

Plant Stress Tolerance: Engineering ABA: A Potent Phytohormone

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Opinion

Abiotic stresses, primarily drought, salinity, heat, cold, flooding and ultra-violet rays are causing widespread crop losses worldwide. Because of the complexity of the stress-tolerance traits, conventional breeding techniques have met with little success in fulfilling the world food-demands [1-3]. Therefore, to face the abiotic stresses, novel and potent approaches should be devised and engineering of phytohormones could be a method of choice to increase the crop productivity. Recent research has shown that phytohormones including the classical well-known auxins, cytokinins, ethylene, gibberellins and newer members including brassinosteroids, jasmonates and strigolactones may prove to be potent targets for their engineering for producing abiotic stress tolerance crop plants. Considering phytohormones being key-regulators of plant growth and development as well as mediators of the environmental stress-responses [4], hormone metabolism and signaling process are the potential targets for manipulation to obtain enhanced abiotic stress tolerance. Amongst various phytohormones, Abscisic Acid (ABA) is perhaps the most sought-after hormone for engineering abiotic stress tolerance in crop plants owing to its identity as stress-hormone and vast array of functions it carry out under environmental stress conditions, particularly drought. It is credited as an essential messenger involved in stress adaptive response of plants and regulates the expression of stress-responsive genes involved in accumulation of compatible osmolytes, synthesis of Late Embryogenesis Abundant (LEA) proteins, dehydrins and other protective proteins beside antioxidant enzymes [5,6].

As a result, many of the key ABA biosynthetic pathway enzymes have been manipulated for conferring improved abiotic stress tolerance in resultant transgenics [7]. Transgenic Arabidopsis constitutively overexpressing the zeaxanthin epoxidase gene involved in ABA synthesis from isopentenyl pyrophosphate (IPP) and β -carotene exhibited enhanced drought and salinity tolerance [8]. Similarly, Park et al. [9] reported enhanced osmotic stress tolerance by overexpressing an ABA-responsive stress-related gene in Arabidopsis. C-Repeat Binding Factor (CBF) and/or dehydration-responsive element-binding (DREB) genes have been manipulated to confer improved drought tolerance. For example, overexpression of CBF1/DREB1B from Arabidopsis was able to improve tolerance to water-deficit stress in tomato [10]. Furthermore, when driven by three copies of an ABA-responsive complex (ABRC1) from barley HAV22 gene, the resultant transgenic tomato expressing CBF1 showed enhanced tolerance to chilling, water deficit, and salt stress, while maintaining the normal growth and yield under non-stressed conditions as compared to their control counterparts [10]. However, on some occasions, though over-expression of gene(s) involved in ABA biosynthesis/catabolism pathways resulted in increased drought tolerance, but with undesired growth penalties due to pleiotropic effects even with the use of inducible promoters [11]. To offset this, Zhang et al. [12] overexpressed CRK45, a stress-inducible kinase involved in ABA signaling, and the resultant transgenics showed enhanced drought tolerance but with a more tight control of ABA levels and signaling, indicating the role of CRK45 in fine-tuning of ABA levels. Recently, transgenic poplars were produced via overexpressing Arabidopsis YUCCA6 gene (a member of the YUCCA family of flavin monooxygenase-like proteins), which is involved in tryptophan-dependent IAA biosynthesis pathway and known to respond to environmental cues, under the control of stress-inducible SWPA2 promoter [13]. The transgenic lines displayed auxin overproducing phenotypes and exhibited tolerance to drought stress, associated with reduced levels of reactive oxygen species. However, as

biosynthetic pathways and convergence points for cross-talk are still not clear with great understandings, there is a further scope to increase our understandings in this regard and identify novel genes encoding phytohormone metabolisms to be targeted for engineering abiotic stress tolerance in crop plants. Nevertheless, the recent findings have opened various avenues in transgenic breeding via targeting ABA for conferring abiotic stress tolerance in important crop species.

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