Study of Root Anatomical Traits That Contribute to Environmental Adaptation of Plants in the Family Poaceae

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Abstract

Plants have no active oxygen transport mechanisms, and thus oxygen movement within plants is dominated by diffusion. Lysigenous aerenchyma, which is formed by the creation of gas spaces as result of cortical cell death, is essential for the stimulation of internal oxygen diffusion in waterlogged soil. Rice (*Oryza sativa*) forms aerenchyma constitutively under aerobic conditions and increases its formation under low-oxygen conditions. It has been known since long that gaseous phytohormone ethylene induces aerenchyma formation.

We first identified a respiratory burst oxidase homolog (RBOH), expression of which is stimulated by ethylene in the cortex of maize roots. In rice roots, RBOHH, which is closest homolog to the maize RBOH, is highly expressed in the cortex under low-oxygen conditions, while genes encoding calcium-dependent protein kinase (CDPK5 and CDPK13) were also expressed in the cortex. Coexpression of RBOHH with CDPK5 or CDPK13 induced production of reactive oxygen species (ROS), and knockout of RBOHH reduced aerenchyma formation under low-oxygen conditions. From these results, we demonstrated that CDPK- and RBOH-mediated ROS production is required for inducible aerenchyma formation[1)].

Auxin signaling, which is mediated by auxin/indole-3-acetic acid protein (AUX/IAA; IAA) and auxin response factor (ARF), comprehensively regulates root development. Number of lateral roots is reduced by the dominant-negative effect of an AUX/IAA protein in rice *iaa13* mutant. We found that aerenchyma formation is also reduced in roots of *iaa13* under aerobic conditions. We identified ARF19 as an interactor of IAA13 and a lateral organ boundaries domain (LBD)-containing protein (LBD1-8) as a target of ARF19. Because restoration of LBD1-8 expression recovered aerenchyma formation in *iaa13*, we concluded that constitutive aerenchyma formation is regulated through AUX/IAA- and ARF-dependent auxin signaling[2)].

Although many studies focus on the amounts of aerenchyma in roots, significance of the area of root cortex in which aerenchyma forms has received less attention. We evaluated the cross-sectional area of each root tissue in roots of wheat (*Triticum aestivum*), maize and rice under aerobic and low-oxygen conditions, and revealed that the cortex to stele ratio (CSR) and aerenchyma to cortex ratio (ACR), both of which determines the ratio of gas spaces to living cells (which require oxygen for respiration), were much higher in rice roots than those in wheat and maize roots. From these results, we proposed that CSR and ACR are useful quantitative indices for the evaluation and improvement of crop tolerance to soil waterlogging[3)].

References

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