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Review Article

Recent Advances and Novel Strategies to Combat Biotic and Abiotic Stresses in Plants with Hydroponic Technology

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Abstract

Plant responses to various stresses are complex, involving alterations in the physiological, cellular, and transcriptome levels. Polyamine accumulation in diseased tissues is difficult to identify as it is found in both pathogenic fungus and plants. Abiotic stressors, as a group, pose a serious challenge to the ecosystem and agriculture also responsible for significant agricultural production losses. Benzoxazinoids are plant secondary metabolites found in grasses that have a significant potential for chemical defense against biotic stresses seen across the animal world. EREBP (Ethylene Response Element Binding Protein) transcription factor gets highly expressed in association with the ROS scavenging system, with decreased expression of the dehydrogenases gene. Crop productivity is also affected by biotic stresses. Plants physiological characteristics are altered by drought, excessive heat, and with their combined effect. Heat and drought stress have been proven to affect photosynthetic activity. Hydroponic systems operate by allowing precise control of environmental factors such as pH-balance and temperature, as well as increased nutrient and water exposure.

Keywords: Biotic and abiotic stresses, environmental responses, hydroponic.

INTRDOCUTION

In biology and ecology, abiotic factors are the nonliving component of the environment which affects an ecosystem. Biotic factors are the living things in the ecosystem. A living organism is that which influences another organism in the environment is referred as biotic factor. Animals and plants are the example of these organisms which consumes as food, as well as the animals which consume the organisms [1, 2]. Plant responses to various stressors are complex, involving alterations in the physiological, cellular, and transcriptome levels. Plant responses to numerous stresses differently than they do to single stresses, according to new research, triggering a particular pattern of gene expression tailored to the specific environmental circumstances faced [3]. The introduction of an abiotic stress can reduce or enhance vulnerability to a biotic pathogen or pest, instead of being cumulative, and viseversa[4, 5].

Polyamine metabolism in the plant cells has long been known to be distorted in response to minute changes in the plants interacting with fungi, viruses, and mycorrhizae. Polyamine accumulation in diseased tissues is difficult to identify as it is found in both pathogenic fungus and plants. The prospect of controlling fungal plant diseases by inhibiting polyamine production specifically excites researchers for future developments [6, 7].

Table-1: Shows the different type of responses in stresses and defense systems

Factor/defense system	Target sources	Expression system/responses	References
Abiotic factors	Environment	Ecosystem, Plant responses	[1,2]
Polyamine metabolism	Fungi, viruses, and mycorrhizae	Biochemical changes	[6,7]
Benzoxazinoids	Grasses	plant secondary metabolites	[15,16]
EREBP	ROS scavenging system	Molecular expression	[17,18]
HAMPs	Helping it to avoid harm to other parts of the plant	Chemical response	[21,22]
ProteinPP2A	Pathogenic responses	Gene expression	[23]
Phytoremediation	Cr, arsenic, nickel	Ultimately reduced environmental pollution	[24]
Hydroponic systems	precise control of environmental factors	increased nutrient and water exposure	[34]

Since their commencement, land plants have existed in an essentially hostile environment. Lower or higher temperature, high salinity, insufficient or excess water, heavy metals, and UV radiation are only a few of the chemical or physical variables that are harmful to them. Abiotic stressors, as a group, pose a serious challenge to the ecosystem and agriculture, and are responsible for significant agricultural production losses [8, 9]. Plants, unlike vertebrates, lack an adaptive immunity, which allows them to adapt to new illnesses and retain previous infection. Plants have developed a variety of complex methods to combat biotic stressors despite the lack of an adaptive immunity. The genetic coding of the plant contains the genetic component for various defensive systems. Dozens of biotic stress resistance genes are encoded in plant genomes [10, 11].

Fig-1: Shows the environmental stress to plant in the form of temperature Different pant responses under stressed conditions

A number of significant molecular studies have lately been conducted to better understand the plant molecular responses to the combined disease and drought stressors. These investigations have identified several possible options for improving plant tolerance to combined stresses as well as gives insight on a plant's defence system against combined stresses. Methionine homeostasis gene; AtMGL (methionine gamma lyase), rapid alkalinization factor-like 8 (AtRALFL8) engaged in cell wall restructuring, and azelaic acid induced 1 (AZI1) acting in systemic plant immunity are some of the major candidate genes found thus far[12-14].

BXs (Benzoxazinoids) are plant secondary metabolites found in grasses that have a significant potential for chemical defence against biotic stressors seen across the animal world. Benzoxazinoid biosynthesis, metabolism, and biological functions are all covered in depth. They discuss a wide range BXs biological activity, including poisonous to insect-health promoting actions. BXs are among the best-studied chemical defence chemicals in maize and have significant agronomic implications [15, 16]. EREBP (Ethylene Response Element Binding Protein) transcription factor gets highly expressed in association with the ROS scavenging system, with decreased expression of the dehydrogenases gene. When the resistant cultivar is infected with bacteria, these substances cause hypersensitive cell death. During infection, stimulation of glutathione mediated detoxification and flavonoid biosynthesis pathways, as well as up regulation of defence genes, prevents the further spreading of pathogen in the host tissue [17-19].

A plant must be capable of distinguishing between biotic and abiotic stress in order to protect itself against the biotic stress. The identification of specific compounds present in animal saliva is the first step in a plant's reaction to herbivores. HAMPs (herbivore associated molecular patterns), or Elicitors are chemicals that cause plants to respond. These herbivores associated molecular patterns activate signal transduction pathways throughout plant, triggering the plant's defence system and helping it to avoid harm to other parts of the plant [20]. Crop productivity is also affected by biotic stresses. Understanding the processes associated with plant pathogen defence will aid in the development of biotechnological and breeding techniques for the crop protein. The proteinPP2A (Protein Phosphatase 2A) is a key component which regulate the pathogenic responses in a variety of plant species. Individual stressors would typically stimulate conflicting responses in plants; therefore, they must create a customized response to particular multiple stress situations. For instance, the heat stress leads plants to expand their stomata to cool their leaves, but this would be counterproductive in a drought since more water would be lost [21, 22].

Heavy metal contamination is a major subject of concern. Till lately, phytoremediation of soil employing plant species with high metal absorption capability, like Brassica species are the major focus. Cr is a strongly phytotoxic metal that enters the food chain and affects agricultural production and public health. Phytoremediation of chromium polluted soil has primarily been proven using herbaceous plants, with cotton cultivars being the least investigated [23, 24].

Plants may use phosphorus primarily in the form of dissolved inorganic Pi (phosphate), but they are vulnerable to abiotic stress due to limitation of P when insoluble PO4 is in short supply in soil. In alkaline soils, phosphorus makes insoluble complex with Mg and Ca, whereas in acidic soils, it forms insoluble compounds with Fe and Al, rendering it inaccessible to plant roots [25].

Plants cultivated in the field face a variety of separate or concurrent biotic and abiotic stresses, and in responses, they use a varied range of genes to mitigate the detrimental effects development and growth. Plant breeding techniques, both traditional and biotechnology, are used to minimize climate-induced stressors in a variety of crops [26]. Plants' physiological characteristics are altered by drought, excessive heat, and with their combined effect. Heat and drought stress have been proven to affect photosynthetic activity. Stomatal closure limited photosynthesis during drought condition by reducing CO supply [27].

Most stress combos have considerably more complicated interactions, with varying effects on plants. Drought-pathogen and heat–pathogen stress are examples of complex combination. For instance, Avena sativa and T. aestivum become more sensitive to Puccinia spp. as the temperature rises, but certain forage crops, such as Cynodon dactylon become more resistant to the rust disease. Water deficiency slows plant development through lowering water absorption into growing cells and altering the rheological characteristics of the cell wall enzymatically, such as through the action of ROS on cell wall enzymes [28, 29]. The impact of diverse abiotic and biotic stresses on tree development varies depending on the kind and severity of the stresses, as well as the species of trees. For instance, the decline in P. abies growth infected with the fungal pathogen *Heterobasidion annosum* was shown to be greater in dry and warm environments [30].

Hydroponics technology in plants

Hydroponics is high tech approach for growing plants in mineral-rich water rather than soil. Hydroponics is a great concept for today's agricultural industry, which is struggling to locate additional fertile land for food production, since it will allow crops to be produced in greenhouses or multilevel structures [31]. Some plants can provide crop yields that are nearly identical to those produced on rich soils. Hydroponic crop production on a large scale, on the other hand, would be cost-effective only in particular intensive forms of agriculture or under specific conditions. This approach is used to cultivate some greenhouse crops, including flowers and vegetables. Hydroponic methods have shown to be highly beneficial in areas with no soil or highly barren soil but a suitable environment, such as several Pacific's coral islands [32, 33].

Hydroponic systems operate by allowing precise control of environmental factors such as pH-balance and temperature, as well as increased nutrient and water exposure. Hydroponics is based on a simple principle: give plants exactly everything which they need and when they need. Hydroponics uses fertilizer solutions that are specifically suited to the demands of the plant [34]. The wick system is the most basic form of hydroponic-system for growing plants, which can easily be used by almost anybody. Pumps, aerators, and electricity are not used in the wick systems. It is, in fact, the only hydroponic-system which does not rely on power. Whereas hydroponic innovation will never completely replace conventional system of farming, it is changing the agricultural production paradigm; we may see a new breed of contemporary farmers construct green walls inside their homes or recreation centers to provide fresh vegetables all year [35].

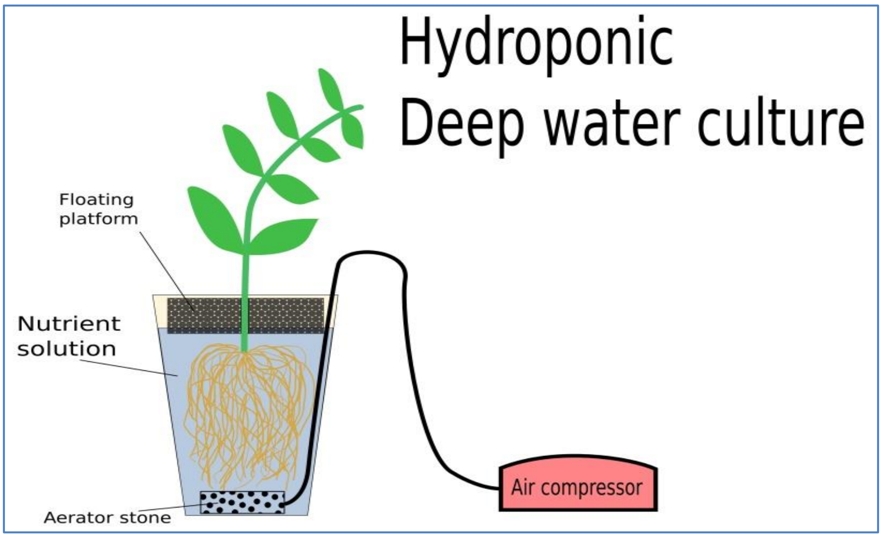

Fig-2: Shows those principle components of hydroponics system

Frequently mixing aquacultural solutions by means of specific salts is unreasonable for small scale commercial cultivators because salable goods are available at very suitable prices. Multi component fertilizers are common even when purchasing commercial goods. These products are frequently purchased in three-part formulations that highlight certain nutritional aspects. These multi part fertilizers should be applied simultaneously as the plant's is at development stage [36, 37].

CONCLUSION

Frequently mixing aquacultural solutions by means of specific salts is unreasonable for small scale commercial cultivators because of salable goods are available at very suitable prices. Multi component fertilizers are common even when purchasing commercial goods. These products are frequently purchased in three-part formulations that highlight certain nutritional aspects. These multi part fertilizers should be applied simultaneously as the plants are at development stage.

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