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COMMENT

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Towards improving drought resistance and lodging resistance in cotton

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Abstract

Cotton is one of the most important fiber and oil crop in the world and the fiber yield as well as quality traits are negatively affected by drought and lodging. Improving root gravitropism is a very effective way to enhance the crop resistance to drought and lodging stresses. Recent advance in origin and formation of root gravitropism may provide new insights to increase drought and lodging resistance in cotton.

Keywords: Cotton, PIN, Drought resistance, Lodging resistance, Root gravitropism

Cotton (*Gossypium* spp.), one of the most important oil and industrial crops in the world, contributes about ten billion dollars to the global economy per year and provides several million jobs in the industry and on the farm. Besides its economic value, cotton is also an excellent system for studies of cell elongation, polyploidization and cell wall biosynthesis. However, fiber yield and quality are greatly constrained by various abiotic and biotic stresses. Among these abiotic stresses, drought and lodging are the major factors causing extensive and massive yield reduction near the crop harvest stage worldwide (Shah et al. 2019). Therefore, improving drought and lodging resistance in cotton cultivars is one of the most important projects during cotton breeding. Increasing gravitropism to make root deep into soil to seek water is considered as an effective way. Recently, one important finding about the origin of gravitropism was published in the journal *Nature Communications* (Zhang et al. 2019), which greatly broads our view in plant gravitropism and provides clues to enhance drought and lodging resistance in cotton.

The published paper, entitled “evolution of fast root gravitropism in seed plants”, was led by Institute of Science and Technology, Austria, and Shaanxi Normal University, China and Northwest University, China (Zhang et al. 2019). In this study, multiple plant species representing the lineages of mosses, lycophytes, ferns, gymnosperms and flowering plants (*Arabidopsis* and cotton) were enlisted to examine the speeds of their root gravitropic response. After gravistimulation, non-seed plants (mosses, lycophytes and ferns) showed much slower root gravitropism than that in seed plants (gymnosperms and flowering plants). The anatomical analysis of root structure indicates that the amyloplasts, acting as the statolith to sensor the gravity in higher plant roots, are located above the root apex of basal vascular plant lycophyte and fern; however, they are specifically localized within root apex of seed plants. Interestingly, compared with the random localization of amyloplasts and their immobility within the root cells of lycophytes and ferns after a 180^0 reorientation of roots, the basal cellular localization and fast sedimentation of amyloplasts were observed in *Arabidopsis*, suggesting that root apex-specific amyloplast might function as the statolith to perceive gravity signal in seed plants. In *Arabidopsis*, PIN2 plays an essential role in fast root gravitropism and loss of PIN2 function led to the defective root gravitropism (Luschnig et al. 1998). Interspecies genetic complementation experiments revealed that the *PIN* genes, carrying the function equivalent to PIN2, only presented in the gymnosperms and flowering plants. Nonetheless, Zhang et al. showed that the homologous *PIN* genes from green alga, moss, lycophyte and fern were unable to rescue the defective *pin2* root gravitropism. The PIN2 function in mediating the fast root gravitropism relies on its exclusive property with their shootward subcellular localization in epidermal cells of root. This specialized property is attributed to a two-step evolutionary innovation of PIN2 protein: the first functional innovations in the transmembrane domains and the second innovations in the central hydrophilic loop. In addition, taking advantages of the sequenced whole genome of Upland

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cotton, 17 *GhPIN* genes were identified and the biological roles of *GhPIN* genes were widely characterized (Zeng et al. 2019; Xu et al. 2019; Zhang et al. 2017). Among the 17 *GhPIN* genes, *GhPIN1–3* and *GhPIN2* are involved in cotton root development (He et al. 2017). In addition, the expression levels of many *GhPIN* transcripts are induced by salt and drought stresses (He et al. 2017), indicating that *GhPIN* genes may be involved in abiotic stress response in cotton. Together, these studies systematically characterize the evolution and biological functions of *PIN* genes in *Arabidopsis* and cotton. Potentially, *PIN* genes can be used to improve the drought and lodging resistance in cotton by molecular selection breeding and gene editing (for example CRISPR / Cas9 system, i.e., clustered regularly interspaced short palindromic repeats / CRISPR-associated proteins) technology in the future.

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Li FG prepared and wrote the manuscript. The author read and approved the final manuscript.

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