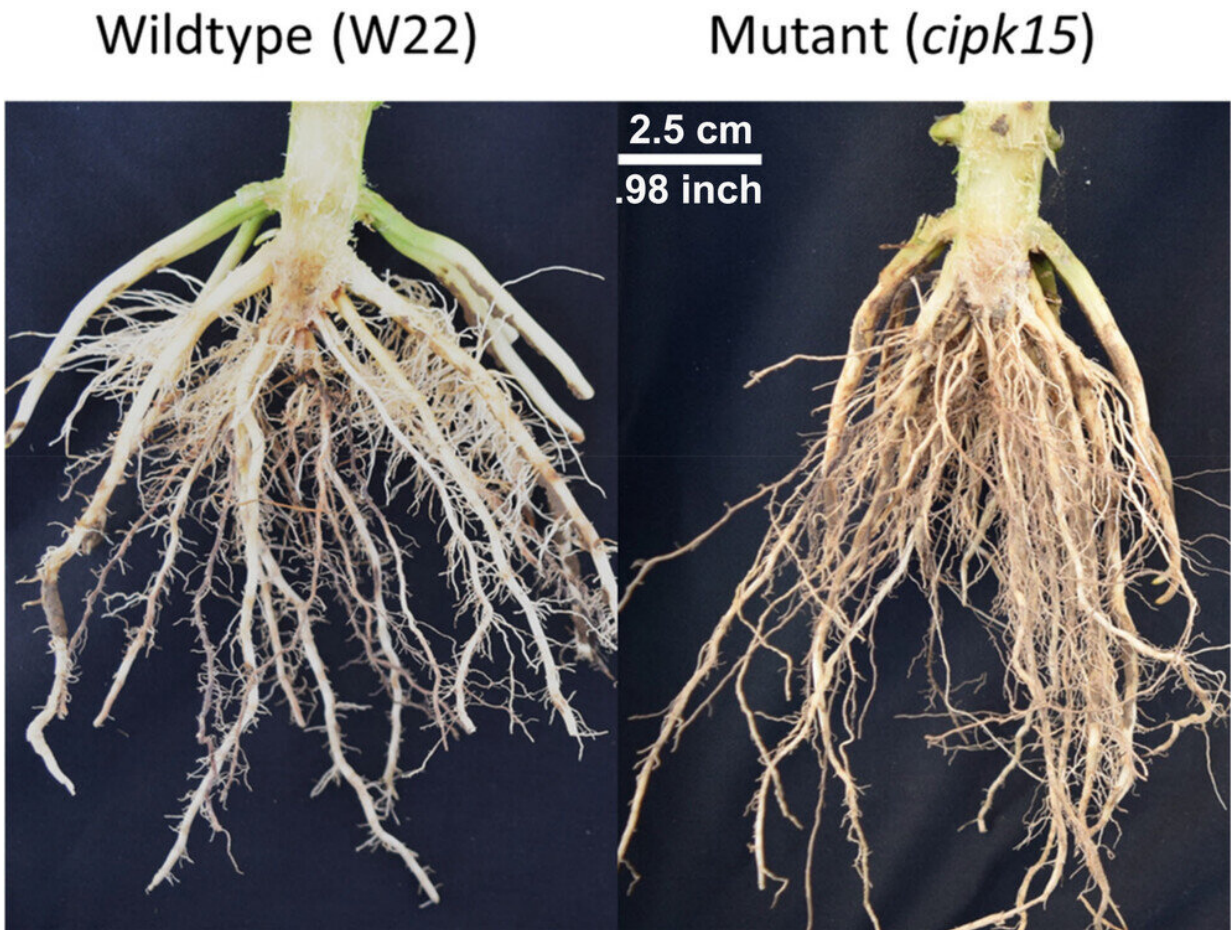


Researchers identify a gene that regulates the angle of root growth in corn

July 28 2021, by Jeff Mulhollem



These images of root architecture in the field show the *cipk15* mutant corn genotype had significantly steeper angles compared to the wildtype genotype. Plants were grown in low nitrogen conditions. The mutant corn line that produced the root on the right lacks a gene that regulates root growth. Credit: Hannah Schneider/Penn State

The discovery of a gene that regulates the angle of root growth in corn is a new tool to enable the breeding of deeper-rooting crops with enhanced ability to take up nitrogen, according to an international team of researchers, led by Penn State.

The gene, called ZmCIPK15—a moniker indicating where it is located in the genome and how it functions—was found to be missing in a naturally occurring mutant [corn](#) line that grows roots at steeper angles that make them go deeper into the soil. They identified the gene using a technique called a genome-wide association study, which involves a painstaking statistical analysis of a genome-wide set of genetic variants in different plant lines to see what genes are associated with a trait.

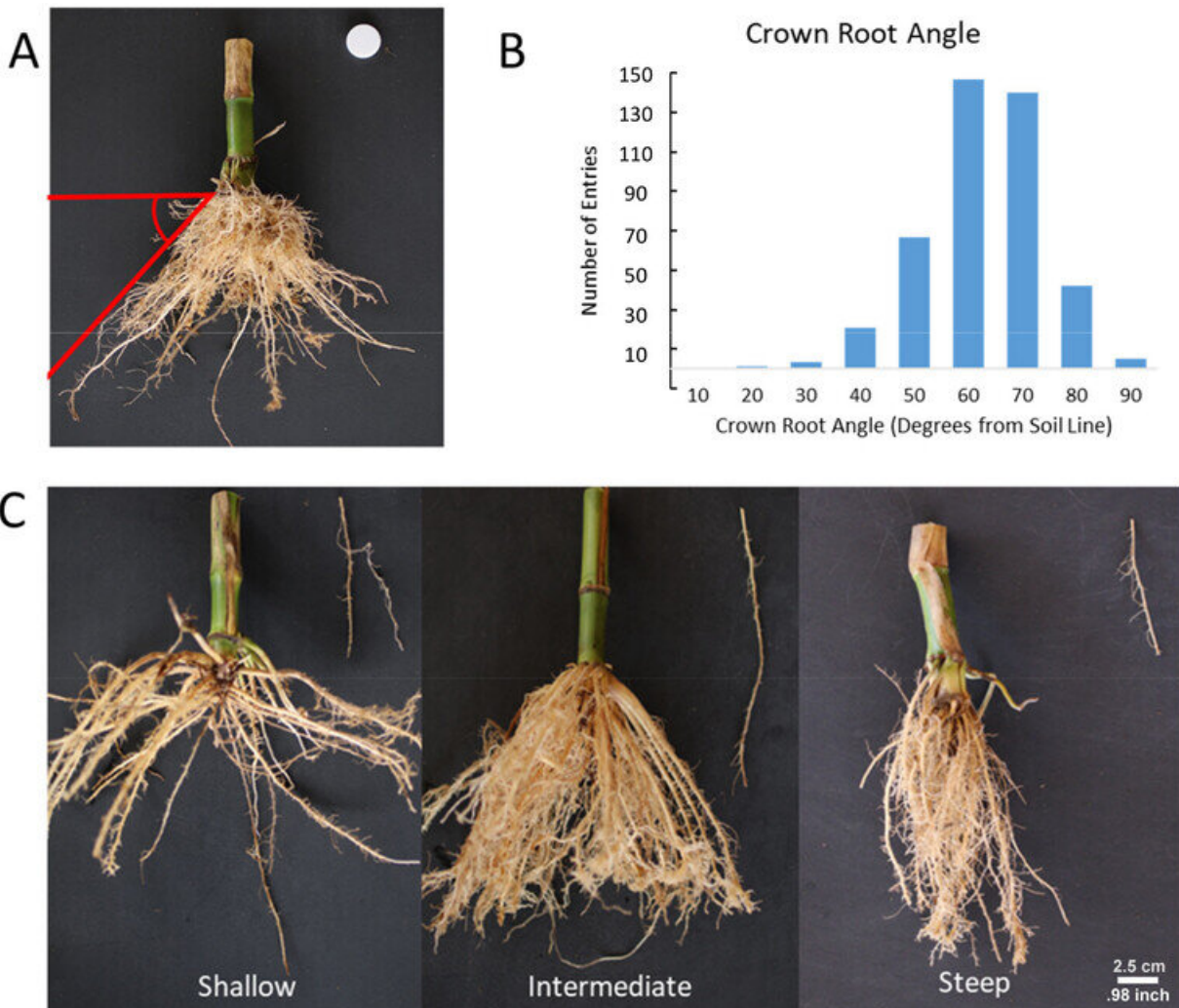
Identifying a gene that controls the angle of root growth in corn—influencing the depth to which roots forage—is important because deeper roots have a greater ability to capture nitrogen, according to research team leader Jonathan Lynch, distinguished professor of plant science in Penn State's College of Agricultural Sciences. Corn with an enhanced ability to take up nitrogen has implications for the world's environment, economy and food security, he noted.

"Corn is the most important crop in the world. In rich countries like the U.S., the biggest energy, economic and environmental cost of growing corn is nitrogen fertilizer," Lynch said. "And more than half of the nitrogen fertilizer applied to corn is never even taken up. It's just wasted—washed deeper into the soil where it pollutes groundwater, and some of it goes into the atmosphere as the greenhouse gas, nitrous oxide. It's a massive problem."

In contrast, in regions like Africa where people are more dependent on corn for food, soils are nitrogen deficient and farmers can't afford to buy fertilizer, if it even is available, Lynch added. Corn yields in Africa are just a fraction of what they are in the U.S. Deeper-rooting corn would

help poor countries harvest more food with the limited amount of nitrogen that they have.

To find the gene regulating the angle of roots, researchers at Penn State screened nearly 500 lines of corn over four years in South Africa. Field experiments at Penn State's Russell E. Larson Agricultural Research Center and greenhouse experiments at the University Park campus were conducted to confirm the phenotype of the mutant and wild-type plants and to test the functional utility of changes in root angle for nitrogen capture.



Researchers observed a wide variation in crown root angles in corn, ranging from shallow to steep. They reported that a steeper root growth angle markedly improved nitrogen capture. Credit: Hannah Schneider/Penn State

Roots of selected plants were excavated and measured, validating the functional importance of the ZmCIPK15 gene. It caused an approximate 10-degree change in root angle, noted Hannah Schneider, former postdoctoral scholar in the Lynch lab, now a faculty member at Wageningen University in the Netherlands, who spearheaded the research.

"Along with enhanced deep nitrogen acquisition, we expected to see that the steeper growth angle of cipk15 mutants' roots would result in better performance in drought, but in our experiments, it did not translate to improved plant water status," she said. "However, that only may be because we have difficulty simulating drought conditions in Pennsylvania."

In findings recently published in *Plant, Cell and Environment*, the researchers reported that a steeper root growth angle markedly improved nitrogen capture. In field studies under suboptimal nitrogen availability, the cipk15 mutant with steeper growth angles had 18% greater shoot biomass and 29% greater shoot nitrogen accumulation compared to the wild type, after 70 days of growth.

The results of the research are eye-opening, Lynch pointed out, admitting that he was surprised by the outcome. It's quite unusual, when you knock something out, that the plant gets better, he explained. Because plants are like finely tuned machines.

"You take a gene out of that finely tuned machine, you don't expect it to work better, but this shows that if you knock out the single gene, you'll get deeper roots and better nitrogen capture," he said. "For America, here's a way to reduce a major cost and environmental impact from corn production. For Africa, this discovery could result in higher corn yields that will reduce food insecurity. And this discovery may support the discovery of genes regulating steeper root angles for other cereal plants, especially those closely related to corn, like sorghum and pearl millet."

Also involved in this research at Penn State were Kathleen Brown, professor of plant stress biology, Meredith Hanlon, postdoctoral scholar, and Alden Perkins, graduate student. Vai Sa Nee Lor, Shawn Kaeppler, Xia Zhang and Jonas Rodriguez, Department of Agronomy, University of Wisconsin, Madison; Aditi Borkar, Malcolm Bennett and Rahul Bhosale, University of Nottingham; and Alexander Bucksch, Department of Plant Biology, University of Georgia, also are part of the team.

More information: Hannah M. Schneider et al, Root angle in maize influences nitrogen capture and is regulated by calcineurin B-like protein (CBL) -interacting serine/threonine-protein kinase 15 (ZmCIPK15), *Plant, Cell & Environment* (2021). [DOI: 10.1111/pce.14135](https://doi.org/10.1111/pce.14135)

Provided by Pennsylvania State University

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