What secrets are stored in the roots of corn plants?

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University of Illinois researchers have developed technology to examine corn root complexity and how it impacts corn development. Credit: University of Illinois

With corn being a critical U.S. crop expected to help feed livestock and people around the world and also be a source for the production of clean energy, plant breeders are continually seeking ways to make the plants more productive. To better understand the role corn roots play in this regard, an agricultural engineer and a crop scientist at the University of Illinois at Urbana-Champaign have teamed up to examine corn root complexity and how it impacts corn development.

"Corn root structure is very complex, and it is critical to the growth of

the plant," said Martin Bohn, U of I associate professor of crop sciences. "Only with an efficient and well-developed root system can the crop produce the high yields producers are looking for and meet world demand."

Tony Grift, U of I associate professor of agricultural and biological engineering, is partnering with Bohn to examine corn root systems and to evaluate differences among corn genotypes. The team has developed innovative technology that uses high-resolution images of corn roots and statistical software to evaluate root complexity. The 'softbox' imaging tool they designed assures proper light penetration into the corn roots and automatically acquires six images per root at the click of a mouse button. These images are then analyzed using a statistical software program to generate a value for root complexity. The highly automated procedure stores the data in a library containing tens of thousands of images. This allows revisiting the imagery when new measurements or methods are developed.

"We define root complexity as the number of root branching points," Bohn said. "For the human eye, it's virtually impossible to meaningfully evaluate these differences in root systems. Very importantly, we are looking at the root structure of plants grown in actual soil in the field. Previous methods have examined the root complexity of plants grown in artificial environments, such as through hydroponics. The root systems we look at better represent what actually happens in the field."

According to the researchers, a complex root structure could lead to a more productive plant. "Root systems with a greater number of branching points allow the plants to be more efficient at taking up water and nutrients from the soil," Bohn said.

The software analysis employed to evaluate the root systems uses fractal dimensions - a statistical evaluation of geometrical shapes - to provide an

indirect estimate of the number of branching points. Not only does the analysis of the roots provide an estimate of root complexity, it also allows the researchers to correlate differences in the complexity of the root systems with the plants' genetic makeup.

"We have found significant variation in the complexity of the root systems among various corn genotypes," Bohn said. "We also discovered regions in the maize genome that are responsible for the inheritance of root complexity."

These findings have allowed the researchers to identify variations in root systems due to the plant's genetics, beyond the variations resulting from environmental factors such as weather, soil type, and available nutrients.

"With this new technology, we have found that more than half of the variation we observe for root complexity can be explained by genetic differences among plants," Bohn said. "This is allowing us to separate corn genotypes and identify the genes responsible for the plant's root structure."

An important question is: how does root complexity transfer into productivity or how much complexity is really needed?

To unlock information regarding the importance of root complexity on plant performance, the researchers are looking at 10 to 15 above-ground traits of corn plants with varying root complexities. Traits being examined include plant architectural traits like leaf length and width, leaf angle, and yield components like number of ears, number of kernels per ear, and kernel weight. Efforts are also under way to expand the research initiative to determine if root complexity provides the plant with the ability to grow better under low nitrogen or drought conditions.

"We now have the technology, which includes both hardware and

software, to study corn root complexity in a high-throughput manner and link this complexity to the genetics of the plant," Bohn said. "We hope to uncover a wealth of important and useful information being stored in the corn plant's roots."

Provided by University of Illinois at Urbana-Champaign

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