Popping the Cork on Biofuel Agriculture

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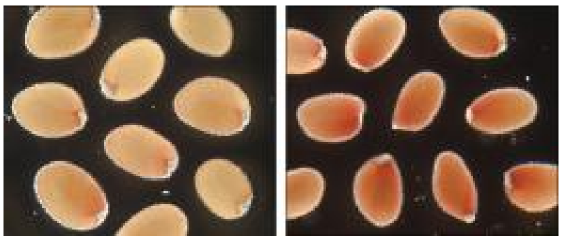

These images show that seeds deficient in HHT (right), an enzyme needed to synthesize an important component of plant cell walls, are more permeable to a red dye than normal plant seeds (left). Controlling the level of this enzyme may offer scientists a new way to alter plant growth for improved biofuel production.

(PhysOrg.com) -- Scientists at the U.S. Department of Energy's Brookhaven National Laboratory have identified a novel enzyme responsible for the formation of suberin -- the woody, waxy, cell-wall substance found in cork. While effective at keeping wine inside a bottle, suberin's most important function in plants is to control water and nutrient transportation and keep pathogens out. Adjusting the permeability of plant tissues by genetically manipulating the expression of this enzyme could lead to easier agricultural production of crops used for biofuels.

The research, led by Brookhaven biologists Chang-Jun Liu and Jin-Ying Gou, will be published online in the Proceedings of the National Academy of Sciences the week of October 19, 2009.

Plants use different polymers in constructing cell walls, each with unique qualities essential for growth and survival. Suberin, the polymer analyzed in this study, is mostly located in the cell walls of seed and root systems. It moderates the substances that pass into the organism, acting as a barrier to harmful substances and microorganisms while facilitating the intake and storage of water and other nutrients.

"We sought to understand the synthesis of the 'wall-bound' phenolic component of different biopolymers, including this important suberin polymer, by identifying the enzymes responsible for their construction," said Liu. This information could eventually be used to modify plants for agricultural purposes, including improved biomass production. "Knowing which enzymes do what may allow the properties of polymers to be tailored for specific purposes through either plant breeding or genetic engineering," Liu explained.

In this experiment, Liu and colleagues analyzed a strain of Arabidopsis (a common experimental plant) that had been genetically modified to disrupt the expression of a gene that codes for an enzyme now known as hydroxyacid hydroxycinnamoyltransferase (HHT). Chemical analysis showed that "knocking out" the HHT gene led to a deficiency of suberin phenolics, indicating that HHT is the enzyme responsible for biosynthesis of the polymer. Liu and his colleagues then isolated the gene and expressed it in bacteria to further characterize its function.

The team also demonstrated that the HHT-deficient plants were much more permeable to salt in solution than their wild-type counterparts. This finding, together with the ubiquitous presence of suberin in plant root tissues that control water and salt uptake, suggests that suberin plays an important role in the adaptation of plants to their terrestrial habitats.

Harnessing the mechanism responsible for suberin production might therefore allow scientists to create crop breeds tailored to thrive in specific — even harsh — environments, an important milestone on the road toward economically efficient biofuel production.

"Identifying the key biosynthetic enzymes and understanding suberin production may be particularly important for growing plants on the marginal soils that have been proposed for use in farming bioenergy crops," Liu said.

For example, if certain breeds can be created that are more adept at absorbing and storing water and nutrients, the crops could be farmed in much drier climates — maybe even the desert. In addition, the team's finding that modifications in suberin phenolic production can alter plants' tolerance to salt suggests that the newly-identified gene might be used to generate crops able to grow under salty conditions.

These approaches to biofuel agriculture would leave more-fertile land open for food crops, helping to strike a much-needed balance between the nutrition and energy needs of the world.

Synergistic studies

Liu also studies the biosynthesis of lignin, the polymer mostly responsible for strength in plant cell walls. His work confirms that suberin polyphenolics and lignin — two structurally distinct but functionally relevant cell-wall polymers — share the same biosynthetic precursors but are produced using different enzymes. A coordinated effort to modify both polymers could potentially make plants easier to digest for the production of biofuels, while, at the same time, redirecting photosynthetic carbon to improve carbon-sequestration efforts. Liu's group is currently engaged in proof-of-concept experiments to demonstrate this approach.

Source: Brookhaven National Laboratory (news : web)