

Plant Response to Water Stress

Water stress occurs when water loss from a plant exceeds water uptake, commonly during drought or low soil-water availability. Plants respond by trying to conserve water, maintain cellular function, and survive.

1. Basic sequence

Water shortage → stress perception → signaling → physiological adjustment → survival

Major Plant Responses to Water Stress

1. Stomatal Closure

Under water stress, plants close their stomata, mainly through ABA-mediated signaling. This reduces transpiration and helps conserve water. However, reduced stomatal opening also limits CO₂ entry into the leaf, which can decrease photosynthesis.

2. Reduction in Leaf Growth

Water shortage reduces cell expansion because of decreased turgor pressure. Consequently, leaf area and shoot growth decline, reducing the surface area available for water loss. This is an early adaptive response that helps the plant conserve water.

3. Root Growth Adjustment

Plants may alter their root architecture in response to water stress. Under moderate stress, greater allocation of resources to roots can promote deeper roots, lateral roots and root hairs, allowing the plant to explore a larger soil volume and access available water.

4. Osmotic Adjustment

Plants accumulate compatible solutes such as proline, soluble sugars, glycine betaine and other osmolytes. These compounds lower cellular osmotic potential and help maintain water uptake and cell turgor without disrupting normal cellular metabolism.

5. Reduction in Photosynthesis

Water stress decreases photosynthesis primarily because stomatal closure restricts CO₂ diffusion into leaves. Under severe stress, it can also affect chlorophyll, photosynthetic enzymes, chloroplast structure and electron transport, further reducing photosynthetic activity.

6. Activation of Antioxidant Defense

Water stress can increase the formation of reactive oxygen species (ROS). Plants respond by activating antioxidant systems such as superoxide dismutase (SOD), catalase (CAT) and ascorbate peroxidase (APX), which help protect membranes, proteins and other cellular components from oxidative damage.

7. Hormonal Response

Absciscic acid (ABA) is a major hormone involved in drought responses. Its accumulation promotes stomatal closure and activates stress-responsive genes. Other hormones, including ethylene, auxin, cytokinins and jasmonates, interact with ABA to regulate growth, root development, senescence and stress adaptation.

8. Activation of Stress-Responsive Genes

Water stress triggers changes in gene expression. Plants activate genes encoding protective proteins, antioxidant enzymes, osmolyte-producing enzymes, aquaporins and regulatory transcription factors. These molecular changes help cells maintain their structure and function during dehydration.