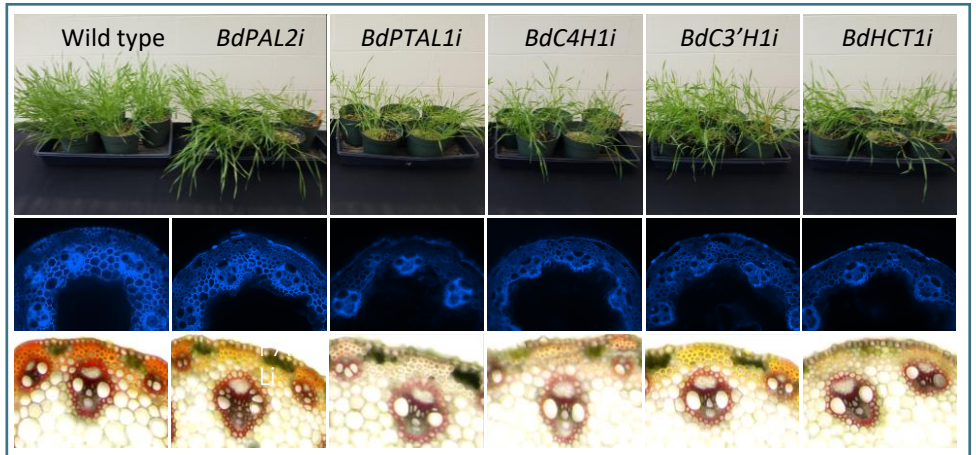
Lignin Pathway Modifications in a Model Grass Show Central Role of Ammonia Lyases in Carbon and Nitrogen Allocation

Background

- Lignin genetic engineering may improve the natural ability of plants to capture atmospheric carbon in cell wall polymers and/or to render plant biomass less recalcitrant to bioprocessing. However, the factors controlling growth inhibition in lignin-modified plants remain unclear (Fig. 1). *B. distachyon* is a model annual grass species.

Approach

- Most prior research on lignin biosynthesis regulation has focused on genes and transcriptional control; in this work, we undertook a large-scale proteome and metabolome analysis in a set of transgenic lines silenced in five early lignin pathway genes.



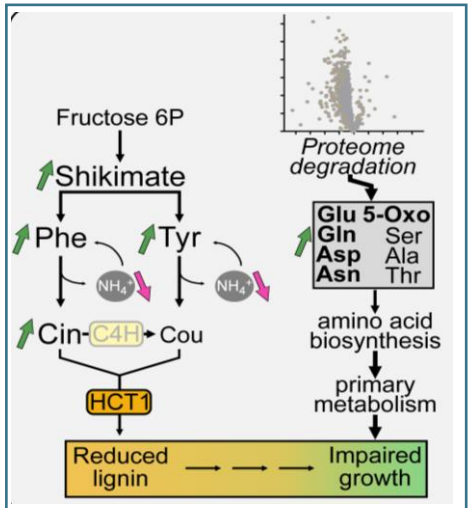
Lignin phenotype of RNAi lines exhibiting altered growth and lignin deposition.

Results

- Our findings support a model in which plant ammonia-lyases (ALs) play a central role in coordinating the allocation of carbon for lignin synthesis and the nitrogen available for plant growth.
- ALs are among the most abundant proteins in lignifying tissues in grasses. Integrated metabolomic and proteomic data support a link between lignin biosynthesis and primary metabolism mediated by the ammonia released from ALs that is recycled for the synthesis of amino acids via glutamine (Fig. 2).
- RNAi knockdowns of lignin genes confirmed that the route of the canonical pathway using shikimate ester intermediates is not essential for lignin formation in *Brachypodium*, and there is an alternative route to lignin formation from tyrosine via sinapic acid for synthesis of syringyl lignin involving yet uncharacterized enzymatic steps.

Significance

- Our data suggest that the molecular mechanism underlying the growth defects seen in lignin-modified plants is associated with a balance between phenylpropanoid and nitrogen metabolism mediated by ammonia-lyases. This is a new hypothesis to our understanding of this phenomena.
- Control of plant lignin carbon allocation may provide technologies to remove CO_2 from the atmosphere – critical to fight against climate change.



Model linking plant growth and lignin.

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