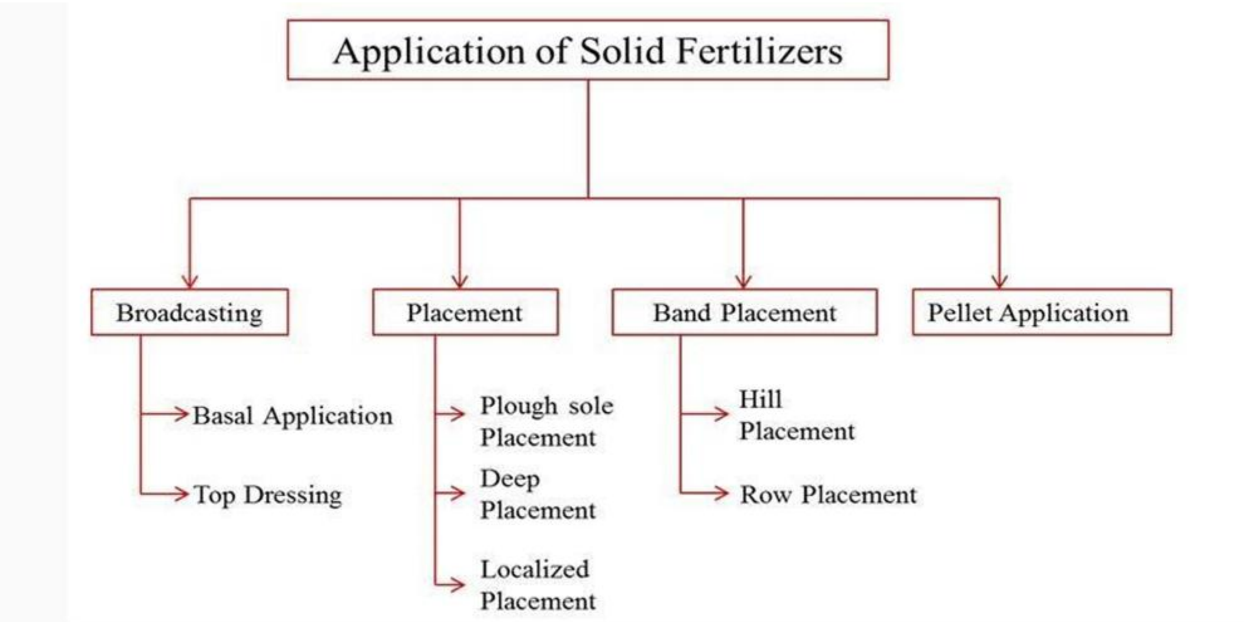
Aim: Examining Various Methods of Applying Fertilizers

Fertilizers are chemical substances that contain essential nutrients for plant growth. They provide vital nutrition to crops, enhancing yields and supporting overall plant health and development. Nitrogen, present in fertilizers, stimulates growth, often indicated by the green color in plants. Phosphorus, another key component, aids in seed formation and root development. To optimize the benefits of fertilizers, it is crucial to apply them at the right time and in the correct manner, considering various factors. Different soils interact uniquely with fertilizer applications, and the nutrient requirements of crops, including nitrogen (N), phosphorus (P), and potassium (K), vary. Additionally, even within a single crop, nutrient needs change at different growth stages.

These fertilizers come in solid granules and can be fully or partially soluble, while some are available in liquid form. The methods of applying solid and liquid fertilizers differ.

Techniques for Applying Solid Fertilizers

Various methods for solid fertilizer application are illustrated in the following classification chart.



Broadcasting

Broadcasting involves evenly spreading fertilizers across the entire field. This method is most suitable for crops with dense stand, where plant roots penetrate the entire volume of the soil. Normally broadcasting results in the application of high doses of fertilizers. Insoluble phosphatic fertilizers, such as rock phosphate, are commonly used with this method. There are two types of broadcasting methods:

a) Broadcasting at sowing or planting (Basal application)

The primary goals of broadcasting fertilizers during sowing are to ensure uniform distribution over the field and proper mixing with the soil.

b) Top Dressing

This method involves broadcasting nitrogenous fertilizers, especially in closely planted crops like paddy and wheat, to supply readily available nitrogen to growing plants.

Disadvantages of Broadcasting

The main drawbacks of broadcasting fertilizers include:

i) Nutrients may not be fully utilized by plant roots as they spread laterally over long distances.
ii) Stimulated weed growth throughout the field.
iii) Nutrients may get fixed in the soil when coming in contact with a large soil mass.

Placement

Placement refers to positioning fertilizers in the soil at specific locations, with or without considering the seed's position. This method, recommended for applying small quantities of fertilizers, is preferred in cases of poor root development, low soil fertility, and the need for Phosphatic and Potassic fertilizers. Common placement methods include:

a) Plough Sole Placement

In this method, fertilizers are deposited at the base of the plough furrow in a continuous band during ploughing. Every band is covered as the next furrow is turned.

This technique is effective in arid regions where the soil tends to be dry up to a few centimeters below the surface and in soils with a dense clay layer just beneath the plow sole.

b) Deep Placement

Deep placement involves placing ammoniacal nitrogen fertilizers in the root zone of the soil, especially in paddy fields, to ensure the availability of nitrogen to the crops. This method improves fertilizer distribution in the root zone and minimizes nutrient loss through runoff.

c) Localized Placement

Localized placement refers to applying fertilizers near the seed or plant to supply sufficient nutrients to the developing roots. Some common methods of localized fertilizer placement include the following:

Drilling:

In this method, fertilizers are applied during sowing using a seed-cum-fertilizer drill. While this method is suitable for applying Phosphatic and Potassic fertilizers to cereal crops, high soluble salt concentrations may sometimes harm seed germination and young plants.

Side Dressing:

Side dressing involves spreading fertilizer between rows and around plants. Common side dressing methods include:

1. Hand placement of nitrogenous fertilizers between crop rows, such as maize, sugarcane, and cotton, to provide additional nitrogen to growing crops.
2. Placement of fertilizers around trees like mango, apple, grapes, and papaya.

Band Placement:

When discussing the application of fertilizers in bands, two main methods are commonly used:

a) Hill Placement

This method involves placing fertilizers in bands near the plant in orchards. The length and depth of the bands vary based on the crop being grown.

b) Row Placement

For crops like sugarcane, potato, maize, and cereals planted closely together in rows, fertilizers are applied in continuous bands on one or both sides of the row.

Pellet Application

Nitrogenous fertilizer in pellet form is placed 2.5 to 5 cm deep between rows of paddy crops. The fertilizer is mixed with the soil, formed into pellets, and deposited in paddy fields.

Advantages of Band Fertilizer Placement:

i) Minimizes soil-fertilizer contact, reducing nutrient fixation.
ii) Limits weed access to fertilizers.
iii) Enhances residual fertilizer response.
iv) Improves fertilizer utilization by plants.
v) Decreases nitrogen loss through leaching.
vi) Enhances utilization of immobile phosphates when placed.

Liquid Fertilizer Application Methods

Liquid and water-soluble granular fertilizers can be applied in various ways, as indicated in the classification chart for application methods

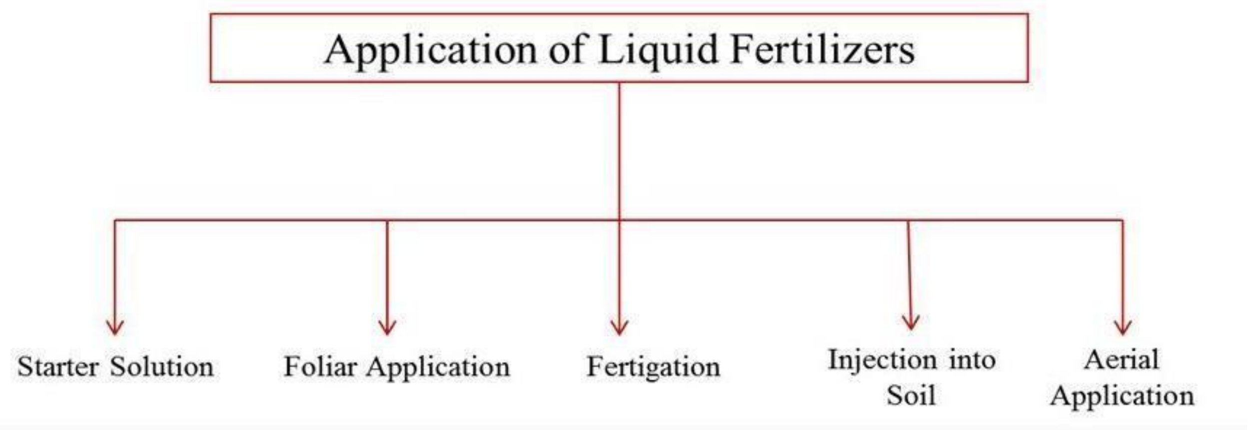
Starter Solutions

Starter solutions involve applying a mixture of N, P2O5, and K2O in the ratios of 1:2:1 and 1:1:2 to young plants, especially vegetables, during transplanting. This solution aids in the rapid establishment and growth of seedlings.

The drawbacks of starter solutions are:

(i) It requires additional labor.

(ii) There is a higher fixation of phosphate.



Foliar Application

Foliar application refers to spraying fertilizer solutions containing one or more nutrients onto the foliage of growing plants. Nutrient elements are easily absorbed by leaves when they are dissolved in water and sprayed on them.

It is crucial to control the concentration of the spray solution to prevent leaf scorching, which could lead to serious damage.

Foliar application is beneficial for minor nutrients such as iron, copper, boron, zinc, and manganese. Sometimes, insecticides are also mixed with fertilizers for application.

Injection into Soil

Liquid fertilizers for soil injection can be of either pressure or non-pressure types. Non-pressure solutions can be applied on the surface or in furrows without significant loss of plant nutrients.

Anhydrous ammonia needs to be placed in narrow furrows at a depth of 12-15 cm and covered immediately to prevent ammonia loss.

Aerial Application

In areas where ground application is unfeasible, fertilizer solutions are applied by aircraft, especially in hilly terrains, forest lands, grasslands, sugarcane fields, etc. This method results in some fertilizer loss and is only adopted in special cases.

Fertigation

Fertigation involves applying water-soluble solid or liquid fertilizers with irrigation water through a pressurized irrigation system. Nitrogenous fertilizers like urea, which are easily water-soluble, are commonly used. Fertigation increases yield, reduces soil and water pollution, and helps save on fertilizers, thereby conserving foreign revenue as these fertilizers are often costly and imported.

EXPERIMENT 7: STUDY OF YIELD CONTRIBUTING CHARACTERS AND YIELD ESTIMATION

Aim: To investigate the parameters influencing crop yield and estimate yield

Yield attributing characteristics of selected crops - Cereals

- Number of plants per square meter
- Number of effective tillers per plant
- Number of filled grains per plant (or Number of spikes per tiller and Number of grains per spike)
- Test weight of grain/1000 grain weight

Maize

- Number of plants per square meter
- Number of cobs per plant
- Number of grains per cob
- Test weight of grain

Sesame

- Number of plants per square meter
- Number of branches per plant
- Number of capsules per branch
- Number of seeds per capsule
- Test weight of seed

Mustard

- Number of plants per square meter
- Number of branches per plant
- Number of siliqua per branch
- Number of seeds per siliqua
- Test weight of seed

Lentil

- Number of plants per square meter
- Number of branches per plant
- Number of pods per branch
- Number of seeds per pod
- Test weight of seed

Groundnut

- Number of plants per square meter
- Number of effective pods per plant
- Number of kernels per pod
- Test weight
- Shelling percent

Cotton

- Number of plants per square meter
- Number of bolls per plant
- Number of locules per boll
- Number of seeds per boll
- Seed to lint ratio
- Test weight of cotton seed

Harvest Index (HI)

Procedure:

Harvest index is calculated by dividing economic yield by biological yield. The economic yield represents grain yield, while the biological yield includes the total yield (grain + straw) from the plot

Harvest index (HI) was calculated using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (grain + straw) (kg/ha)}} \times 100$$

EXPERIMENT 8: SEED GERMINATION AND VIABILITY TEST

Aim: To study Seed germination and viability testing

Materials Required:

1. Petri dishes
2. Alcohol (70-90%) for sterilization
3. Absorbent paper
4. Filter paper - Whatman Grade 181
5. Distilled water
6. Funnel
7. Cereal seeds
8. Thin plastic bag

Theory:

Seed viability is the measurement of how many seeds in a batch are viable and capable of developing into plants that can reproduce under suitable field conditions.

Top-of-paper method:

This method is most appropriate for species with seeds smaller than 2 mm in diameter, such as small-seeded vegetables and forage grasses. The seeds are germinated on top of moist absorbent paper in containers with tight-fitting lids to prevent moisture loss. Commonly used containers include 9 cm glass or plastic Petri dishes.

Procedure:

1. Sterilize container surfaces by wiping with 70–95% alcohol or soaking in 20% bleach or hot water at 55°C for 10–15 minutes.
2. Cut the absorbent paper to fit the size and shape of the container. For Petri dishes, round filter paper like Whatman Grade 181 of appropriate diameter can be utilized.
3. Place the paper substrate at the bottom of the container or Petri dish.
4. Label containers with an accession number, number of replicates, and testing date; use a pencil or permanent marker for labeling.1. Add the necessary amount of distilled water. If distilled water is unavailable, you can use boiled and cooled tap water instead. The required volume of distilled water depends on the thickness of the paper substrate and the size of the container. For Whatman Grade 181 filter paper in 9 cm Petri dishes, 4 ml of water is needed. Ensure that the filter paper is not excessively wet, avoiding the formation of a water film when pressed with a finger.

5. Press down firmly on the paper substrate in the container using either an inverted funnel or tweezers.
6. Spread the seeds evenly across the paper surface, ensuring they do not touch. It is advisable to maintain a distance between seeds of at least three to five times the diameter of each seed.
7. Cover the containers securely, making sure there are no airlocks caused by excess moisture on the covers.
8. Position the containers in a germinator or incubator set to the recommended temperature for the species' germination.
9. Monitor the substrate's moisture levels regularly, especially if the humidity in the cabinets is unregulated or the temperature is maintained at 25°–30°C. Blotters usually require watering multiple times during the testing period. Alternatively, place the containers in a thin plastic bag (loosely folded at the open end to allow oxygen diffusion) to prevent the substrate from drying out. Run the test for the advised duration and quantify the number of seeds that have sprouted.
    - If certain seeds remain ungerminated and seem dormant, apply suitable methods to encourage germination and prolong the test until all seeds have sprouted or until no additional germination occurs after two consecutive assessments.
    - Take note of seeds that did not sprout but are healthy and viable by the conclusion of the initial assessment, as well as those that did not germinate and are presumed nonviable at the end of the germination trial.

EXPERIMENT 9: NUMERICAL EXERCISES ON FERTILIZER REQUIREMENT

Aim: To study the fertilizer requirement

Question:

What will be the recommended dose of fertilizer for rice crop sown in the area of 1 ha (10000 sq.m) if N, P2O5, K2O is supplied as 120:60:40 kg/ha through Urea, DAP (Diammonium phosphate) and MOP (Muriate of potash).

[Urea: 46%, N, DAP: 46%, P;18% N: MOP: 60% K2O]

Solution:

First, we calculate the dose of DAP, because DAP contains both nitrogen and phosphorus.

Calculation:

Calculation of P2O5 and N from DAP: -

46 kg of phosphorus is supplied by = 100 kg DAP

60 kg of phosphorus is supplied by = $\frac{100}{46}$ x 60 = 130.43 kg of DAP

Now,

18 kg of nitrogen is supplied by = 100 kg of DAP i.e,

100 kg of DAP gives = 18 kg N

130.43 kg DAP gives = $\frac{18}{100}$ x 130.43 kg N = 23.47 kg of N

Calculation of Nitrogen from urea: - Nitrogen is supplied by both urea and DAP

Hence, required nitrogen supplied through urea is = (120 – 23.47) kg N = 96.5 kg N

Calculation of potash from MOP: -

60 kg of potash is supplied by 100 kg MOP

40 kg of potash is supplied by = $\frac{100}{46}$ x 40 kg MOP = 66.66 kg MOP 46

Result:

The recommended dose of fertilizers for supplying 120:60:40 kg of N: P2O5:K2O per hectare forrice crop is:

Urea = 209.83 kg/ha

MOP = 66.66 kg/ha

DAP = 130.43 kg/ha

EXPERIMENT 10: NUMERICAL EXERCISES ON PLANT POPULATION AND WATER REQUIREMENT

Aim: To calculate plant population and water requirement

Theory:

Plant population – Plant population refers to the plant density which depends on number of viable seeds, germination percentage and survival rates.

Formulae:

Plant population = $(Area)$/ Spacing of crop (R.R X P.P) m^2

Where,

R.R is row to row spacing between the plants,

P.P is plant to plant spacing

Question:

Calculate the plant population for following plants

a) Rice (20 X 10) cm
b) Wheat (22.5 X 10) cm
c) Maize (60 X 20) cm
d) Sorghum (45 X 15) cm

Solution:

a) Plant population of rice = $10000\ m^2/((0.2x0.1)m\ 2)$= 5000/ha
b) Plant population of wheat = 454545/ha
c) Plant population of maize = 83333/ha
d) Plant population of sorghum = 148148/ha

Water requirement of a crop:

- Irrigation Requirement IR = WR – (ER+S) Where,

IR = Irrigation requirement

WR = Water requirement of a crop

ER = Effective rainfall

S = Depth of shallow water table

Irrigation Requirement:

Irrigation Requirement (IR) refers to the quantity of water, exclusive of effective rainfall (ER) and soil profile contribution from that of shallow water table also (S), required for clop production. This amounts to net irrigation requirement plus other economically unavoidable losses.

EXPERIMENT 11: USE OF TILLAGE IMPLEMENTS

Aim: The aim of this study is to investigate the use of various tillage implements including the reversible plough, harrow, leveller, and seed drill.

Materials Required:

1. Reversible plough
2. Harrow
3. Leveller
4. Seed Drill

THEORY:

Uses:

1. **Reversible Plough:**

   It is a one-way plough that enables the inversion of the furrow slice to one side only.

2. **Harrow:**

   Harrows are utilized for shallow cultivation tasks such as preparing the seedbed, sowing seeds, and eliminating weed seedlings. There are two types of harrows: disc harrow and blade harrow.

3. **Leveller:**

   The leveller is a crucial tool used in farming and agriculture to even out the land, ensuring a uniform slope, good drainage, and a well-prepared seedbed.

4. **Seed Drill:**

   a. A seed drill is a secondary tillage implement comprising a wooden beam with 3 to 6 Tynes attached. These Tynes create furrows in which seeds are deposited. Seeds are uniformly dispensed into the hopper of the seed drill by a skilled laborer walking behind the equipment

EXPERIMENT 12: STUDY OF SOIL MOISTURE MEASURING DEVICES

Aim: To investigate soil moisture measuring devices

Materials Required:

1. Tensiometer
2. Neutron moisture meter
3. Pressure membrane and pressure plate apparatus

Theory:

Tensiometer:

1. Tensiometers, also known as irrometers, are employed in irrigation scheduling. This device comprises a long tube with a porous ceramic cup at one end. The tube is sealed with a rubber cork at the other end, and a vacuum gauge is attached to the side. The length of the tube ranges from 30 cm to 100 cm, depending on the depth required for estimating moisture levels.
2. To use the tensiometer, a hole is created in the soil at the desired depth using a crowbar. The device is then inserted into the hole and firmly pressed on all sides to ensure close contact between the soil and the ceramic cup.
3. Water is slowly filled into the tube to prevent the formation of air bubbles. As the soil dries, water from the ceramic cup seeps into the soil.
4. By measuring the vacuum in the tube, the depletion of water can be determined.
5. The tube needs to be refilled after each irrigation or rainfall event.
6. Tensiometers can detect soil moisture levels up to 0.9 bars.
7. Thus, tensiometers are best suited for sandy soils where water availability is typically up to 1 bar potential.

Neutron Moisture Meter

Soil moisture can be quickly and continuously estimated using a neutron moisture meter without soil disturbance. An additional benefit is the ability to estimate soil moisture from a large soil volume. This meter scans the soil up to a 15 cm diameter around the neutron probe in wet soil and 50 cm in dry soil.

The neutron moisture meter comprises a probe and a scalar or rate meter. The probe houses a fast neutron source, which can be a blend of radium and beryllium or americium and beryllium.

Access tubes are aluminium tubes ranging from 50 to 100 cm in length and are positioned in the field to estimate moisture. The neutron probe is lowered into the access tubes to the desired depth.

Fast neutrons emitted from the probe scatter into the soil. When these neutrons interact with hydrogen atoms of water nuclei, their speed decreases. The scalar or rate meter quantifies the slow neutron count, which is directly linked to water molecules.

The moisture content of the soil can be determined from the calibration curve using the count of slow neutrons. However, two limitations of this instrument are its costliness and the inability to estimate moisture content accurately from shallow top layers. Fast neutrons can also be decelerated by other sources of hydrogen (present in organic matter), as well as by atoms like chlorine, boron, and iron, resulting in an overestimation of soil moisture content.

Pressure Membrane and Pressure Plate Apparatus

Pressure membrane and pressure plate apparatus are commonly utilized to assess field capacity, permanent wilting point, and moisture content under various pressures

1. The apparatus comprises an air-tight metallic chamber housing a ceramic pressure plate with pores. The pressure plate, along with the soil samples, is saturated and placed inside the chamber.
2. A specified pressure, such as 0.33 bar or 15 bars, is applied using a compressor. The water from the unsaturated soil sample drains out until equilibrium against the applied pressure is attained.

Subsequently, the soil samples are extracted and subjected to oven-drying to determine the moisture content.

EXPERIMENT 13: MEASUREMENT OF FIELD CAPACITY, BULK DENSITY AND INFILTRATION RATE

Aim: Investigating the Measurement of Field Capacity, Bulk Density, and Infiltration Rate

Field Capacity Definition: Field capacity occurs when water drainage from large pores continues for a day or two after water supply stops, becoming minimal thereafter. Macropores are refilled with air, while micropores retain water due to capillary force, known as capillary water. At this point, soil is considered to be at its field capacity (FC). Soil moisture tension, ranging from 1/10 to 1/3 atmospheres, can vary across different soil types. Soil water potential at FC typically ranges between -0.1 to -0.3 bars or -0.01 to -0.03 MPa (Mega Pascal). Field capacity signifies the upper limit of water availability to plants, with soil water content at FC able to move in any direction, always trending towards increased tension.

Dry Bulk Density Description: Soil bulk consists of not only solids but also about 50% pore space occupied by water and air. Dry bulk density (Pb) represents the ratio of the mass of oven-dried soil solid particles (Ms) to the total soil volume (Vb), encompassing soil solids (Vs), soil water (Vw), and soil air (Va). Factors such as soil texture, structure, organic matter content, and soil management practices influence soil bulk density. In soils where pores occupy half of the volume, bulk density equates to half the particle density, typically ranging from 1.3 to 1.35 g cm-3. Sandy soils can exhibit bulk densities as high as 1.6 g cm-3. The ideal bulk density for optimum crop growth varies from 1.2 g cm-3 for regular soil to approximately 1.4 g cm-3 for sandy soil.

Infiltration Description: Infiltration refers to the ingress and downward movement of water into the soil surface.

Infiltration Rate: The infiltration rate denotes the speed at which water passes through the soil surface. Initially high, the infiltration rate gradually declines as the soil saturates. Infiltration rates are categorized into four groups based on the rate at which water enters the soil from the surface.

Very slow: Soils with less than 0.25 cm h^{-1} - very clay soils

1. Slow: Infiltration rate of 0.25 cm to 1.25 cm h^{-1} - soils with high clay
2. Moderate: Infiltration rate of 1.25 to 2.5 cm h^{-1} - sandy loam/silt loam soils
3. Rapid: Infiltration rate is more than 2.5 cm h^{-1} - deep/sandy silt loam soils

EXPERIMENT 14: MEASUREMENT OF IRRIGATION WATER

Aim: To measure irrigation water

Water measurement is crucial for effective management of irrigation systems. An important aspect of optimizing irrigation water use is the accurate measurement of water delivered and utilized to ensure adherence to the appropriate delivery schedule in order to:

- Determine the volume of water supplied to the land
- Assess the productivity of wells in meeting crop water demands
- Estimate conveyance and other losses
- Identify the source of these losses for corrective measures.

Most flow rate measurements are typically based on the fundamental equation:

$$Q = A \times V$$

where,

Q = Volume flow rate (discharge) in liters per second (1 s-1),

A = Cross-sectional area of flow (cm^2),

V = Velocity of flow through the cross-section (cm/s).

Volumetric Method:

The volumetric method is a straightforward approach for measuring water discharges from pumps or other water lifts commonly employed in small-scale farming. Water is allowed to flow from an irrigation channel through a siphon tube into a container. The time taken to fill the container is recorded, and the flow rate in the channel is calculated as detailed below:

$$\text{Discharge rate} = \frac{\text{Volume of water collected in the bucket}}{\text{Time required to fill the bucket}}$$

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A Practical Manual on Fundamentals of Agronomy

(ISBN: 978-93-95847-73-5)

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Bhumi Publishing

ISBN 978-93-95847-73-5

9 789395 847735