An Introduction to Osmoprotectants

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Osmoprotectants

- Osmoprotectants are small and highly soluble, organic and compatible compounds that have low molecular weight with hydrophilic properties.
- Unlike inorganic compounds, osmoprotectants, at high cellular concentrations, are nontoxic to intracellular metabolisms operating in plants under harsh environmental conditions.
- Osmoprotectants are probably universal and regulate the cellular osmotic adjustment, mitigate damaging risk caused by ROS, prevent membrane injury and stabilize proteins and enzymes.
- Generally, three distinct categories on the basis of chemical composition of osmoprotectants are:
    - Amino acids
    - Quaternary ammonium compounds
    - Polyols, sugars, and sugar alcohols
- Under unfavorable conditions, osmoprotective compounds that accumulate in plants are proline, ectoine, fructan, pipecolic acid, trehalose, polyols, quaternary ammonium compounds including glycine betaine, alanine betaine, proline betaine, choline-O-sulfate, γ-aminobutyric acids, hydroxyproline, betaine, pipecolaite betaine, polyamines, D-ononitol, fructan, raffinose, sorbitol, inositol, amino acids, mannitol, gamma amino butyric acid (GABA), and carbohydrate sugars, etc.
- The accumulation, concentration, structure and compartmentalization of osmoprotectants at cellular level in plants under abiotic stresses depend on following factors that include:
    - Growth conditions,
    - Stress type
    - Severity of stress and
    - Plant species

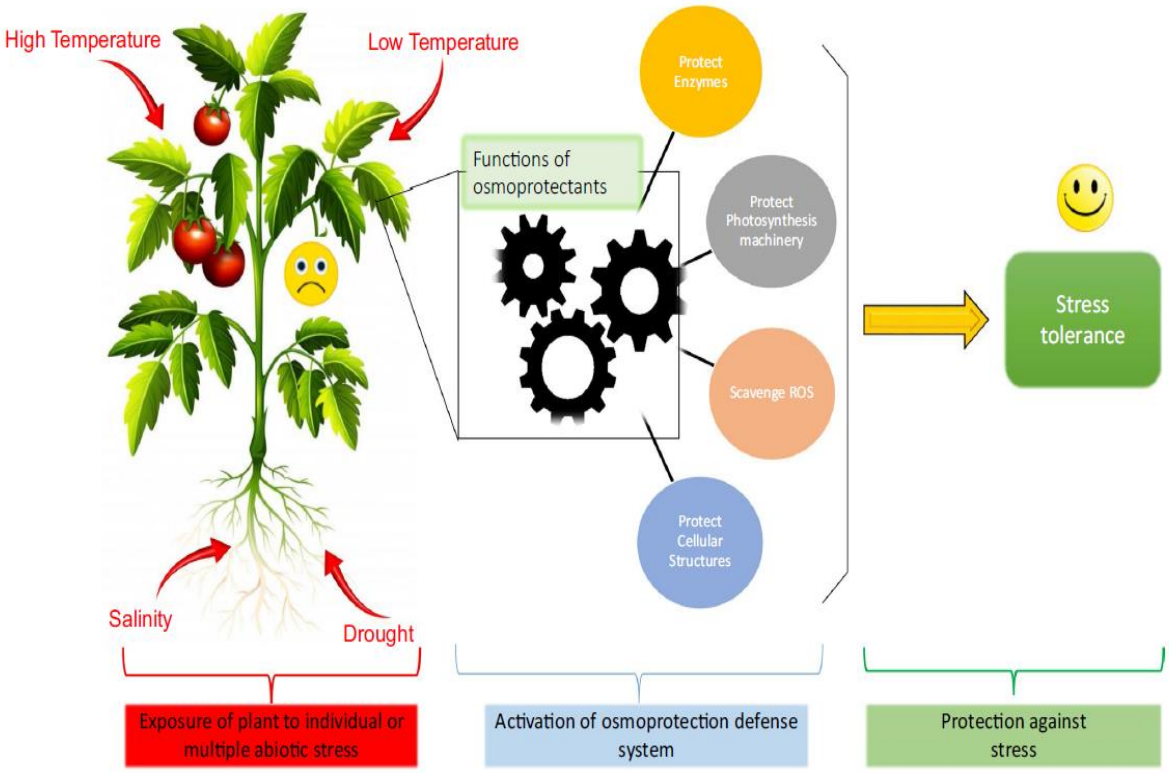

Fig.: A schematic representation describing the functions of osmoprotection in plants. On the onset of individual or multiple stresses (red part in the left side), plant activates its natural osmoprotection system and ultimately acquires stress tolerance. Various functions performed by osmoprotectants to mitigate the negative effects of abiotic stresses are illustrated in middle step (blue portion).

Functions of Osmoprotectants:

- Osmoprotectants preserve the cellular apparatus from the injury caused by dehydration, and at the same time they do not interfere with the normal metabolic processes at cellular level.
- The main role of osmoprotectant accumulation under harsh conditions are as follows:
  - Regulation of osmotic balance in plants
  - Maintenance of cell turgor pressure via osmoregulation
  - Replace inorganic ions
  - Protect cellular components and
  - Alleviation of ion toxicity

- Osmoprotectants play a diverse role in improving stress tolerance by protecting biological membranes, stabilizing protein structure and other cellular structures, detoxifying ROS, and maintaining cellular redox balance.
- Osmoprotectants also control the regulation of protein folding that assists in mediating stress signalling.
- These organic compounds also help to stabilize thylakoid membranes, resulting in upregulation of photosynthesis.
- The osmoprotective compounds improve the antioxidant defense system of plants by directly scavenging toxic ROS and protecting key antioxidant enzymes.
- Osmoprotectants play their role in the activation of defense related genes under various stresses.
- Overall, the osmoprotectants in plants are an important and well-organized evolutionary strategy to survive under hostile environments.