

**Stress resistance mechanisms in plants:**

Stress occurs when a plant is exposed to adverse and abnormal external conditions, which have a clear impact on the growth and production of plants.

The degree of resistance or sensitivity of plants to stress conditions depends on the type of plant, genetic makeup, and growth stage.

There are also several factors that determine a plant's response to environmental stress conditions, such as:

- 1- The type of stress the plant is exposed to.
- 2- The number of times the plant is exposed to stress.
- 3- The period of exposure to stressful conditions.
- 4- Stress level (stress intensity).
- 5- Plant age stage.
- 6- Genetic composition.
- 7- The presence of some stimulating factors that encourage the multiplication of the effects and intensity of stress.

**Stress resistance mechanisms:**

Stress resistance occurs through one of two methods:

1. Avoiding exposure to stressful conditions (avoidance mechanism).
2. Encouraging the plant to tolerate stress, such as by acclimatizing and improving growth before exposure to stressful conditions (tolerance mechanism).

It has been observed that some plants can tolerate stressful conditions through acclimatization, such as prickly pear and cactus, which are known for their drought resistance, due to their leafy stems, succulent leaves, and deep roots in the soil. It also causes physiological changes that increase the osmoticity of the cell juice of plant tissues. It was also found in some plants that are characterized by their tolerance to stress conditions that there is a process of regulating internal hormones in plant tissues, such as Ethylene, Jasmonic acid, and ABA abscisic acid, and all of this is subject to genetic action and control (Gene expression).

### **Tolerance to drought and salinity:**

#### **Adjusting osmotic regulation and its role in tolerance to drought and salinity stress:**

- It is well known that osmotic regulation of plant tissue cells is the mechanism that helps plants acclimatize to drought and salinity conditions.
- It is also known that the plant cannot absorb water from the soil because the osmoticity of the root cells is less than the osmoticity of the soil solution surrounding the plant in saline conditions.
- Some plants are very sensitive to stress conditions and therefore their roots wither and die, while some plants are resistant to stress conditions without any plasmolysis occurring in their cells.
- Plants resistant to drought stress are able to adjust the osmotility of their cells by increasing the concentration of cell sap with some components that raise the osmotic pressure to resist stress conditions.
- Among the compounds that can increase cell osmosis are: proline (proline betaine), mannitol and pinitol.

- Some plants, under salt stress conditions, inhibit sucrose synthesis while activating the synthesis of mannitol, which is the reduced form of mannose. This phenomenon occurs in celery plants and therefore celery seeds can germinate efficiently under high salinity conditions.
- Some plants accumulate pentol sugar under stress conditions, which is a cyclic alcohol sugar. It accumulates in some plants of the conifer and legume families, such as *Sesbania sp.*, when they are irrigated with a saline solution. Pentol sugar accumulates in the chloroplast and systole, while it does not accumulate at all in the vacuoles.
- Accumulation of a type of protein, such as Osmotin, an alkaline protein, was observed in tobacco plant leaves exposed to salt stress conditions. It has also been observed that this protein accumulates to a high degree when the plant is exposed to pathogens, and this protein inhibits the growth of fungal hyphae and bacteria as well.
- Transcription of synthesis Osmotin gene is activated under the following conditions:
  - 1- The presence of ABA.
  - 2- The presence of Ethylene.
  - 3- The presence of Auxin.
  - 4- Infection with TMV virus.
  - 5- Water deficiency.
  - 6- Ultraviolet radiation (UV).
  - 7- Wounds.
  - 8- Fungal infection.

**Oxidative stress:**

This type of stress occurs under conditions of production of active oxygen radicals (AOS), which have the ability to damage metabolic processes, plasma membranes, DNA damage, and cell death.

**Environmental factors that cause oxidative stress conditions:**

- 1- Air pollution (Ozone & Sulfur oxide).
- 2- Oxidant Forming herbicides (paraquat dichloride).
- 3- Heavy metals.
- 4- Drought
- 5- Heat and cold stress.
- 6- Wounding.
- 7- Uv light.
- 8- Intense light that stimulate photoinhibition.
- 9- Pathogen infection.

It has been observed that ROS such as hydrogen peroxide and super oxide anion are very important and are needed for the formation of lignin, which is a very important compound because it is a means of protection and defense against pathogen infections.

Ozone is one of the most important compounds that cause oxidation processes in plant tissue cells. Ozone is created when hydrocarbons, nitrogen oxides ( $\text{NO}_2$  &  $\text{NO}$ ), and sulfur oxide ( $\text{SO}_4$ ) are present, which react with UV rays to create ozone ( $\text{O}_3$ ).

Ozone negatively affects plants, as it:

- 1- decreased photosynthetic rate
- 2- Leaf injury.
- 3- Reduced growth of shoots & roots.
- 4- Accelerated Senescence.
- 5- Reduced Crop yield.

Plants also vary in their sensitivity or tolerance to ozone exposure.

Ozone causes harmful oxidation processes of biochemical contents, destroying lipids, proteins, and plasma membranes. It also causes the production of free radicals, hydroxyl radicals, superoxide ions, and hydrogen peroxide, due to the reaction of ozone with ethylene.

Ozone encourages wounds to form ethylene and accumulate salicylic acid. Ozone also destroys plasma membranes, as previously mentioned, causing the membranes to:

- 1- Alter ion transport.
- 2- Increase membrane permeability.
- 3- Inhibits H<sup>+</sup> Pump activity.
- 4- Collapses membrane potential.
- 5- Increases Ca<sup>+2</sup> uptake from apoplasm.

### **Tolerance to oxidative stress:**

Increasing the synthesis of antioxidant compounds and substances, as well as antioxidant enzymes, encourages and leads to increased tolerance to oxidative stress.

The following table gives examples of oxidative stress conditions with different etiologies and the antioxidants or antioxidant enzymes that lead to oxidative stress tolerance in each case of oxidative stress:

#### **Stress Conditions and antioxidants or antioxidant enzyme**

Stress Condition	Antioxidant or antioxidant enzyme
Chilling – high CO <sub>2</sub>	Anionic peroxidase
Drought– CO <sub>2</sub> – Ozone – high light intensity	Ascorbate peroxidase
Chilling	Catalase
Chilling – drought , heat – CO <sub>2</sub> - Ozone , SO <sub>2</sub>	Glutathion
Chilling – drought - CO <sub>2</sub> – Ozone – paryuate	Glutathion reductase
Deficiency of K , Ca , Mg , Mn , S , B-drought –heat – ozone	Polyaminase
Chilling - CO <sub>2</sub> - highlight – Ozone – paraquat– SO <sub>2</sub>	Super oxide dismutase SOD