

**Stress in Plants:**

Stress in plants is a condition in which the plant growing in non-optimal or poor state that negatively influences the plant growth, crop productivity, reproductive capacity or death if the stress exceeds the plant tolerance limits. It comprises a large range of factors which can be generally divided into two major groups: biotic or biological stress factors and abiotic or environmental stress factors. Abiotic stress factor includes the various environmental issues that disturb plant growth (such as light, water-logging, temperature, salinity, drought and heavy metal toxicity), whereas biotic stress factor is a biological harm (pathogens and pests), which a plant faces during its period. Due to constant climatic change and worsening of situation, a high risk is developed for food security and this state is imbalanced by human action.

This chapter continues with the actual knowledge of general views of the various types of plant stresses, their effects and how plants respond to these different types of stress. Responses to stress generally involves the various defense mechanism shown by plants to cope up all these stresses. In this chapter we will also make available the different defence mechanism adopted by plant to defend themselves from the environmental stress includes hypersensitive response, accumulation of plant hormones such as salicylic acid, jasmonic acid, and systemic acquired resistance (SAR).

**Introduction to Stress Physiology in Plants:**

Plants stress can be well-defined as any external factor that affects the plant development, production, and all the processes of its life forms. Any changed physiological condition caused by factors in surrounding environment may disrupt homeostasis. Environmental changes in this equilibrium condition defined as biological stress. It is an adverse effect on the plant which induced upon a rapid conversion from some normal environmental condition and it disrupts this initial homeostasis state.

Strain is somewhat physical or chemical alteration formed by a stress, i.e. a well-known condition, which forces a system away from its normal state. These environmental stresses signify various aspects which diminish the agricultural production. Their detrimental effect is not only on present crop, but they also develops barricades in the introduction of new species to the environment, so that the new species are not used for cultivation.

**Types of stress:**

Plant stress can be divided into two main groups. Abiotic stress is a physical (e.g., water, light, salt) or chemical way of damaging the plant and its surrounding. Biotic stress is a biological harm, (e.g., insects, disease) which a plant faced during its lifeforms. Many plants affected by a stress, shows abnormality in their growth and biochemical functions. Plants may recover soon, when the stress is low or for short time, the damage induced is temporary. But when the stress is more or for a long time, plants shows inhibition in their development processes such as flowering, germination, and reproduction that leads to death of the plant. These types of plants are called susceptible. Those plants which escape the stress overall are stress escapers, For example; desert plants, ephemeral or short-lived.

These short-lived plants germinate quickly following seasonal rains, and complete their life cycle during a period of suitable moistness and leads to the formation of dormant seeds before the beginning of the dry season. Similarly, many arctic plants rapidly complete their life cycle during summer and survive in the form of seeds in winter. These plants avoid stress condition in the environment by the avoidance mechanism and never come in contact of it. If stress is present in the environment, avoidance mechanism reduce the influence of any stress in plants. Some plants have the ability to tolerate a wide range of stress which is called stress tolerance or resistance by adapting or acclimating to it.

**Two main types of stress:**

1. Biotic Stress
2. Abiotic Stress

**Biotic Stress:**

It is the most important environmental stress factor which occur by the communication among the plant and any living organisms that results in either incomplete injury that the plant can overcome or complete injury that the plant can die. Almost all kinds of pathogens, viruses, bacteria and fungi contribute to the biotic stress in plants. But microorganisms are most important in the form of diseases (viral, bacterial and fungal diseases) inducing biotic stress. As we can say that, biotic stress is an external biological stress that disturbs the plant growth and affects almost all the group of plants, as well as cells, tissue, molecules, organelles, entire plants or even entire plant residents. In this chapter we will examine about the biotic stresses and the response shown by plants to the different biotic stresses.

### **Abiotic Stress :**

Abiotic stresses are external stress factors that can affect the plant growth for a longer duration. In normal condition each plant have the ability to completing its life processes and reaching to the maturity stage. Any abiotic stress or any change in the normal biological factor in the environment alters the different physiological, biochemical and metabolic function of plants and affect the plant growth. To cope up with these abiotic stresses in the surrounding, plants protect themselves by acquiring various defense mechanism to prevent their negative effect on growth and production. Drought or water-logging condition, high or low temperature, metal toxicity, excessive soil salinity, too much or too little light and nutrient deficiency in the soil are some causes of abiotic stresses. Plant shows various antioxidant defense mechanism to deal with all these severe stresses. In this chapter, we will discuss in more detail about the abiotic stresses and response of plants for these abiotic stresses.

The concept of stress is closely associated with the two terms i.e. **adaptation** and acclimation in plants. When tolerance increases in plant as a result of prior stress exposure, it is said to be **acclimated (or hardening)**. It is a temporary process while adaptation is permanent. Adaptation is an evolutionary process and continues over many generations in plants and animals. Both adaptation and phenotypic plasticity provide tolerance to the plants in highly stress condition.

### **Strategy to face the stress condition:**

- **Escaper:** Those plants or organism who completing their life cycle before the occurrence of a stress.
- **Stress Avoider:** By altering their morphology in accordance with the stress, such as reduced leaf area, stomatal conductance.
- **Stress Tolerant:** Tolerate the effect of stress without dying or suffering injury. Attained by specific physiological, biological and molecular mechanism at cell level which include specific gene expression and accumulation of specific proteins.

### **Stress Factors:**

As we discussed earlier that only at normal condition, plant grows and reproduce in a better way and produce good yield quality. But when plants are subjected to a different level of stresses, (biotic and abiotic) changes the growth condition from the normal state. These stress factors also known as stressors. When plants faces these kinds of stressors, they

trigger certain mechanisms for their adaptation and defences which we will discuss later in this chapter. This section deals with some important biotic and abiotic stresses and their effect on plant growth.

### **Some Major Types of Abiotic Stress :**

1. Drought or water stress
2. Salt stress
3. Temperature stress
4. Light stress
5. Heavy metal stress

### **Drought or water stress**

Water is the main component of life forms containing 80-90% of the inner mass of non-woody plants, and the major intermediate for conveying various nutrients and metabolites by which plants complete their different processes of development. The availability of excessive (flooding) or inadequate (drought) supply of water is called the water stress. It is one of the major abiotic stress that affect the overall status of plant and its development and happens for numerous reasons, such as excessive salinity, flooding, insufficient rainfall, excess of light and fluctuations in temperature. Plants faces water-deficit condition either when the uptake of water through roots becomes restrictive, or when the rate of transpiration turn into high. The first response of drought stress is wilting because the function of turgor pressure is lost, which expands plant cells and retains them rigid. In plant leaves, cells start to collapse without this turgor pressure and forming a floppy appearance. Plant cells start collapsing due to increase in wilting and leads to deaths. Drought stress occurs when plant demands more water at a given time or its ability of uptake is reduced.

### **Changes in plant growth:**

- Under prolonged drought, plants will dehydrate and die.
- Reduce the plant-cell's water potential.
- Affects translocation indirectly by altering the source to sink relationships for assimilates.
- Changes in structure of macromolecules by removal of water.
- Rate of cell expansion is inhibited due to loss in turgor pressure.
- Dehydration of mesophyll cells inhibits photosynthesis.
- Decrease in turgor causes stomatal closure.
- Overproduction of reactive oxygen species.

- ABA inhibits shoot growth appears to be promoted.
- Alters gene expression in the plant leaves decline during water deficit condition by suppressed synthesis.
- Disturb the membrane stability by destabilization between proteins and membrane lipids. Alteration in fatty acid arrangement causes drought condition.
- Osmotic adjustment- certain organic compounds such as sucrose, amino acids (especially proline and betaine), inorganic ions (especially  $K^+$ ) and several others that lower the osmotic potential and thus, maintain water potential of cells without limiting enzyme function.

### **Plant Responses to Drought Stress for Prevention:**

- Primary responses of plants to drought stress generally support the plant to relive for a while.
- The main aspects of plant responses to water involve the maintenance of homeostasis by ionic balance and osmotic adjustment.
- Detoxification of plant cells through antioxidant enzyme such as SOD and Catalase are produced by the activation of defense responsive mechanism.
- Reduced leaf area, stomatal conductance and highly developed root system.
- Osmolytes is the accumulation of certain compatible solutes like proline and betaine in the plants during water stress condition and provide resistance to the plants by the osmotic adjustment in cells. These osmolytes helps in various stress conditions.
- Abscisic acid, a plant hormone which is produced mostly in stress condition, also known as stress hormone. Accumulation of ABA under drought conditions helps the plant to survive from dehydration and provide tolerance.
- ABA induces the expression of various genes and closing of stomata as a defensive response during drought stress. Increase in concentration of ABA near the guard cell results in closure of stomata and supports the plant to save water from transpiration.
- During drought tolerance plants perform functions normally even at low water potential whereas in drought avoidance, plants maintains its ability of high water potential under water-deficit conditions.