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Role of Abiotic stresses in plants

Alisha Goyal
Research Scholar, ICAR- Central Soil Salinity Research Institute, Karnal

Abstract: External factors that have a significant impact on a plant's growth, development, or output are referred to as stress in plants. Numerous plant reactions are brought on by stress, including changed gene expression, cellular metabolism, adjustments to growth rates, and variations in crop yields. Some abiotic stressors, such as low or high temperature, a lack of water, and UV radiation, have a negative impact on plant growth and development, which lowers food yields globally. The abiotic stress elements that affect plant growth and development, such as temperature, drought, heat, and cold, were included in the following article. Abiotic stress factors are the non-living factors influencing the metabolism, growth, and development of the plant tissues at that particular time when such abiotic stress affects them. As a result of such abiotic stresses, the plants have generated many stress tolerance factors. Various stress-responsive genes are thus being formulated in response to the abiotic stresses, so the plants can survive even in such extreme conditions as well. Henceforth, it can be concluded that the abiotic stress factors imposed on the plants adversely impact their growth and developmental procedures, and at the same time, they also produce some stress tolerance factors to minimize the damage.

Introduction:

Abiotic stress is the term used to describe the harmful effects that created by abiotic factors on plant tissues [Andjelkovic *et al*., 2018]. Abiotic stress is induced by non- living elements, as opposed to biotic stress, which is brought on by living things. The metabolism of the plant tissues is disrupted by the many stimuli that affect them. The plants adopt newer metabolic processes in response to this stress in order to withstand it. Most of these responses help them control and maintain themselves against diverse environmental variables. The impact of stress conditions on plant tissue is shown in the pattern of growth and development [Bechtold *et al*., 2018]. Numerous forms of plant metabolism are induced by stress, including altered expression of inherited genes, metabolism of plant cells, changing patterns of growth types, crop yields, and many more. However, biotic and abiotic stresses—both of which are seen across plant tissues—are different forms of stress (Zhang *et al*., 2021).

Living things including viruses, bacteria, fungus, nematodes, insects, weeds, and many more can induce biotic stress [Chen *et al*., 2019]. Such stresses deny the host plants of the nutrition and growth components they contain, which ultimately causes the plants to perish. So, the primary cause of the plants' pre- and post-harvest losses is biotic stress factors. Abiotic stress factors are the non-living elements that have an impact on the plant tissues' current growth, metabolism, and development [Dresselhaus *et al*., 2018]. According to Sharma *et al*. 2019, among the many abiotic stress variables that affect plants include high heat, extreme cold, salt, drought, mineral availability or toxicity, and a host of others. Thus, these abiotic stress factors have had a detrimental influence on agricultural yields as a whole, necessitating the development of resistant plant cultivars that can withstand abiotic stress elements. These abiotic challenges are interrelated and may manifest as osmotic stress, an issue with ion distribution, or an imbalance in plant cell homeostasis. A collection of genes react by altering their expression patterns, which affects growth and production. Therefore, in order to comprehend the abiotic stress response mechanisms in agricultural plants, the identification of sensitive genes against abiotic challenges is required. Following are some of the several abiotic stress variables and their mechanisms:

Salt stress:

Soil salinity is a global hazard to agriculture because it reduces crop production and, ultimately, crop productivity in salt-affected areas. Crops under salt stress have several methods of reduced growth and output. Salt stress has two main impacts on agricultural plants: osmotic stress and ion toxicity. The osmotic pressure in the soil solution during salinity stress surpasses the osmotic pressure in plant cells owing to the presence of additional salt, limiting the capacity of plants to take up water and minerals such as $K+$ and $Ca2+$. These main consequences of salt stress lead to several downstream effects, such as decreased cytosolic metabolism, assimilate synthesis, and impaired cell growth and membrane function. Higher salt concentrations cause the genes that reduce stressors from salt concentration to be released again, improving the plants' ability to live in such dangerous conditions.

Cold stress:

Abiotic factors that impact crop quality and post-harvest life have been shown to be the primary abiotic stresses that reduce agricultural crop yield. Since they are naturally static so, plants are always working to alter their defences to fend off stress. Plants are subjected to cold and freezing temperatures in temperate climates, which are particularly detrimental to plants as a kind of stress. Plants acclimatise themselves to such fatal cold shocks by developing chilling and freezing resistance, a process known as acclimatisation. Many significant crops, however, are still unable to adapt to the cold stress. Many significant crops, however, are still unable to adapt to the cold stress. Cold-induced abiotic stress has a profound impact on all cellular processes in plants. There are a number of signal transduction pathways by which these cold stressors are transduced, including protein kinase, protein phosphate, ABA, $Ca2+$, and others. However, ABA emerges as the most effective of them.

Drought stress:

Nowadays, climate is changing all across the world as temperatures and $CO2$ levels in the atmosphere continue to rise. Due to climate change, which is a significant stress in the form of drought, rainfall is distributed unevenly. Due to the extreme drought circumstances, the amount of soil water that plants have access to is continuously growing, which causes plants to die before their time. Growth arrest is the initial reaction that agricultural plants undergo after being treated to drought. When there is a drought, plants develop fewer branches and have lower metabolic needs. Then, in response to dryness, plants produce defensive chemicals by mobilising the metabolites necessary for their osmotic adjustment.

Heat stress:

The rise in global temperatures has become a major worry since it affects plant development and production, particularly in agricultural produce plants. The proportion of seed germination, photosynthetic efficiency, and yield all decrease when plants are under heat stress. The function of tapetal cells is lost during the reproductive development stage when there is heat stress, and the anther becomes dysplastic.

Toxins:

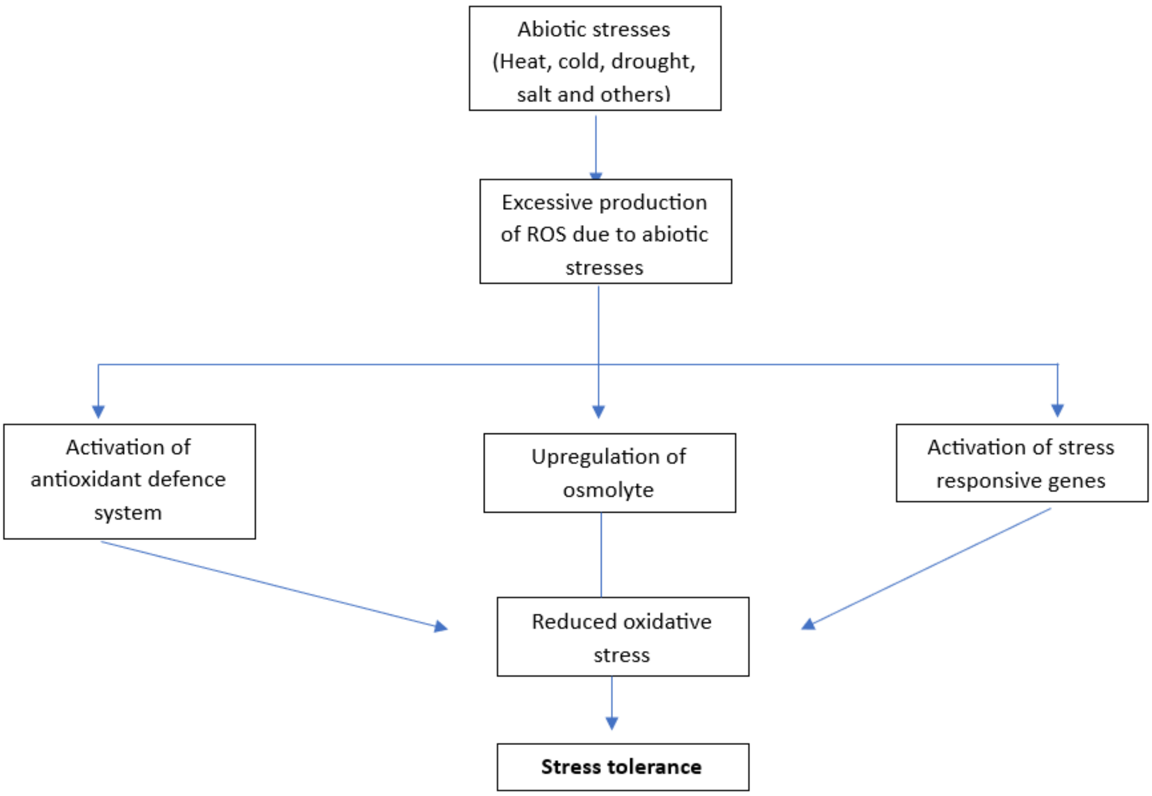
Toxic metals have been introduced to agricultural soils as a result of growing reliance on chemical fertilisers, irrigation with sewage waste water, and fast industrialisation, which has a negative impact on the soil-plant environment system.

Mitigation strategies used by plants to combat abiotic stresses

Plants are recognised for creating new mechanisms inside their internal metabolism to balance the excessive negative effects produced by the outside environment since abiotic stress factors are the ones that cannot be sustained and reduced by plants externally [Sharma *et al*., 2019]. Plants use a variety of such mitigation techniques to combat these abiotic stressors.

Figure 1 illustrates the progressive actions taken by plants to mitigate the effects of abiotic stress. According to the graph, under abiotic stress, plants tend to produce an excessive amount of ROS. Three additional steps—activation of oxygen antioxidants, up-regulation of osmolytes, and activation of stress-responsive genes—are added as a result of this excessive production [Zandalians *et al*., 2020]. Because the stress-responsive genes are turned on, the plants are far more tolerant and can withstand such dangerous temperatures. Identification of the targeted genes is therefore required since these gene controls are the only ones that affect the entire process. Therefore, it can be deduced that oxidative stress reduction increases stress tolerance variables and the plants' capacity to survive over the long term in such challenging settings.

Fig 1: Mitigation strategies for the effects of abiotic stresses



Conclusion:

In the next 50 to 100 years, it is predicted that the earth's temperature would rise by 3 to 5°C. As temperatures continue to rise and rainfall patterns become more erratic, variations in flood and drought are constantly taken into account. Salt stress may be further exacerbated by anthropogenic activities such overuse of fertilisers, poor irrigation practises, and resource exploitation. Plants will likely experience both biotic and abiotic stressors more frequently under these conditions. To safeguard both the safety of the farmers and the security of the food supply, it is the responsibility of plant breeders to create cultivars that can withstand stress. It will take molecular effort at the genetic level to create systems in plants that will protect them from various stress scenarios. The plants will be constantly under these stresses, which will end up posing a severe threat to world agriculture.

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