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Special Issue: Plant Abiotic Stress

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The world population is increasing at an alarming rate and will probably reach over nine billion by the end of year 2050, yet global food productivity shows a decreasing trend due to the accumulating negative effects of environmental stress originated by global climate change (www.walker-institute.ac.uk/).

Minimizing these losses is a major concern for all nations in order to cope with increasing loss of biodiversity and increasing food requirements. Drought, salinity and cold are among the major stresses that adversely affect plant growth and productivity. In fact, these abiotic stresses represent the principal cause of crop failure world wide, decreasing average yields for major crops by more than 50%. In Europe, this accounts for losses of millions of Euros. In general, low temperatures mainly result in mechanical constraints, whereas salinity and drought exert their negative effects mainly by disrupting the ionic and osmotic equilibrium of the cell. Higher plants are sessile organisms; thus they cannot physically avoid environmental stresses that negatively affect their growth, but plants have evolved strategies to deal with them. First, plants must be able to "sense" environmental cues to be able to respond appropriately to stress. Due to the complex nature of stresses, multiple sensors, rather than a single sensor, are responsible for perception of stress stimuli. After initial recognition of a stress stimulus, a signal transduction cascade is invoked. Secondary messengers relay the signal, ultimately modulating the expression of stress-regulated genes, generating the initial stress response.

Stress-induced genes can be divided into two major classes: genes involved in stress tolerance and genes required for signal transduction. Stress-tolerance genes enable plants to cope with the stress situation, in terms of both short- and long-term responses. These include genes controlling the synthesis of chaperones, osmolytes, and the production of other protective compounds. Genes involved in signaling encode important regulators, such as transcription factors that control sets of stress-responsive genes, or act in the production of regulatory molecules such as the plant hormone abscisic acid (ABA). Certain factors also known as accessory molecules may not directly participate in signaling, but are essential for the modification or assembly of signaling components. These factors include important protein modifiers that are added during or after translation to the signaling proteins and enzymes required for post-translational modification of proteins by phosphorylation, myristoylation, glycosylation, methylation, ubiquitination and sumoylation. It is therefore clear that a basic understanding of the mechanisms of stress tolerance through functional characterization of a plethora of genes involved in stress signaling is a prerequisite for effective crop improvement.

Our knowledge on the molecular mechanisms governing plant responses to abiotic stress has considerably increased during the last few years. However, we are still far from understanding the regulation and coordination of these complex pathways, which is further complicated by the fact that rarely is there a single abiotic stress affecting a plant. Therefore there are key aspects that are missing. For example, receptor molecules involved in primary stress perception and transduction are largely unknown. Further downstream processes including different classes of transcription factors and their target genes, chromatin remodeling, small interfering RNA, regulation of RNA processing, gene silencing, translation and proteolysis are not well understood. Protective mechanisms and metabolic networks connecting with upstream regulatory signaling pathways are relatively unknown as well as how different pathways interact with each other. Many of the previously identified "stress-tolerance" genes have been of limited use as they confer effects only in a narrow range of stress conditions that are mostly not relevant in the field. It is therefore necessary that additional efforts and finding are needed to support basic and applied research oriented towards the understanding of abiotic stress tolerance in plants in order to effectively transfer the knowledge to the industrial sector.

In the EC 5th framework, several European groups participated in a project (QLRT-2001-00841), which aimed at the functional analysis of regulatory elements of signaling pathways that control plant responses to osmotic stresses. The results clearly showed that pathways controlling different abiotic stress responses share numerous common regulatory elements and targets. In addition to the maintenance of cellular energy and osmotic balance, the role of several amino acid derivatives in protecting cellular components (e.g. membranes, protein complexes) as molecular chaperones or regulators of redox status was revealed. Among these, polyamines and proline were identified as key protective elements in drought, salinity and cold tolerance. These observations led to the foundation of a COST (Cooperation in Science and Technology) Action proposal entitled "Signaling control of stress tolerance and production of stress protective compounds in plants" (FA0605) taking

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the acronym INPAS ("International Network on Plant Abiotic Stress") (cost-inpas.org).

The Action started in 2007 with 32 participants from 19 countries. Currently, there are 76 group leaders from 38 countries (30 EU-COST and 8 non-COST from overseas: w3.cost.esf.org/index.php?id=181&action_number=FA0605), and members from additional countries have already expressed their intention to join the Action. Collaboration with companies like Metapontum Agrobios in Metaponum, Italy and Bayer BioScience in Gent, Belgium and contacts with Monsanto in St. Louis, Missouri, USA have already been established in the context of INPAS. So, as far as we know this is the largest international network dealing with plant abiotic stress in the world involving not only members from academia working with model plants and crops but also from private industry. Experiments among partners have been conducted at many levels: in the laboratory, greenhouse and in the field.

The major goal of INPAS is to stimulate cutting-edge collaborative research towards understanding the regulatory mechanisms of abiotic stress signaling pathways leading to the production of major stress-protective plant compounds. By stimulating scientific exchange among molecular geneticists, biochemists, plant physiologists and breeders, the network program aims at the identification of key regulators of plant abiotic stress responses and their essential stress-protective end-targets.

At the scientific level, INPAS is composed of four Working Groups. WG1 is mainly concentrated on understanding the regulatory roles of two major classes of protein kinases (SnRKs and MAPK), the activities of which are differentially controlled by specific abiotic stress stimuli. WG2 deals with the identification and functional analysis of signaling compounds directing gene expression under stress conditions. WG3 mainly concerns dissecting stress-associated signaling cascades that control the accumulation of osmoprotectans and other protective compounds. WG4 is aimed at integrated molecular analysis of the polyamine metabolic pathway in response to abiotic stress.

INPAS has organized three annual international workshops: Matera, Italy, Tartu, Estonia and Valencia, Spain with the fourth workshop scheduled in Cyprus from November 18-19th 2011. Leading scientists have been invited with a total number of more than 350 participants coming from around the world. Dissemination of INPAS has also been performed in several national and international scientific events, EC politician authorities and public media.

One of the most important activities of INPAS is the possibility to exchange personnel between laboratories (STSM) allowing the formation of students in new techniques and protocols. This has established a niche for integrative collaboration between different participant groups. Up until now around 30 STMS have been successfully performed and some of them have produced joint publications. Thus, from a total number of more than 200 publications of INPAS members, around 15% are the result of collaboration between members of the Action.

The production of this Special Issue on Plant Abiotic Stress is an initiative of INPAS with the aim to disseminate some of the results produced by members of the COST Action FA0605. Several contributions are the result of collaborative work between COST members. This special issue presents a wealth of excellent articles, both broad overviews as well as detailed accounts, aimed at advancing our understanding of plant abiotic stress tolerance phenomena. The articles, written by experts in their respective fields, cover a large array of topics and interpret our recently enlarged view of the genetic basis of stress-affected plant development, biochemistry and physiology. This comprehensiveness should make this special issue equally valuable not only to basic investigators and application-oriented plant scientists but also for teachers and students entering this field of plant biology.

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