



NUTRIENT, WATER AND WEED MANAGEMENT

Plants are like human beings. They need adequate food at right time for optimum growth and development. In absence of proper nutrition, they show characteristics symptoms. Similar to human body, plants are also infected by bacteria, fungus and other organisms. A successful harvest of agricultural produce depends heavily on the accurate detection of these plant abnormalities. In this lesson, we are going to learn about scientific way of managing nutrients, water and weeds for growing a healthy crop.



LEARNING OUTCOMES

After studying this lesson, the learner:

- defines the essential and beneficial plant nutrients;
- explains the role of proper nutrition in the plant's growth and development;
- identifies water requirement of various crops and the significance of supplying irrigation;
- discusses the different irrigation techniques; and
- describes the preventive and curative strategies of weed control.

7.1 TYPE OF PLANT NUTRIENTS

Plants absorb a large number of elements from soil but all are not essential for them. Crop plants need certain essential elements or nutrients for their optimal growth and development. These nutrients are taken up from soil, air and water in the form of ions, atoms or their simple molecules or compounds. To be considered as essential, Arnon and Stout (1939) proposed the criteria for nutrients, according to which.

Crop Production
Practices



Notes

- I. An essential element is one if plants cannot complete their life cycle due to its deficiency,
- II. The deficiency can be corrected by supplying that element only.
- III. The element is directly involved in the metabolism of the plant.

There are 17 mineral elements essential for plant growth which is classified on the basis of amount taken up by the plants. Carbon (C), hydrogen (H), and oxygen (O) are obtained from air and water, called as **basic or framework elements**. The six **macronutrients**, nitrogen (N), phosphorus (P), potassium (K), Calcium (Ca), Magnesium (Mg) and Sulfur (S), are required by plants in large amounts. Out of these, N, P and K are considered as primary or major nutrients because of their requirement in larger quantities. Ca, Mg and S are called as secondary nutrients as they are required in relatively lesser amount. The rest of the nutrients (8) are required in trace amounts (**micronutrients**). Essential micronutrient elements include Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Molybdenum (Mo) and Nickel (Ni). Few elements are not considered essential (as per the Arnon & Stout definition) to all plants but are beneficial to growth of some, are called as **beneficial** nutrients e.g., Sodium (Na), Silicon (Si) and Cobalt (Co), etc. The classification of essential plant nutrients is summarized as:

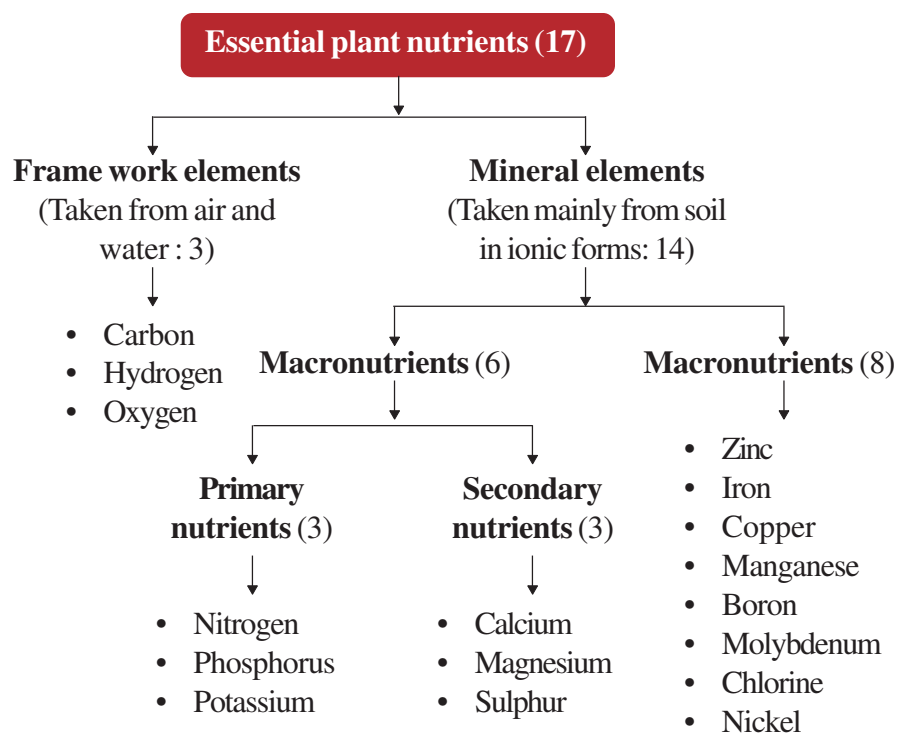


Fig. 7.1: Classification of essential plant nutrients

*Notes**Table 7.1: The different chemical forms of nutrients taken up by plants*

Essential nutrient	Forms absorbed by plants	Average concentration in plant tissue
Nitrogen	NH_4^+ , NO_3^-	1.5%
Phosphorus	H_2PO_4^- , HPO_4^{2-}	0.2%
Potassium	K^+	1.0%
Calcium	Ca^{2+}	0.5%
Magnesium	Mg^{2+}	0.2%
Sulphur	SO_4^{2-}	0.1%
Iron	Fe^{2+}	100 mg/kg
Manganese	Mn^{2+}	20 mg/kg
Zinc	Zn^{2+}	20 mg/kg
Copper	Cu^{2+}	6 mg/kg
Nickel	Ni^{2+}	0.1 mg/kg
Boron	H_3BO_3	20 mg/kg
Molybdenum	MoO_4^{2-}	0.1 mg/kg
Chlorine	Cl^-	100 mg/kg

7.2 ROLE OF NUTRIENTS

Each essential nutrient has specific roles in plant as abstracted in Table 7.2

Table 7.2: Functions and deficiency symptoms of essential nutrients in plants

Nutrient	Functions or roles in plants	Deficiency symptom
Nitrogen	A major component of proteins, hormones, chlorophyll, vitamins, and nucleic acids	Yellowing of the older leaves and stunted growth

**Crop Production
Practices**

Notes

Phosphorus	Part of nucleoproteins, stimulates root growth, energy storage and transfer function	Purpling of plant parts
Potassium	Activator of many enzymes, regulates osmotic potential in cells, helps in translocation of sugars and carbohydrates, imparts resistance against pests	Marginal leaf burn and tip burn, speckled and mottled leaf
Calcium	Important for cell division, cell wall formation, nitrogen accumulation	Stunting of new growth in stems, flowers and roots
Sulfur	Constituent of many amino acids and vitamins, important nutrient for oilseed and cruciferous crops.	Yellowing of younger leaves
Magnesium	Component of chlorophyll	Interveinal chlorosis in older leaves
Iron	Component of enzymes, essential for chlorophyll synthesis	Interveinal chlorosis in new leaves
Manganese	Activates enzymes, involved in chlorophyll synthesis and carbohydrate metabolism	Interveinal chlorosis in younger leaves
Zinc	Components of many enzymes, essential for plant hormone auxin synthesis	Stunted growth, reduction in internodes, mottled leaf
Copper	Component of enzymes, involved in photosynthesis	Terminal bud die, interveinal chlorosis
Boron	Plays role in sugar transport, pollination, fruiting	Terminal buds appears as witches broom, dying of growing points
Chlorine	Turgor regulation, disease resistance, fruit quality	Deficiency rarely seen. When deficient, appear chlorotic

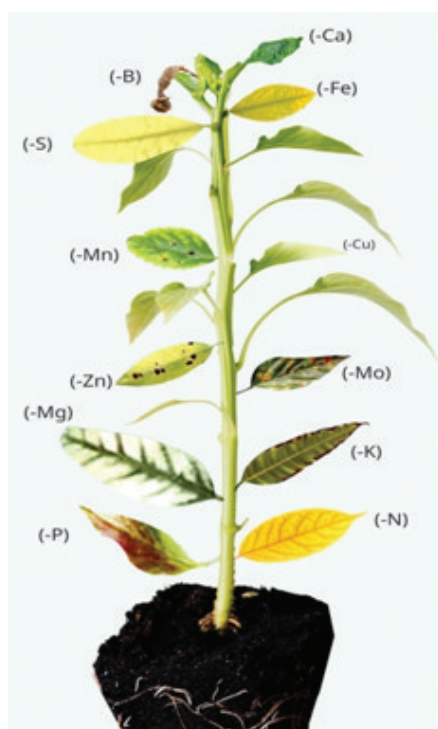


Fig. 7.2: Deficiency symptoms of essential nutrients in plants

7.3 SOURCES OF NUTRIENTS

Nutrients taken up by plants are supplied from soil, crop residues, fertilizers and manures. **Fertilizers** are chemicals produced industrially which are rich in specific nutrients. **Manures** are organic in nature prepared from plant and animal residues. Soil health is decided by its physical, chemical and biological characteristics. Soil is a reservoir of all nutrients as required by crop plants. However, removal of those nutrients by raising crops without replenishment strategy results in depletion of soil fertility. Under this circumstances, nutrient demand of crops need to be met from external sources as organic manures, chemical fertilizers, biofertilizers, and crop residues, etc.

A. **Organic Manures:** These are of two types

- a. **Bulky Organic Manure:** Farm yard manure (FYM), compost, vermicompost and green manures are called bulky organic manures as they are applied in large quantities. These manures contain less amount of plant nutrients. These improve soil physical condition, increase activities of microorganisms and supply all the plant nutrients, though in small quantities. FYM is prepared from cattle dung, animal bedding material and plant residues. Compost is produced from crop residues, grasses, leaves and

Crop Production
Practices

Notes

cattle shed bedding materials. Green manure crops are generally legumes which have ability to fix atmospheric N in root nodules in symbiotic association with bacteria. Besides enriching soil nitrogen status, they supply other nutrients when incorporated in soil. Most common green manure crops are dhaincha (*Sesbania aculeata*) and sunnhemp (*Crotalaria juncea*).

- b. **Concentrated manure** contain higher amount of plant nutrients than bulky organic manure. They are oilcakes, blood meal, meat meal, bone meal and fish manure. Oilcakes of neem, karanj, groundnut, sunflower, safflower, castor, soybean, linseed, and mustard, etc. are used as source of nutrients.

B. Bio-fertilizers

Soil is home to a large number of microorganisms out of which many are beneficial to soil and crop. They supply or make the nutrients available to plants, especially nitrogen (N) and phosphorus (P). However, due to their declining population and activities, they are added externally as bio-fertilizers. These are bio-inoculants or products containing live and latent cells of such microorganisms. Bio-fertilizers are either inoculated with seeds before sowing or applied to soil. *Rhizobium*, blue green algae, azolla, *Azotobacter*, *Azospirillum* and *Acetobacter* are nitrogenous bio-fertilizers, whereas, phosphate solubilising microorganisms (PSM), vesicular arbuscular mycorrhiza (VAM) solubilize insoluble soil P and make it available to plants. Similarly, potassium mobilizing bio-fertilizers contain bacteria that are capable of solubilizing inorganic potassium from insoluble compounds and providing it for plant uptake.

C. Fertilizers

Chemical fertilizers are inorganic or synthetic organic materials with concentrated nutrients which are applied to soil or plants to supply plant nutrients. Plants get nutrients quickly after application of fertilizers unlike that from organic manures. Fertilizers usually supply major nutrients like N, P and K which are applied in higher amounts, e.g. urea, di-ammonium phosphate (DAP), muriate of potash (MOP) etc. Micro-nutrients based fertilizers are also available in market as these nutrients are also deficient in soil. Important micro-nutrients for which fertilizers are available are boron, zinc, iron and molybdenum.

The nutrient content of a fertilizer is labeled on the bag or container, and called fertilizer grade. It is the minimum guaranteed concentration of nutrients expressed in percentage of N, P and K in order. The fertilizer grade information depicts the percent of total elemental nitrogen (N), percent available phosphorus (P_2O_5)

and percent water soluble potassium (K_2O). Thus, a fertilizer grade is presented as $N-P_2O_5-K_2O$. A complex fertilizer with grade 10-26-26 means, the material contains 10% N, 26% P_2O_5 and 26% K_2O .



INTEXT QUESTIONS 7.1

- How many mineral elements are essential for plant growth?
- Which of the following is a micronutrient?
 - Calcium
 - Magnesium
 - Potassium
 - Iron
- Element that is responsible for disease and pest resistance in plants
 - Potassium
 - Chlorine
 - Nitrogen
 - All of these
- Bulky organic manure contains higher amount of plant nutrients than concentrated manures. (True/False)
- Which essential nutrient for plant is supplied by urea fertilizer?



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7.4 CLASSIFICATION OF FERTILIZERS

Fertilizers are classified as straight or complex fertilizers based on the number of primary nutrients contained in them. **Straight fertilizers** supply only one primary nutrient, N or P or K. Urea, single super phosphate, potassium sulphate, etc. are examples of such fertilizers. These are again grouped into nitrogenous, phosphatic and potassic fertilizers. Fertilizers which contain two or three primary nutrients are called **complex fertilizers**. Di-ammonium phosphate (DAP), urea phosphate, NPK 19-19-19 etc. are such fertilizers. When it contains two of the primary nutrients, it is designated as **incomplete complex** fertilizer, while those contain all three primary nutrients are called **complete complex** fertilizers. They are available in granular formulation with good physical condition and are cheaper compared to individual fertilizers.

Fertilizers are classified as **high and low analysis fertilizers** based on the content of nutrients present in them. High analysis fertilizers have a concentration of more than 25% total primary nutrients, e.g. di-ammonium phosphate has 18% N + 46% P_2O_5 , urea (46% N), and urea phosphate (17% N + 44% P_2O_5). Some fertilizers have total

Crop Production
Practices

Notes

primary nutrient content of less than 25%, are called low analysis fertilizers, such as single super phosphate (16% P_2O_5), ammonium sulphate (20% N) etc.

7.4.1 Selection of Fertilizers

Right choice of fertilizers for crop production is crucial for ensuring good crop growth, higher profitability and soil health. There are number of options before farmers while selecting which fertilizer to apply for their crop. It is not decided by a single factor rather several factors influence their decision, important among those are,

- Type of crops (cereals/pulses/oilseeds/vegetable crops)
- Time of application with respect to crop growth stages
- Routine application or application to rectify deficiency
- Price of kg nutrient in the fertilizer
- Number of nutrients contained in fertilizer
- Efficacy of fertilizer on plant growth
- Storability and ease of transportation
- Peerfarmers' feedback on the fertilizers
- Recommendations by extension system

7.4.2 Fertilizer Management in Crops

Three important aspects of fertilizer management required to be considered are

- I. **Type of Fertilizers:** Factors influencing the type of fertilizers to be used are explained earlier.
- II. **Time and Dose:** The entire dose of nitrogenous fertilizer is not given to crop at once, rather applied to crops in different splits following the schedule. The first application happens before or during sowing/planting is called as the basal application. Subsequent application during growth stages of crop is called as top dressing. Generally, 50% of total N, and full dose of P and K fertilizers are applied as basal and the rest N amount is given in 1-2 splits depending upon the crop and soil types. N is highly mobile in soil unlike P and lost from rhizosphere zone by various processes for which nitrogenous fertilizers are applied in split doses. Full dose of soil applied phosphorous and micro-nutrients are given as basal.

Optimum dose of fertilizers of a crop depends upon the fertilizer need of the crop and nutrient supplying capacity of soil. Climate and crop management practices also influence it. Therefore, the dose of fertilizer for different crops varies across the locations. Accordingly, states of India have different fertilizer recommendations.

N is applied at a relatively higher rates compared to other nutrient due to its low use efficiency. Rice consumes about 40% of total fertilizer N consumption in India. Usually, rice responds up to 120 kg N/ha and some places even up to 150-180 kg/ha has also been observed. Leguminous crops generally require a basal dose of 15-20 kg N/ha as they meet most of their N demand from atmospheric N fixation.

III. Methods of Application: Further, fertilizers are applied through different **methods**, such as broadcast, placement, foliar application and fertigation. **Broadcast** is the most preferred method adopted by farmers because of ease of application and cost effectiveness. However, nutrient use efficiency is very low if adequate soil moisture is not available. In contrast to this method, fertilizers can be put near the root zone as **placement** either manually or using seed-cum-fertilizer drills. Due to low mobility and fixation of P in soil, placement method is the most appropriate for phosphatic fertilizers. Pellet application of urea fertilizer improves its efficiency under deep water rice ecology.

Fertilizers which are available in liquid formulations are given to crops as **foliar application**. Besides, few solid form fertilizers like urea, DAP, borax, zinc sulphate etc. are also recommended for foliar application. Requirement of lower dose, high use efficiency and quick absorption of fertilizers by leaves are major advantages of foliar application. Above discussed methods are followed for field and horticultural crops under open cultivation condition. In protected cultivation or when drip irrigation is installed, fertilizer is precisely applied through irrigation water called as fertigation. Water soluble fertilizers with high water solubility are used here.



INTEXT QUESTIONS 7.2

1. Nitrogen content in DAP is
 - a. 18%
 - b. 30%
 - c. 25%
 - d. 46%



Notes

Crop Production
Practices

Notes

2. State whether true (T) or false (F).
 - a. Straight fertilizers supply only one primary nutrient.
 - b. Generally nitrogen is applied at lower rate due to its high application efficiency.
 - c. Fertigation is the most preferred method of fertilizer application by farmers.

7.5 WATER MANAGEMENT

Water is all around us. It is the lifeline of every living being on earth. Just imagine if water would not be there also how life would be? Like animals or other organisms, water is absolutely necessary for crop plants too. But how to manage the water in best way for the crops is essential to make the system sustainable. In this section let's study the different principles and practices involved in water management for raising a crop successfully.

7.5.1 Irrigation

Water is one of the key ingredients of life, may it be human, plant, or animal. It is required for photosynthesis, translocation of nutrients, and maintaining heat balance in the plant body. Soil water is the major source of water for plant uptake which is depleted due to evaporation from the soil surface, transpiration through the plant, and deep percolation into the soil beyond the root zone. Roots cannot grow if the soil is dry. Rainfall and other forms of precipitation are the natural sources from which the depleted soil water is replenished into the soil. When natural rainfall is not sufficient to supply the water required for plant growth, there is a need for the artificial application of water to the crops. Irrigation can be defined as the artificial application of water to soil to supplement rainfall for crop production. It provides a favorable environment for better crop growth and yield.

7.5.2 Soil Water

Soil water relations deal with those physical properties of soil and water that affect the movement, retention, and absorption of water by plants. These must be understood in order to plan or improve an irrigation system. The soil is a poly-phasic system viz., solid, liquid and gaseous phases. The solid phase constitutes the soil matrix, the liquid phase consists of soil water (which always contains dissolved substances so that it should properly be called the soil solution) and the gaseous phase is the soil atmosphere. The liquid portion of the soil which consists of water, dissolved minerals, and soluble organic matter fills part or most of the spaces between the solid particles. This water is

absorbed by the plant roots and must be periodically replenished by rain or irrigation for the successful production of crops.

7.5.3 Water Movement in Soil

Immediately after the application of irrigation or receipt of rain, water enters the soil. It moves laterally, upwardly, and/or downwardly from higher water potential to lower potential sites. **Infiltration** is the process of entry of water into the soil, generally by downward flow through all or part of the soil surface. The movement of water within the soil influences the water supply to roots and also contributes to the underground water table. It occurs in three different ways:

- a) **Saturated Flow:** Saturated flow occurs when all pores are filled with water either due to rain or irrigation or under a waterlogged situation. The major driving force in such flow is gravity.
- b) **Unsaturated Flow:** The unsaturated flow occurs in soil micropores due to differences in soil water potential.
- c) **Vapor Movement:** When soil becomes dry, water from micro pores is also emptied and mainly present in the form of vapour. The movement occurs due to a difference in vapour pressure called vapour movement.

7.5.4 Retention and Uptake of Water

Water in the soil does not exist individually. A water molecule sticks to another water molecule with great energy and this property is called **cohesion**. Water attaches itself to surfaces of many substances through the property of **adhesion**. Because of these forces water in the soil exists as a thin film in the pore spaces. When water enters the soil it first fills the micropores and then macropores are filled whereas when the water leaves out of the soil it empties the macropores first and then the micropores are drained up.

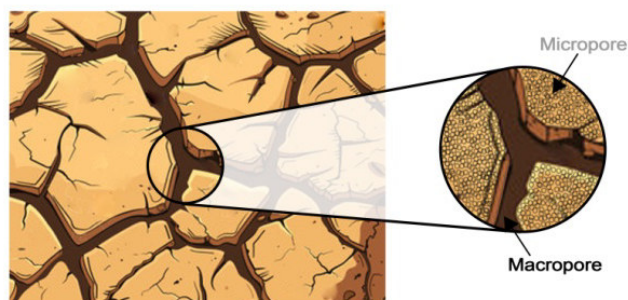


Fig. 7.3: Macro and micro pores in soil



Notes

Crop Production
Practices

Notes

7.5.5 Water Requirement

Water requirement is defined as the quantity of water required by a crop for its normal growth and development under a given field conditions. Water requirement (WR), if considered as a demand, it includes the quantity of water required for evapotranspiration (ET), plus the losses during the application of irrigation water and the quantity of water required for special operations such as land preparation, transplanting, leaching of salts below the crop root zone, and frost control, etc. Considering the supply sources, water requirement is the sum total of quantity of water supplied through irrigation (IR), effective rainfall (ER), from soil moisture in crop root zone ("S) and ground water (GW). Water requirement is expressed in depth per unit of time. **Irrigation requirement (IR)** is the total amount of water applied to a cropped field for supplementing effective rainfall, soil moisture, and groundwater contribution to meet the crop water requirements for optimum growth. It is a part of the total water requirement of the plant.

$$\text{WR} = \text{ET loss} + \text{losses during irrigation} + \text{water required for special operations} \\ = \text{IR} + \text{ER} + \text{S} + \text{GW}$$

(WR: Water requirement, ET: Evapotranspiration, IR: Irrigation requirement, ER: Effective rainfall, S: soil moisture contribution, GW: ground water contribution)

Water requirement along with number of irrigations required by major field crops are given in table 7.3.

Table 7.3: Water requirement of major field crops

Crop	Water requirement in mm	Number of irrigation
Rice	1100-1250	18
Maize	500-600	8
Pulses	200-450	4
Groundnut	500-550	10
Sugarcane	1800-2200	24
Cotton	550-600	11

The above data on water requirement and number of irrigation of crops are average figures only, which vary according to the duration of crop, soil types, climatic conditions and crop management practices.

7.5.6 Scheduling of Irrigation

Irrigation scheduling is a technique of deciding the time of irrigation and the quantity of water to irrigate for obtaining optimal production. The main purposes for scheduling irrigation are to optimize the water use in irrigation, decrease the cost, improve soil hydrological condition and obtain higher yield. Irrigation scheduling depends upon the depletion of available soil moisture in the root zone, evaporative demand of atmosphere and growth stage of crop when water is essential called as critical crop growth stage. These stages of irrigation have been identified in different crops at which occurrence of moisture stress leads to decrease in crop yield.



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INTEXT QUESTIONS 7.3

1. What is irrigation?
2. Which of the following is not a natural source of water in soil?
 - a. Rainfall
 - b. Snow
 - c. Hail
 - d. Irrigation
3. State whether true or false.
 - a. Unsaturated flow occurs when all pore spaces in soil are filled with water.
 - b. Water in soil moves from higher potential to lower potential.
4. Which of the following crop has maximum water requirement?
 - a. Rice
 - b. Maize
 - c. Sugarcane
 - d. Cotton

7.6 METHODS OF IRRIGATION

Every crop is not irrigated same way. Different irrigation methods are followed to supply needed quantity of water to the crop, minimizing the field losses and improving application efficiency. Each method has specific advantages that make it suitable for

Crop Production
Practices

Notes

certain farming conditions, crop types, climate and geographical settings. These are classified as surface methods and micro-irrigation methods (sprinkler and drip irrigation).

7.6.1 Surface Irrigation

These methods are widely used in many crops in India. Flooding, check basin irrigation, basin method, border strip and furrow irrigation are different types of surface irrigation methods followed in different crops.

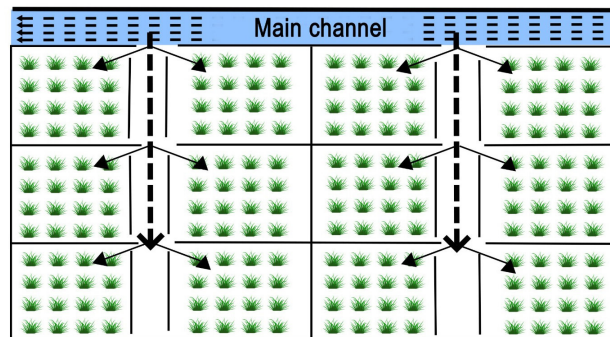


Fig. 7.4: Check basin irrigation

In the **flooding method**, water is allowed from the channel into the entire field. This method is usually practiced in low-land rice cultivation. The **check basin method** is suitable for closely spaced crops, like groundnut, wheat and finger millet, etc. The field is divided into smaller unit areas with bunds around it forming basins, within which the irrigation water is applied.

In **furrow method** of irrigation, ridges and furrows are made to grow the crop on ridges and apply irrigation through furrows.



Fig. 7.5: Furrow irrigation

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7.6.2 Micro-Irrigation Methods

Water use efficiency in surface irrigation methods is very low due to loss of large amount of water during application through percolation, seepage and overflow. In contrast, micro-irrigation is the slow application of water as continuous drips, tiny streams or miniature sprays above or below the soil surface. Micro-irrigation system broadly of two types, sprinkler irrigation and drip irrigation system. Water is applied via pressurized piping system which requires pumps for developing the required pressure for delivering water through pipelines. Micro-irrigation system is effective in saving water and increasing water use efficiency as compared to the conventional surface irrigation method.

Sprinkler Irrigation

Sprinkler irrigation is a method in which water is sprayed/sprinkled with pressure over the crop canopy. It is suited for most row, field and tree crops. Sprinkler systems are also used for irrigating lawns and gardens. The sprinkler breaks up the water into droplets sized 0.5–4 mm and spray released through nozzles. The drop size is controlled by pressure and nozzle size of the sprinklers. Sprinklers are operated at recommended pressure levels so as to ensure proper distribution of water. This method is not suitable for areas with hot dry winds as a considerable amount of water is lost as evaporation.

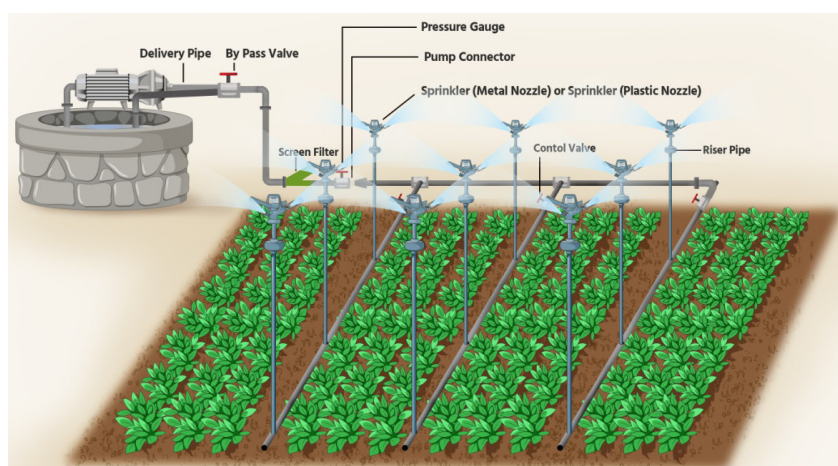


Fig. 7.6: Layout of a sprinkler irrigation system

Drip Irrigation

Drip is yet another micro irrigation method wherein the precise and slow application of water in the form of discrete or continuous drops. Water is delivered through mechanical devices called **emitters** installed along water delivery lines. This method has the highest

Crop Production
Practices

Notes

irrigation efficiency and is useful for crops grown in water-scarce areas, saline areas and widely spaced crops. **Fertigation** is a method of application of fertilizers through irrigation. Fertigation has the potential to apply the precise quantity of water and nutrients both in amount and location as per the plant requirement.

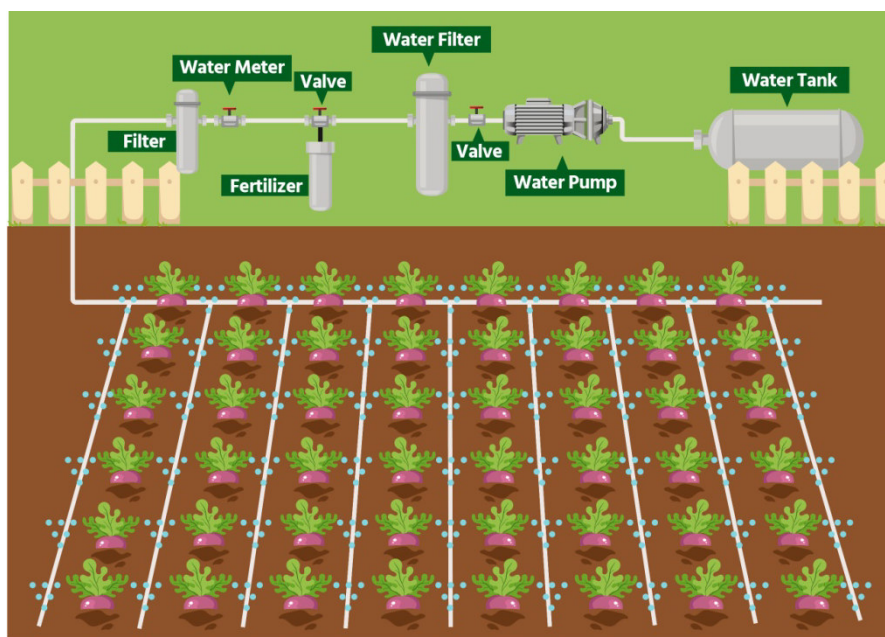


Fig. 7.7: Layout of a drip irrigation system



INTEXT QUESTIONS 7.4

1. Name any two surface irrigation methods.
2. Irrigation type where water is applied in precise and slow way through emitter is
3. Irrigation method which is suitable to saline areas
 - a. Drip
 - b. Sprinkler
 - c. Furrow
 - d. Check basin

**ACTIVITY 7.1**

Visit a nearby agricultural field. Observe how irrigation is being practised by the farmer. Check the type of irrigation whether it surface/sub-surface/sprinkler/drip. Recognize the source of irrigation water (ground water/ canal/well/other). Prepare a layout/sketch of irrigation systems installed in agricultural field.

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*Notes***7.7 WEEDS: CLASSIFICATION AND CHARACTERSTICS**

When you are travelling through a bus or a train you must have seen some plants on the road sides and railway tracks. What are these plants? Whether these are of any use or not? Such question might be there in your mind. When you visit farmer field, along with the crop plants you may also see some other plants growing there. Whether these are planted there or have grown at their own? Really it may be quite interesting for you to understand their biology and characteristics which make them stand in the adverse type of climate. Let us discuss about these weed plants in this section.

7.7.1 Weeds

Among all the plants around us, some plants are of economic value either as a source of food, fiber, fuel, or timber, which we call crop plants. Along with the crop plants, some plants grow voluntarily which are not of any use. These are known as weeds. Weeds can be defined as unwanted or undesirable plants that compete with crops for water, soil nutrients, light, and space and thus reduce crop yields. Weeds are more competitive and adaptable to all adverse environments. Fig. 7.7 shows how weeds are more competitive than crop and growing prolifically utilising nutrients in fertile soil patches. They cause a reduction in yield and quality of the economic product. The extent of losses depends on the intensity of infestation, time of occurrence, and type of weeds.

Crop Production
Practices

Notes



Fig. 7.8: Prolific weed infestation in fertile soil patches in a rice crop field

Weeds also interfere with agricultural operations, their presence contaminates the food grains and they harbor organisms like mosquitoes that cause or transmit diseases. Some weeds are poisonous and others produce pollen which causes allergies to humans. Some weeds are useful to us too as they have various cultural and religious importance like *Bermuda* grass used in puja, and some weeds like *Typha* grass used as thatching material. *Cyprus* is used for the preparation of agarbatti. Some weeds are used as vegetable (*Chenopodium album*) for human beings and fodder (*Melilotus alba*) for animals. Weeds have certain medicinal properties and they also act as genetic material for plant breeding.

7.7.2 Classification of Weeds

There are over 30,000 species of weeds all around the world amongst which about 18,000 cause serious losses to crops. Weeds are classified into several categories based on different characteristics. Among these classifications, the important and commonly used are based on morphology, duration, and the number of cotyledons.



Fig. 7.9: Mixed weed flora in rice crop



Depending on the duration of the life cycle, weeds are classified into **annuals**, **biennials**, and **perennials**. Most of the weeds present in crops are annual in nature, their life cycle is short and they compete with the crop plants e.g., *Echinochloa*, *Chenopodium*, *Phyllanthus*, etc. They usually propagate through seeds. Biennial weeds complete their life cycle in two years or in two seasons e.g., carrot grass, etc. Perennials grow for more than two years e.g., *Bermuda* grass, *Cyperus* sp, star grass, and field bindweed, etc.

Based on the number of cotyledons, weeds are classified as **monocots** and **dicots**. Monocots have narrow and upright leaves whereas dicots have broad and horizontal leaves.

Weeds are also classified as **grasses**, **sedges**, and **broad-leaved weeds** based on their morphological characteristics like leaves, branches, and underground plant parts.



Fig. 7.10: Morphological classification of weeds

7.7.3 Managing Crop Field Weeds

Before managing weeds infesting crop field, it is quite essential to understand how and from where weeds enter crop field. Annual weeds are prolific seed producers which are small in size compared to crop seeds. Whereas, most perennial weeds propagate vegetatively by rhizomes, stolons, bulbs, etc. which remain below the soil and thus making them difficult to eradicate. The vast reservoir of dormant and viable weed seeds in the top layer of soil act as a weed seed bank. Weeds germinate in different flushes at periodical intervals. Most of the weed seeds germinate when proper environmental conditions exist. Often weed seeds from one field enter another through crop seeds as mixture, manures, farm machineries and other dispersal agents like wind and water.

Crop Production
Practices

Notes

7.7.4 Crop Weed Competition

Till now we understand, weeds compete with crop plants for nutrients, water, light, and carbon dioxide. This relationship between weeds and crop is called as crop-weed competition. Increase in weed biomass in a crop field reduces the crop yield with similar intensity. The period at which maximum crop weed competition occurs is called the **critical period of crop weed competition**. It is the period during which weeding of crop field results in the highest economic returns. That means, the crop field should be kept weed free during this period to obtain maximum yield.

**INTEXT QUESTIONS 7.5**

1. Unwanted and undesirable plant that competes with crop plant for nutrient, water and sunlight is termed as
2. Weed species that is used as vegetables by human beings
3. The propagating materials of perennial weeds are

a. Bulb	b. Rhizome
c. Stolon	d. All of these

7.8 WEED MANAGEMENT METHODS

Weed management is the approach and set of practices aimed at minimizing the weed infestation in crop field. Preventive and curative strategies are two broad ways adopted to manage weeds. Preventive measures restrict the entry and spread of weed propagules in new fields. Curative methods comprised of eradication, physical, cultural, biological and chemical method. The approach is integrated weed management (IWM) wherein many different weed management methods are used in an integrated way, to manage weeds and to reduce dependency on herbicides.

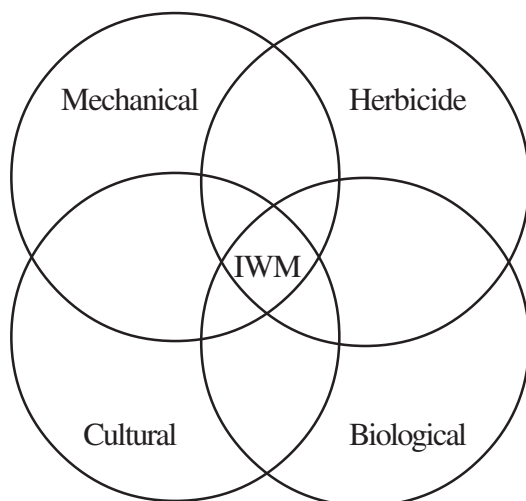


Fig. 7.11: Integration of multiple approaches of weed management

A. Preventive Methods

Important weed prevention practices include

- ❖ using clean and weed-free crop seeds,
- ❖ using clean implements
- ❖ removing weeds before it produces seeds
- ❖ use of well decomposed manures

B. Curative Methods

Eradication: Eradication is complete removal of all live plant parts and seeds of the weed from an area. It may be a field/farm/village/geographical region depending upon the need.

Control methods: Control method indicates that weed infestations to be reduced but not necessarily eliminated. Various methods of controlling weeds are physical and mechanical methods, cultural methods, biological control and chemical methods.

(i) Physical and Mechanical Methods

- ❖ **Hand weeding:** It involves uprooting weeds from crop field with the help of hoe or khurpi. Besides removal of weeds, soil is loosened which helps in growth of plants. This method is very effective in managing weeds but expensive.

Crop Production
Practices

Notes

- ❖ **Mulching:** It is the practice of covering the soil in inter-row spaces with straw, crop residues, plastic etc. In absence of light and with the physical barrier weeds find difficult to germinate and emerge.
- ❖ **Weeder:** Use of weeding tools such as manual and power operated weeders and tillers etc. for tilling the inter-row soil and uprooting weeds.

(ii) **Cultural Methods:**

The principle behind this method is to give a competitive advantage to the crop. Different cultural methods which are commonly in use are proper crop stand and early seedling vigor, proper planting method, planting time, crop rotation, stale seedbed technique, smother crops, flooding, soil solarization etc.



Fig. 7.12: Smothering effect of crop on weeds

(iii) **Biological Control:**

This method refers to utilization of natural living organisms such as insects, herbivorous fish, other animals, disease causing organisms and competitive plants for managing weed population. The herbicide as produced using living organisms, viz. fungi and bacteria are called bio-herbicides, e.g. fungi like *Colletotrichum sp.*, *Bipolaris sp.*, *Phytophthora sp.*

(iv) **Chemical Methods:**

Herbicides are chemicals capable of killing or inhibiting the growth of plants. Today we have 150 herbicides in common use for selective and nonselective control in different areas. **Selective herbicides** kill only targeted plants or weeds while crops are not affected like 2,4-D, Ethoxysulfuron, Fenoxaprop p ethyl etc. in rice. **Non-selective herbicides**, Glyphosate and Paraquat kill all vegetation that they come in contact with irrespective of whether it is a crop plant or weed. Herbicides are not aimed at substituting the physical, biological, or good crop husbandry methods but to replace the drudgery of manual weeding.

7.8.1 Classification of Herbicides

Based on time of application herbicides are classified as pre-plant, pre-emergence and post emergence herbicides.

1. **Pre-plant Herbicides:** Herbicides which are applied before sowing the crop. However, these are not popular herbicides among farmers. Pre-plant herbicides include Fluchloralin, Trifluralin, Diphenamid etc.
2. **Pre-emergence Herbicides:** These are applied after sowing the seeds but before emergence of weeds i.e. 0-3 days of sowing. These herbicides are of selective in nature and applied on soil. Oxyfluorfen, Pendimethalin, Pretilachlor are pre-emergence herbicides.
3. **Post-emergence Herbicides:** These herbicides are applied after the emergence of weeds and crops. Selective herbicides are used in crops at 2-4 leaf stages of weeds, e.g., 2, 4-D, Bispyribac sodium, Fluazifop butyl, Fenoxaprop-p-ethyl etc.

7.8.2 Herbicide Application

The selected herbicide must reach the target part of plant to show its efficiency. Method of application is as important as the selection of proper herbicide. Herbicides are available with different formulations such as emulsifiable concentrates, granular, wettable powder, soluble liquid etc. which decides the application methods and equipments. Granular herbicides can be applied directly manually or using spreaders. Back pack knapsack hand pump or power sprayer are commonly used to spray herbicides. In big fields or farms, power sprayer, tractor mounted sprayer, drone sprayer will be more effective.

For herbicide application, flat fan or flood jet nozzles are recommended to get good results. Selecting the appropriate nozzle type based on the specific application needs can lead to improved results in weed management while minimizing environmental risks.



Notes

Crop Production
Practices



Notes



INTEXT QUESTIONS 7.6

1. State whether true (T) or false (F).
 - a. Hand weeding is the cheapest way of weed management.
 - b. Eradication is complete removal of all live plant parts and seeds of the weed from an area.
 - c. Weed management during critical period of crop weed competition provides maximum yield and highest economic returns.
2. The herbicides which are applied after sowing the seeds but before emergence of weeds
 - a. Post-emergence herbicides
 - b. Pre-emergence herbicides
 - c. Selective herbicides
 - d. Pre-plant herbicides
3. Give one example of non-selective herbicide.



ACTIVITY 7.2

Imagine you are a consultant advising a farmer in a region facing water scarcity. The farmer is cultivating a variety of crops and is looking for an efficient irrigation system to optimize water usage and maximize crop yield. Propose a suitable irrigation system for the farmer, considering factors such as the type of crops, soil conditions, and available water resources.

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**WHAT YOU HAVE LEARNT**

- Plants take nutrients from soil, air and water in the form of ions, atoms or their simple molecules or compounds. There are 17 mineral elements essential for plant growth viz. Carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S), Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Molybdenum (Mo) and Nickel (Ni).
- Fertilizers are industrially produced chemicals which are rich in specific nutrients. Manures are organic in nature prepared from plant and animal residues.
- Bulky organic manures are FYM, compost, green manure while oilcakes, blood meal, meat meal, bone meal and fish manure come under concentrated manures. Bio-fertilizers are preparations containing live cells of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms used for application to seeds or soil.
- Right choice of fertilizers for crop production is crucial for ensuring good crop growth, higher profitability and soil health. Type of fertilizer, their method of application, time and dose are the important aspect of fertilizer management.
- Water is one of the key ingredients of life. Soil water is the major source of water for plant uptake. The artificial application of water to soil to supplement rainfall for crop production is called irrigation.
- The quantity of water required by a crop for its normal growth and development under a given field conditions is termed as water requirement of crops. It varies with types and duration of crop, soil types, climatic conditions and crop management practices.
- There are several surface and micro irrigation methods to apply water to the crop plants. Advanced irrigation techniques like sprinkler and drip method of irrigation are employed to improve the efficiency of irrigation.
- Weeds are unwanted or undesirable plants that compete with crops for water, soil nutrients, light, and space and thus reduce crop yields. The top layer of soil serves as vast reservoir of dormant and viable weed seeds.
- Weeds can be classified into annual, biennials and perennials based on life cycle, monocots and dicots depending upon the number of cotyledons present or grasses, sedges, and broad-leaved weeds based on their morphology.

*Notes*

Crop Production
Practices

Notes

- Various preventive and curative strategies have been employed to control weeds. Preventive measures are undertaken to prevent the entry of weed species in an area while several physical, mechanical, chemical and biological methods are combined in integrated weed management (IWM) technique for reducing weed infestation sustainably.

**TERMINAL QUESTIONS**

1. What is the 'criteria of essentiality'?
2. Describe in brief about various role and sign of deficiency symptoms of major macro nutrient elements.
3. Classify the various sources of plant nutrients along with their brief elaboration.
4. What is irrigation? Why is it necessary to irrigate the plants timely?
5. Differentiate between water requirement and irrigation requirement of crops.
6. Give a thorough description of different irrigation techniques.
7. What is weed? Classify them according to duration, morphology and number of cotyledons.
8. Explain critical period of crop weed competition.
9. Discuss different strategies for weed management.
10. Write a short note on following topics.
 - a. Biological control of weeds
 - b. Fertigation
 - c. Beneficial nutrients
 - d. Post-emergence herbicide
 - e. Adhesion and cohesion

**ANSWERS TO INTEXT QUESTIONS****7.1**

1. 17
2. Option d (Iron)



3. Option a (Potassium)

4. False

5. Nitrogen

7.2

1. Option a (18%)

2. a. True b. False c. False

7.3

1. Irrigation is the artificial application of water to soil to supplement rainfall for crop production.

2. Option d (Irrigation)

3. a. False b. True

4. Option c (Sugarcane)

7.4

1. Check basin and furrow irrigation method

2. Drip irrigation

3. Drip irrigation

7.5

1. Weed

2. Chenopodium album

3. Option d (All of these)

7.6

1. a. False b. True c. True

2. Pre-emergence herbicides

3. Glyphosate/Paraquat

Crop Production
Practices

Notes

GLOSSARY

Emulsifiable concentrates (ECs): This is a type of liquid herbicide where an active ingredient is dissolved in an organic solvent, combined with emulsifiers that facilitate the mixing of the concentrate with water to form a stable emulsion.

Evaporation: It is a process of transformation of liquid into gaseous state.

Percolation: The downward movement of water through soil is known as percolation. The gravitational force of earth provides energy for this process.

Seepage: It refers to lateral movement of water in soil. Through this process, water moves horizontally from the zone of higher potential to lower potential.

Soluble liquids (SLs): Soluble liquids are a type of pesticide formulation characterized by their ability to dissolve completely in water or polar solvents, creating a clear solution that can be easily applied.

Spreader: Spreaders are mixtures of mostly nonionic surfactants used for spreading and sticking a spray on plant leaves.

Transpiration: It is the process of evaporation of water from plant surfaces like leaf, stem or flowers.

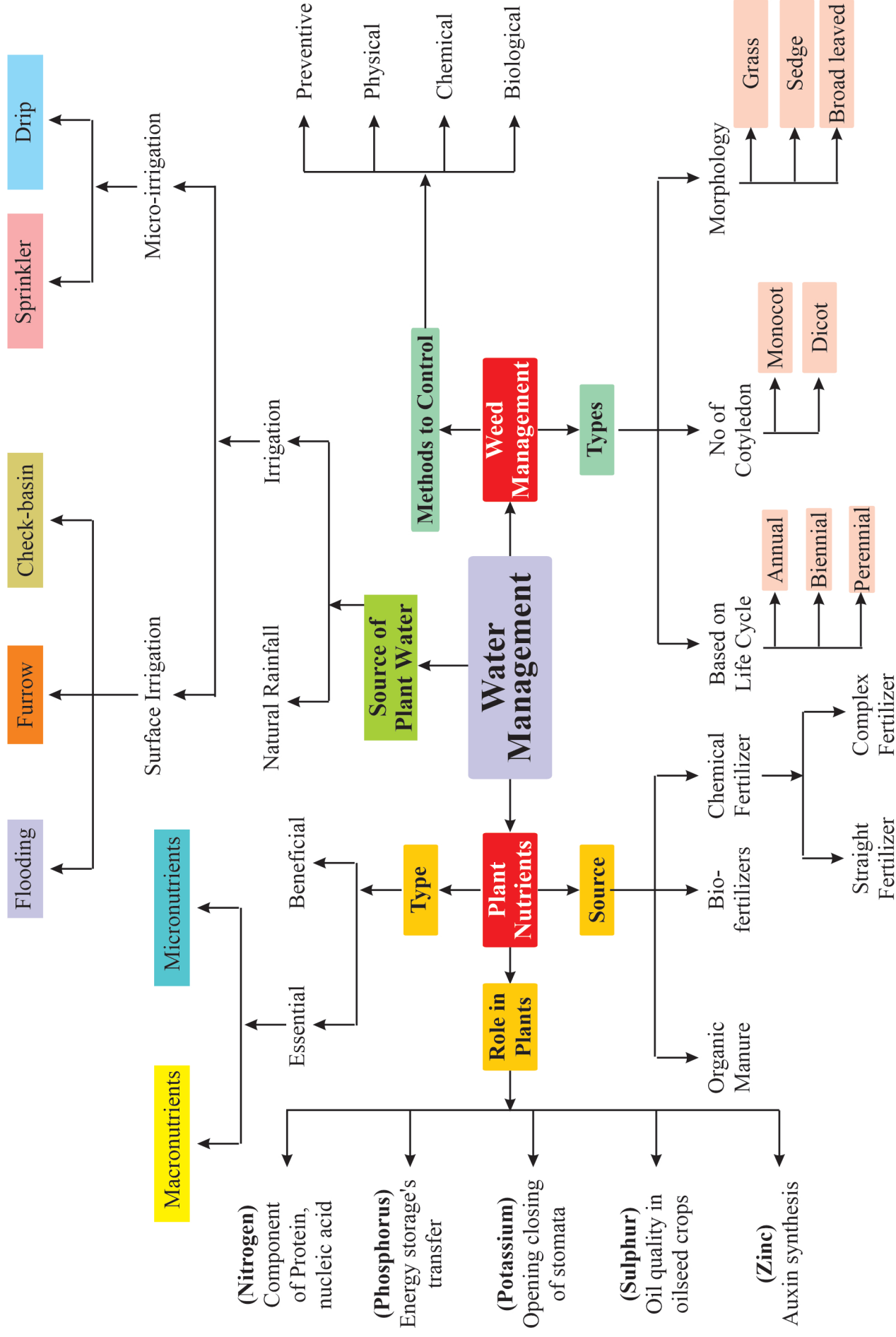
Water potential: It refers to potential energy per unit quantity of water as compared to pure water. Generally pure water has zero water potential. Water potential measures the tendency of water to move from one area to another due to osmosis, gravity, pressure and matrix effects such as capillary action.

Wettable powder: It is a type of pesticide formulation where active ingredients are combined with wetting agents so that it can be mixed with water to create a suspension for spraying.

SUGGESTED READINGS

1. Prasad, R. (2014). *Crop Nutrition – Principles & Practices*, New Vishal Publications, New Delhi.
2. Majumdar, D. K. (2013). *Irrigation Water Management: Principles and Practice*, PHI Learning, India.
3. Reddy, T. Y. and Reddy, G. H. S. (2016). *Principles of Agronomy*, Kalyani Publishers, Ludhiana.

WHAT YOU HAVE LEARNT





NOTE

[illegible]