2. PLANT AND ATMOSPHERE

INTRODUCTION

In the field you have seen the plants growing on the soil. Some portion of the plant is above the ground and is visible while some of it remains in the soil underground. Why the plant sends its root below the ground and keeps its stems and leaves above ground? We will study the role played by leaves, stems and roots of plant for the growth of plant in relation to its water management.

KEY CONCEPTS

Absorption of water by plant from soil, functions of water in plant's growth, soil moisture deficiency and it's effect on plant and climatic influence on evapotranspiration loss.

OBJECTIVES

After reading this lesson, you will be able to :

- *understand how plant absorbs water and transpires it to the atmosphere*
- *know about transpiration, photosynthesis*
- *recognise the different components necessary for photosynthesis, site of photosynthesis*
- *explain the functions of water in plant's growth*
- *state the effect of soil moisture deficit on plant's growth and yield of crop*
- *recognise the effective depth of soil which contributes water and nutrients to the plant*
- *know the influence of climatic factors on the evapotranspiration loss from a cropped field.*

2.1 PLANT STRUCTURE

A plant has roots, stems and leaves. The leaves are borne throughout the stem in all the plants. These leaves are mainly responsible for the loss of water from the plant which absorbs water from the soil. The surface of leaves has small pores surrounded by two cells. This pore is called stomata and the cells surrounding it are called guard cells. Guard cells control the opening and closing of stomata. The stomata regulates the loss of water as vapour and exchange of carbon dioxide from the air in the leaf. When stomata opens, entry of carbon dioxide in the

leaf and release of water as vapour from leaf to the atmosphere, continues. Closing of stomata stops the exchange of gases.

The leaves maintain their continuity of structure with the stem which has conducting tissues called xylem and phloem. Xylem is the main channel of water transport. The stem again maintains its continuity with the root which eventually is in close contact with the water source of the soil. Most plants have enormous absorbing root surface. Near the growing tip of each root or rootlet, there are many root hairs in close contact with soil particles and with the air spaces in soil from which roots get their oxygen. These roothairs extract moisture from the film of water that surrounds each soil particle, along with water, nutrients are absorbed by roots of the plants from soil solution. The water absorbed by roots is transported through xylem in stems and leaves and reaches near the stomata. Water is then lost to the atmosphere as vapour through stomata. **This process is known as transpiration.** Transpiration proceeds at a rapid rate where there is abundant supply of moisture in soil and stomata does not close. Reduction of soil moisture reduces the transpiration rate and consequently nutrient absorption.

2.2. FUNCTIONS OF WATER

You have already learnt that water helps in the transpiration of plant. This keeps the leaves of the plant cool when the atmospheric temperature is very high.

When the guard cells are full with water i.e. turgid, it helps in opening of stomata, which ultimately assists in entry of carbon dioxide. All green plants are capable of producing their own food during photosynthesis. Leaves manufacture food from carbon dioxide and water in presence of sunlight with the help of chlorophyll of the leaf. **This process is known as photosynthesis.** For this purpose, plant keeps its leaves above ground to receive sunlight for production of food and sends its root underground for absorption of water and nutrients from soil. When the water supply from soil decreases, the photosynthesis also decreases.

Water is essential to maintain the turgidity of the cell, which helps in cell elongation and cell division. It increases the growth of the plant parts and thus total area of the leaf is increased. Increase in leaf area contributes to enhanced photosynthesis.

You have already seen that water dissolves solid materials acting as a solvent. Thus water helps in the movement of solution from cell to cell within the plant body.

2.3 MOISTURE STRESS AND PLANT RESPONSE

You have noticed that plants grown with irrigation have better growth than those not supplied with irrigation water. In irrigated

agriculture, plant receives irrigation when there is deficiency of moisture in soil. You have studied the available moisture in soil. In this available range, plant can take up moisture easily up to a certain limit, after which rate of moisture absorption by roots decrease. Moisture stress in plant is developed due to the lag between the supply of moisture from soil and plant's demand at leaf level for transpiration. Moisture stress reduces turgidity of the cell and consequently the cell division is decreased. Thus size of the leaf is reduced and total leaf area is decreased. Reduction in cell turgidity decreases stomatal opening and carbon dioxide entry is restricted leading to decreased photosynthesis. It also decreases transpiration. Water and nutrient absorption is diminished. As a result, net growth of the plant is decreased; because water deficit affects all the physiological processes in plant.

Decrease in leaf area development, reduction in total photosynthesis and decreased growth due to soil moisture deficit influences the yield contributing characters and economic yield of the crop. Soil moisture stress at branching or tillering stage reduces the number of branches or tillers per plant. Moisture stress at flowering diminishes the number of grains in an earhead. Stress after flowering stage decreased grain weight. Finally moisture stress affected the yield of a crop.

The plant can tolerate certain degree of soil dryness without any appreciable decrease in various physiological processes and yield of crop. So it is essential to determine the degree of dryness in soil at which irrigation is to be applied to a crop without any adverse effect on growth and yield of the crop.

2.1 INTEXT QUESTIONS

1. What is the function of guard cells?
2. Through which plant structure water is lost as vapour?
3. What is the main channel of water transport in plant?
4. Which organ of the plant manufactures food?
5. What is photosynthesis?
6. What is the effect of soil moisture stress at flowering stage?

2.4 EFECTIVE ROOTZONE DEPTH

You know that the plant draws water and nutrients from soil with the help of its roots which grow in the porespaces. The size of the soil reservoir that holds water available to a plant is determined mostly by the plant's rooting characteristics. The distribution of

its roots determine its moisture extraction pattern. The soil depth wherein 80-85 per cent active roots of plant are present, is considered as the effective root zone depth of the plant. The effective rootzone depth of some crops at flowering stage and grown on sandy loam soil is given in Table -2.

Table 2
Effective rootzone depth of different crops

Crops	Effective rootzone depth (cm)
Rice, onion	30
Potato, groundnut	45
Wheat, maize, sorghum, soybean, lentil	60
Sugarcane, sunflower	90
Cotton	120

If you dig a soil in the field, you will find that upper layer is dry but the soil layers below has some moisture. As you go downwards the moisture is increasing in the soil. This gives you an idea that moisture is lost more from upper layer than the lower layers. It has been observed that in uniform soils which are fully supplied with available moisture, plants use water rapidly from the upper part of the rootzone and slowly from the extreme lower part. The usual extraction pattern of moisture from soil by plant shows that about 40 per cent of the extracted moisture comes from the upper quarter of the rootzone, 30 per cent from the second quarter, 20 per cent from the third quarter and 10 per cent from the bottom quarter.

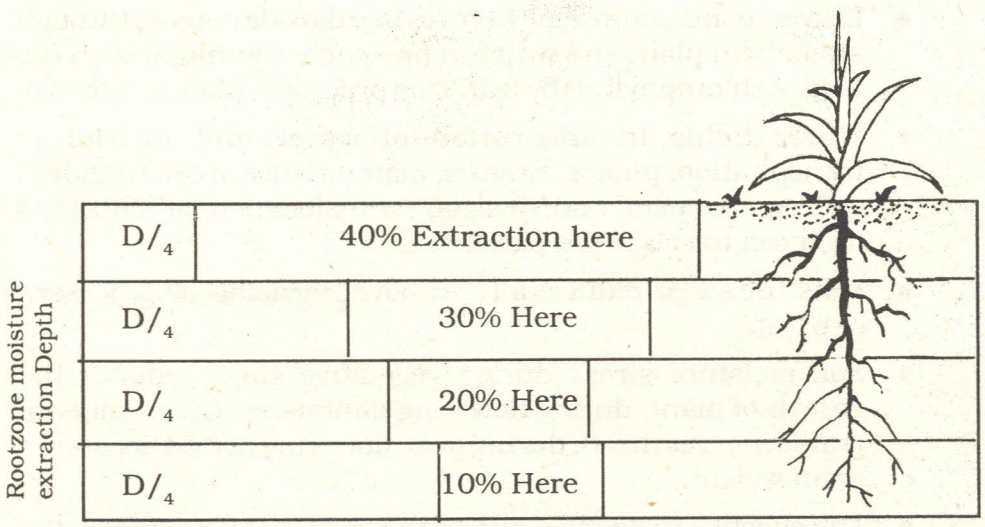

Fig. 6 Average moisture extraction pattern of plants

2.5 ATMOSPHERE

Sun is the ultimate source of energy for causing evaporation from soil and transpiration from plant canopy. So the climatic factors influence evaporatranspiration loss from the cropped field. Higher the temperature, sunshine hours and wind velocity, greater the evapotranspiration loss from plant, whereas increase in humidity of atmosphere decreases it. Same crop growing in summer season has higher evapotranspiration loss than its evapotranspiration loss when it is grown during winter season.

2.2 INTEXT QUESTIONS

1. What do you understand by the effective rootzone depth of the plant?
2. Mention the effective rootzone depth of potato, wheat and cotton?
3. What is the effect of atmospheric humidity on evapotranspiration of crop?
4. What is the ultimate source of energy which causes evapotranspiration?

WHAT YOU HAVE LEARNT

- A plant has roots, stems and leaves. Roots grow underground and draw moisture and nutrients from soil.
- Water absorbed by roots, travels through stems and reaches leaves and escapes to the atmosphere as vapour through leaf stomata. This process is transpiration
- Leaves manufacture food from carbon dioxide entered through stomata in plant and water in presence of sunlight with the help of chlorophyll of the leaf. This process is photosynthesis.
- Water helps in absorption of water and nutrients, transpiration, photosynthesis, maintenance of cell turgidity, cell enlargement and division, translocation of nutrients from cell to cell of the plant.
- Moisture stress reduces all the above physiological processes of plant.
- Soil moisture stress during vegetative stage reduces the growth of plant, during flowering diminishes the number of grains in an earhead, during post-flowering period decreases grain weight.
- The effective rootzone depth of the crop is considered as the soil depth wherein 80-85 per cent active roots of plant are present.

- Atmosphere controls the evapotranspiration loss from cropped field. Same crop grown during different seasons has different evapotranspiration loss due to difference in intensities of weather elements.

TERMINAL QUESTIONS

1. How water is absorbed by plant from soil and how it is lost to the atmosphere?
2. Discuss the functions of water in plant's growth.
3. Write about the effect of soil moisture stress on physiological processes and yield contributing characters of plant.
4. Write short notes on:
   a) Effective rootzone depth of crops.
   b) Extraction pattern of moisture from soil.

ANSWERS TO INTEXT QUESTIONS

2.1 1. Guard cells control the opening and closing of stomata
2. Stomata
3. Xylem
4. Leaf
5. Leaf manufactures food from carbon dioxide and water in presence of sunlight with the help of chlorophyll of the leaf. This process is called photosynthesis.
6. Moisture stress at flowering reduces the number of grains in an ear head.

2.2 1. The soil depth wherin 80-85% active roots of plants are present is considered as the effective root zone depth of the plant.
2 Potato - 45 cm
Wheat - 60 cm
Cotton - 120 cm.
3. Increase in atmospheric humidity decreases evapotranspiration of crops.
4. Sun

SUGGESTED READINGS:

1. Nature and properties of Soil - Buckman & Brady
2. Irrigation Theory & Practices - A.M. Michael.