Getting to the root of the matter

July 3 2013, by Jennifer Donovan

Victor Busov, left; Yordan Yordanov, center; and Hairong Wei, right, examine their experimental poplar trees.

(Phys.org) —Working to identify key genes in the root development of poplar trees, three Michigan Technological University scientists have come up with a new model for how genes interact and affect each other's function. They also identified a network of genes that cause poplar roots to grow well in low-nitrogen soil, making them ideal candidates for biofuel tree plantations on marginal lands.

The research by Hairong Wei, Yordan Yordanov and Victor Busov was published by the international journal *New Phytologist*. The article is titled "Nitrogen deprivation promotes Populus root growth through global transcriptome reprogramming and activation of hierarchical genetic networks."

When the researchers in Michigan Tech's School of Forest Resources and Environmental Science started looking at the question of how nitrogen—widely used as an agricultural fertilizer—affects root growth in plants, their goal was to find ways to produce plants that require less nitrogen.

"Contemporary nitrogen fertilization practices are not environmentally or economically smart," says Busov, who studies the functional genomics of plant development. "Only 30 percent is used by the plants. The rest goes into the ground water. It changes the soil and causes increases in algal blooms, greenhouse gases and insects like mosquitoes that carry disease."

The scientists wanted to grow more nitrogen-efficient plants, so less nitrogen could be used as fertilizer. But first they had to unlock the secret to the genetic mechanisms underlying plant root growth.

"Nobody knew the mechanisms of how low nitrogen affects plant roots," Busov explains.

They turned to the poplar for their studies because it is a major biofuel crop.

There are tens of thousands of genes in the poplar genome. The challenge—and it was a big one—was how to determine which genes are doing what, how they affect each other and how they work together to regulate root growth under low nitrogen conditions.

Wei, a molecular biologist, also has extensive knowledge of computer science, and he is adept at applying it to large biological data sets. He took on the task of untangling the interactions of more than 61,000 genes by searching for a "high hierarchical regulator," the "boss" gene.

In their laboratory at Michigan Tech, Busov and Yordanov planted poplar seedlings under normal nitrogen levels. Then they transplanted them to a medium that contained almost no nitrogen.

What happened? "Surprisingly, the roots got larger and longer," says Yordanov.

"We think that the roots were looking for nitrogen," Busov suggests. "But what is the genetic machinery behind this growth?"

The scientists did a series of experiments over time under the same experimental conditions, to identify the genes involved in the changes they observed. They found 9.198 genes that produced significantly different amounts or kinds of proteins at six different times. By performing genetic network analyses, they narrowed the field to a handful of key genes that appeared to control the majority of the 9,198 others.

Further analysis closed in on a gene called PtaNAC1. "When we tweak this gene, the entire network responds, and the roots grow 58 percent more than controls'," says Busov.

What Wei wound up with is a new model of how genes function together.

"Imagine a manufacturer," he says. "At the bottom of the hierarchy, you find the laborers. They answer to a foreman who reports to a manager, and so on until you get to the president. If you want multiple laborers to do a complicated job, you start with the president, who will pass the instructions down .

Busov likens the process to the functioning of a machine. "There is a master switch that turns on the engine," he says. "The engine activates other switches that make all the little cogs and gears in the machine do what they are supposed to do."

Wei's work with the genetic networks that cause root growth "gave us one of the big switches," says Busov.

Now that the scientists understand the poplar's genetic "engine," they can work to develop new varieties of plants that can thrive on marginal lands. "We want to grow poplars that are even more efficient in a low-nitrogen environment," says Yordanov.

There's a side benefit to growing plants that like low-nitrogen conditions too. They can suck some of the excess nitrogen from crop fertilization out of ground water. "That's good for the plants and good for nature," the researcher observes.

More information: onlinelibrary.wiley.com/doi/10 … 1/nph.12375/abstract

Provided by Michigan Technological University

Citation: Getting to the root of the matter (2013, July 3) retrieved 12 July 2024 from https://phys.org/news/2013-07-root.html