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Adaptation to Environmental Stress in Plants

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Abstract: Current tools have transformed biology into a data-intensive field and meaningfully improved our thoughts on signaling mechanisms in plants. Though, worldwide defense signaling system in plants has not been recognized yet. Very limited knowledge present about the receptors and intercellular signaling molecules/ process indulged in cell communication in plants. In this concern, emergent indication shows that the group of reactive oxygen species (ROS) mainly available common in any plant reaction to different environmental stresses signifies a fact that shows that number of mechanism come together to defend the stress. In this review, we touch base on the complexity of signaling process to combat the environmental stress. An importance of signaling molecules with special care of ROS is the main source of platform in plants will be discussed. The relations among ROS and signaling molecules such as calcium, G-protein, plant hormones, several transcription factors will be mainly considered. A improved knowledge in plant signaling mechanism would benefit transform new approaches to increase the plant production under the situations of the accumulative severity of environmental conditions and supply of food and energy worldwide.

Keywords: Plant stress, signalling, transcription factors, plant production, environment

INTRODUCTION

Our recent world is at the stage of about the wellbeing of humankind and quality of constantly being eco-environment on the basis of gratified food resource. Due to which the thought of biological progress was put onward, and many immense projects developed, comprising of Human Genome Project, FACE Project, Arabidopsis Genome Plan, Rice Genome Project, Western Development of China, related Space Projects and others (Shao et al. 2007). These projects encourage the expansion of stream of biology in far-reaching aspects, including molecular biology and plant stress physiology. Hence the final principle of molecular and plant biology is to make its progress for assisting human welfare timely and resourcefully. From this perspective, plant stress physiology is accumulative its significance and getting its attention on the world under global platform of climate change (Lobell 2012). Some key points for improvements in strategies in physiology of stress with broad associations with systematic biology will be elaborated here.

SIGNALLING APPROACH IN PLANTS DURING ENVIRONMENTAL STRESSES

Most vital abiotic stresses for crop yields alarms about plant dehydration. Most of the plants undergo dehydration with the situation of water stress, high salinity, high and low-temperatures. All of these stress effects hyper-osmotic stress categorized through declined turgor pressure and water loss (Joshi et al., 2022, Joshi and Karan 2013, Shabala and Lew 2002). The biosynthesis of ABA hormone can be stimulated by the process of dehydration and also stimulated the signaling the group of genes which is induced by water stress, high salinity, high and low temperatures (Gonzalez Guzman et al, 2022) Also besides these

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signaling elements, some other specific genes also play a vital role in plan adaptation process. The production of second messenger carried by the signal perception at the plasma membrane that induces the signaling process (Dong et al, 2022).

Among them, calcium played important part as a secondary messenger for initiate the signalling process (McAinsh et al. 1997, Verma et al. 2022). It is observed that under hyperosmotic stress condition an increase of inositol 1,4,5-trisphosphate (IP3) occur, which is restricted by phospholipase C inhibitors. IP3 is act as precursor to activate vacuolar calcium channel and it is known that calcium is released from intracellular pools in reaction to hyperosmotic stresses as a outcome of the activation of the IP3 dependent calcium channels.

ROLE OF ROS IN COMBAT STRESS

The ROS signalling process is extremely defined in biological process like development, reactions to biotic and/or abiotic stimuli (Borges et al. 2014, Mittler et al., 2011). In earlier studies ROS metabolism mainly dependent upon the ROS scavenging mechanisms but recent studies evaluated the role of ROS as signaling molecules. ROS signaling molecules can be utilize by maintaining the balance between ROS molecules production comprising the ROS producing enzymes and ROS scavenging process (Mittler et al. 2004). In ROS production process, NADPH oxidase, respiratory burst oxidase homologues (RBOHs), plays a very important part in plants under stress condition (Suzuki et al. 2011).

Drought and heat stress combination was more detrimental than either of stresses alone with respect to ROS content and damage to membranes and proteins. Drought followed by recovery resulted in induction of co-ordinated antioxidant defense in terms of both enzyme activities and metabolites during subsequent heat stress and, hence provided cross-tolerance (Semwal and Khanna-Chopra 2020). Water deficit stress and heat stress can cause imbalance to cellular metabolic processes leading to accelerated production of toxic metabolic by-products i.e. reactive oxygen species (ROS). ROS, such as $^1O_2$, H_2O_2, O_2^- and $HO^{\cdot}$ are toxic molecules capable of causing oxidative damage to proteins, DNA and lipids.

Plants have developed both non-enzymatic and enzymatic antioxidant defense processes which in co-ordination works to reduce the damage caused by elevated ROS. Antioxidants such as ascorbic acid and glutathione, and ROS scavenging enzymes such as superoxide dismutase (SOD), ascorbate peroxidase (APX), catalase (CAT), peroxidases (POX) and enzymes of ascorbate-glutathione cycle (monodehydroascorbatereductase (MDHAR), dehydroascorbatereductase (DHAR) and glutathione reductase (GR) have been found in almost all cellular compartments, demonstrating the importance of ROS detoxification for cellular survival. ROS are also known for their signaling roles during oxidative stress in plants (Dwivedi et al. 2016). In recent years studies have shown that plant RBOHs are involved in multiple signaling processes such as root hair growth, opening and closing of stomata, pollen-stigma interaction and plant defense mechanism to different kind of environmental stress. It is also identified that dehydration stress can be reduced by activation of antioxidant enzymes and biosynthesis of osmolytes acting as ROS scavengers (Chinnusamy et al. 2005, Singh 2022).

ROLE OF TRANSCRIPTION FACTORS DURING STRESS

Gene expression can be regulated by transcription level which mainly controls many developmental processes in a cell cycle, metabolic and physiological balance and reaction to environmental situations (Lopez-Maury et al. 2008, Riechmann et al. 2000). Plant stress reactions are controlled by several signaling paths that stimulate gene transcription and its downstream technology. In many ROS related microarray studies, the expression of 1,500 TFs in Arabidopsis in reaction to different ROS, with singlet oxygen, H2O2 and OH·. (Gadjev et al. 2006).

ROS signaling is mediated by the transcriptional regulation mechanisms yet not fully understood but it is recommended that TFs activity is regulated by the most vital ROS, H2O2 at different level such as 1. Upregulation of TF expression that regulated the mRNA stability and translation mechanism. 2. TFs stability can be increased by the decreasing the Ubiquitin E3 ligase complex with association of protein degradation. 3. DNA binding and nuclear transactivation by adapting TF affinity toward DNA, co-activators or repressors, and by targeting specific regions of chromatin to activate individual genes (Marinho et al., 2014). Many examples of TF regulated by the ROS signaling have been well understood. ROS production can be increased with redox sensitive TF which is easily sense by the simple bacteria and yeast (Mittler et al. 2004). OxyR (oxygen regulated) and PerR (Peroxide regulated repressor) are the two TFs that can be activated by H2O2 in some of the bacteria. The OxyR protein known as tetrameric protein is classified as a regulatory proten which can activate nine H2O2 induced protein out of twelve early H2O2 induced protein.

CONCLUSIONS AND PERSPECTIVES

In a word, plant physiology cannot be substituted by recent molecular biology. On the other hand it should be advanced in to the systems biology which can help improving the environment under drastic global climate change. It is significant to understand plant stress reactions to increase crop efficiency under unfavourable or stressful conditions. The adverse effects of heat stress can be mitigated by developing crop plants with improved thermos-tolerance using various genetic approaches.

Our group have done tremendous work in plant stress biology and the work has basically established an efficient platform for crop stress molecular biology and biotechnology for the goal (Kadam et al, 2012, Singh et al 2014, Shukla et al 2015, Khanna-Chopra et al. 2019). Of course, related work in this field also need much work of field at larger scales to make significant complements.

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