Water Stress or Drought: Effects and Mechanisms

In this article we will discuss about Water stress or Drought. After reading this article you will learn about: 1. Effect of Water Stress on Growth and Metabolism 2. Mechanisms to Overcome Water Stress.

Effect of Water Stress on Growth and Metabolism:

i. Effects on Growth:

When a plant tissue suffers from water stress, there will be a reduction in turgor pressure. Since cell expansion is influenced by turgor potential 0Ft), developing cells will expand less and cell size will be smaller under this condition. However, the critical water potential for inhibition of cell expansion is different among species and among organs within plants.

ii. Effect of Cell Ultra-Structure:

Water stress affects the structure and function of membranes, which may lead to change in the ultra-structure of cells. Chloroplast and mitochondrial structure can be damaged by severe water stress. With the disruption of thylakoid structure, lipases along with fat droplets increase inside chloroplasts.

Associated with reduced water potential, plastoglobules derived from thylakoid membrane increase in number and size. In plants suffering from water stress, the PS II complexes may be disturbed which in turn may lead to separation of thylakoid membranes from cell membranes.

iii. Effects on Photosynthesis:

Water deficit has several effects on photosynthesis. However, the initial effect of water limitation is usually stomatal closure. Any of the factors, viz., a root signal like ABA, or low turgor pressure in guard cells or increasing vapour pressure gradient between the leaf and air may lead to stomatal closure. When stomata are closed, it is likely that there will be a depletion of CO_2 in the intercellular spaces.

This is termed stomatal inhibition of photosynthesis. Once CO_2 has decreased relative to O_2, diversion of carbon from photosynthesis to photorespiration will be stimulated.

If the light intensity is too high, photo-inhibition of photosynthesis may occur resulting in the formation of free radicals in the chloroplasts, which is caused by failure to utilize all the energy-rich products of electron transport chain. These free radicals, generally active oxygen species, generated

inside the chloroplasts, are harmful to the protein environment in which the chloroplast reactions occur.

Photo-inhibition is the main non-stomatal inhibition of photosynthesis under water stress. In some cases, however, water stress directly inhibits the photosynthetic apparatus through reduced turgor, which results in a change in chloroplast pH and ion concentrations.

As a consequence, the activity of rubisco changes along with a few other enzymes of the Calvin cycle. Other events of non- stomatal impact of water stress are chlorophyll degradation and the concomitant decrease in light harvesting and electron transport associated with PS II.

iv. Effects on Dark Respiration and Carbohydrate Metabolism:

Dark respiration of whole plants or shoots or mature leaves subjected to moderate water stress either remain unchanged or increase slightly over unstressed material. With increasing stress severity and duration, however, the respiration rate has been found to decline.

Under such water limitation, photosynthesis decreases before respiration. It has been envisaged that decrease in the ratio of photosynthesis to respiration and increase of both photorespiration and dark respiration during water stress may also give rise to plant starvation stress.

As regards carbohydrate metabolism, loss of starch and increase in simple sugars are the common features linked with water limitation. Carbohydrate translocation also decreases during water stress.

The decrease in sucrose translocation is caused by change in source-sink relationships during water stress. A decrease in the gradient of sucrose between source leaves and photosynthetic sinks is caused by low CO_2 assimilation by leaves and increased respiration in mesophyll cells.