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Crop Plants and Abiotic Stresses

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Introduction

Crop plants encounter environmental stresses, both abiotic and biotic stresses. Abiotic stress has main impact on the crop productivity worldwide, reducing average yields for major crop plants. These abiotic stresses are interconnected as osmotic stress, resulting in the disruption of ion distribution and homeostasis in the cell. It is mainly due to changes in the expression patterns of a group of genes, leads to responses that affect growth rates, productivity. Therefore, to understand the stress response mechanism in plants it is very important to identify these genes that are responsive to abiotic stresses.

Cold

Cold stress is one of the mainabioticstresses that limit agricultural crop productivity by affecting their quality and post-harvest life. Because plants are immobile, they must modify their metabolism to survive such stress. Most temperate plants acquire chilling and freezing tolerance upon their exposure to sub-lethal cold stress, a process called cold acclimation. Still, many agronomically important crops are incompetent of cold acclimation. Cold stress affects virtually every aspects of cellular function in plants. The cold stress signal is transduced through several components of signal transduction pathways. Major components are Ca^{2+}, ROS, protein kinase, protein phosphatase and lipid signaling cascades. ABA also mediates the response of cold stress. Different plant species tolerate cold stress to a different way, which depends on the concern gene expression to modify their physiology, metabolism, and growth. The cold response mechanism may be related to various changes like, the expression of kinases related to signal transduction, accumulation of osmolytes, membrane lipid composition.

Salt

Soil salinity is a worldwide problem and poses a serious threat to entire world agriculture, because it reduces the crop yield in the affected areas. Salinity stress limits crop growth and yield in different ways. Salt puts two primary effects on plants: osmotic stress and ionic toxicity. Under normal condition the osmotic pressure in plant cells is higher than that in soil solution. Plant cells use this higher osmotic pressure to take up water and essential minerals from soil solution in to the root cells. Under salt stress the osmotic pressure in the soil solution exceeds the osmotic pressure in plant cells due to the presence of more salt, and thus, limits the ability of plants to take up water and minerals like K^+ and Ca^{2+} meanwhile Na^+ and Cl^- ions can enter into the cells and have direct toxic effects on cell membranes, as well as on metabolic activities in the cytosol. These primary effects of salinity stress causes some secondary effects like assimilate production, reduced cell expansion, and membrane function, as well as decreased cytosolic metabolism and production of ROS. During salt stress the key mechanisms against ionic stress include the reduced uptake of toxic ions such as Na^+ and Cl^- into the cytosol, and also sequestration of these toxic ions either into the vacuole or into theapoplast.

Drought

Global climate changes are leading to increases in temperature and atmospheric CO_2 levels as well as disturbance in rainfall patterns. Prolonged periods of in-appropriate rainfall leads to drought. Severe drought conditions bring about a steadily decrease in soil water availability to plants and cause premature plant death, while intermittent drought conditions affect the plant growth and development but are not usually lethal. The ability to survive longer and maintain normal function under intermittent drought conditions leads to yields, which are much lower than those observed under hydrated conditions. Drought tolerance enables plants to grow and maintain high yields in spite of drought conditions and is a result of the plant's efforts to withstand from stress. If the tolerance is restricted to that particular generation, the plant is said to be acclimated to drought. If it persists over generations, the plant genotype is said to be adapted to drought conditions. First response of plants subjected to drought stress is growth arrest. Shoot growth reduction under drought lowers metabolic demands of the plant and mobilizes metabolites for the synthesis of protective compounds required for osmotic adjustment.

Heat

High temperature has become a global concern, which seriously impacting the growth and production of plants, particularly crops. In near future, the vulnerability of crop plants will increase with increasing high temperature variation. Therefore, much attention must be given to the heat stress response mechanism in plants, particularly in crops, and the cultivation of the heat-tolerant breeds. When plants encounter heat stress the percentage of seed germination, photosynthetic efficiency and yield declines. Under heat stress, during the reproductive growth period, the functions of the tapetal cells are lost, and the anther is dysplastic. Increased temperatures inhibit the swelling of pollen grains during flowering and results in poor release of pollen grains andthe anther indehiscence. Plants have evolved various molecular and physiological mechanisms to overcome heat stress.

Toxin

The increased dependence of agriculture on chemical fertilizers and sewage wastewater irrigation and rapid industrialization has added toxic metals to agricultural soils causing harmful effects on soil-plant environment system. For example, Cadmium (Cd) is the main metal contamination, and is considered as a main environmental concern to the agricultural system as its residence time in soil is over thousands years.

ROS: Reactive Oxygen Species; ABA: Abscisic Acid.

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