Grasses Suppress Shoot-Borne Roots to Conserve Water During Drought

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Project Goals:

- **Define the developmental consequences of drought on the root system of Setaria and related grasses.**
- **Determine the physiological significance of stress-mediated changes in root architecture.**
- **Develop a method for quantifying root system architecture under water deficit stress in soil-like conditions.**
- **Identify the signaling pathways that are regulated during drought that likely affect root development.**

Abstract: Many important crops are members of the Poaceae family, which develop root systems characterized by a high-degree of root initiation from the belowground basal nodes of the shoot, termed the crown (1, 2). While this post-embryonic shoot-borne root system represents the major conduit for water uptake, little is known regarding what effect water availability has on its development. Here we demonstrate that in the model C_4 grass *Setaria viridis*, the crown locally senses water availability and suppresses post-emergence crown root growth under water deficit (1). This response was observed in field and growth room environments and in all grass species tested. Luminescence-based imaging of root systems grown in soil-like media revealed a shift in root growth from crown to primary-root derived branches, suggesting that primary-root-dominated architecture can be induced in *S. viridis* under certain stress conditions (1, 3). Crown roots of *Zea mays* (maize) and *Setaria italica*, domesticated relatives of teosinte and *S. viridis*, respectively, show reduced sensitivity to water deficit, suggesting that this response may have been influenced by human selection. Enhanced water status of maize mutants lacking crown roots suggests that, under water deficit, stronger suppression of crown roots may actually benefit crop productivity.

Significance Statement: Grasses, whose members constitute key food and bioenergy crops worldwide, utilize unique developmental programs to establish the root system from the shoot. Shoot-borne crown roots, originate near the soil surface and provide the main conduits by which the plant takes up water and nutrients. We show that crown root development is the major target of drought stress signaling. Water-deficit triggered crown-root arrest provides an important mechanism to conserve water under drought and this response is widely conserved across grass species. Substantial phenotypic variation exists in maize for this trait, which may be useful target in breeding efforts to improve drought tolerance.

References

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