Stronger corn? Take it off steroids, make it all female

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A mutant of maize that cannot produce brassinosteroids develops feminized sex organs with female kernels growing where male tassel flowers would normally occur. Credit: Purdue University photo/Burkhard Schulz

A Purdue University researcher has taken corn off steroids and found that the results might lead to improvements in that and other crops.

Burkhard Schulz, an assistant professor of horticulture and landscape architecture, wanted to understand the relationship between natural brassinosteroids - a natural plant steroid hormone - and plant architecture, specifically plant height. Schulz said corn could benefit by becoming shorter and sturdier, but the mechanisms that control those traits are not completely understood.

"It is essential to change the architecture of plants to minimize how much land we need to produce food and fuels," said Schulz, whose findings are published in the early online version of the Proceedings of the National Academy of Sciences. "If you can find a natural mutation or mechanism that gives you what you need, you are much better off than using transgenic techniques that could be difficult to get approval for."

Schulz found that when maize loses the ability to produce brassinosteroids, it becomes a dwarf, as he suspected. But another feature caught him off guard: The plants without the naturally occurring steroids could not make male organs - they had kernels where the tassels should be.

That could be a cost-saving discovery for the seed industry. Hybrid seed producers must painstakingly remove the male pollen-producing tassels from each plant so that they do not pollinate themselves. Schulz said maize plants that produce only female organs would eliminate the detasseling step.

"This would be the perfect mutation for hybrid seed production," Schulz said. "There is no way these plants could produce pollen because they do not have male flowers."

Schulz used a multistep process to determine brassinosteroids' role in height and, later, sex determination. He wanted to ensure that light and the addition of gibberelic acid, a hormone that promotes cell growth and elongation, would not eliminate the dwarfism.

Schulz gathered known mutants of maize with short mesocotyls, the first node on a corn stalk. He suspected that even dwarf plants that produced brassinosteroids would have elongated mesocotyls if grown in the dark as they stretched for light, a trait typical of all brassinosteroid mutants. He also added gibberellic acid to the plants to ensure that a deficiency of that hormone was not causing the dwarfism.

The dwarf plants that did not grow in the dark or with the addition of the gibberellic acid were compared to regular maize plants that had been dwarfed by subjecting them to a chemical that disrupts the creation of brassinosteroids. Both exhibited short stalks with twisted leaves and showed the feminization of the male tassel flower.

Schulz then used information that was already known from the research plant *Arabidopsis* about genes that control brassinosteroid production. He found the same genes in the maize genome.

In the dwarf maize plants, those genes were mutated, disrupting the biosynthesis of the steroids. A chemical analysis showed that the compounds produced along the pathway of gene to steroid were greatly diminished in the maize dwarfs. Cloning of the gene revealed that an enzyme of the brassinosteroid pathway was defective in the mutant plants. A related enzyme in humans has been reported as essential for the production of the sex steroid hormone testosterone. Mutations in this enzyme in humans also resulted in feminization.

While Schulz expected brassinosteroids to affect plant height, he said he did not expect those steroids to affect sex determination.

"We don't know if this is a special case for corn or if this is generally the same in other plants," he said. "If it is the same in other plants, it should be useful for creating plants or trees in which you want only males or females."

Gurmukh Johal, a professor of botany and plant pathology and collaborator on the research, identified the mutant used in the research, nana plant1, years ago. He said better understanding the steroid-production pathways could be important to strengthening maize plants and increasing yields.

"Maize produces too much pollen and it actually wastes a lot of energy on that," Johal said. "This implies that by using this gene or the pathway it controls, we could manipulate the plants to improve their quality."

Schulz said he would look at other plants, such as sorghum, to determine if the same genes and pathways control sex determination and height.

More information: Brassinosteroid Control of Sex Determination in Maize

ABSTRACT
Brassinosteroids (BRs) are plant hormones that regulate growth and development. They share structural similarities with animal steroids, which are decisive factors of sex determination. BRs are known to regulate morphogenesis and environmental stress responses, but their involvement in sex determination in plants has been only speculative. We show that BRs control sex determination in maize revealed through characterization of the classical dwarf mutant nana plant1 (na1), which also feminizes male flowers. na1 plants carry a loss-of-function mutation in a DET2 homolog—a gene in the BR biosynthetic pathway. The mutant accumulates the DET2-specific substrate (24R)-24-methylcholest-4-en-3-one with a concomitant decrease of downstream BR metabolites. Treatment of wild-type maize plants with BR biosynthesis inhibitors completely mimicked both dwarf and tasselseed phenotypes of na1 mutants. Tissue-specific na1 expression in anthers throughout their development supports the hypothesis that BRs promote masculinity of the male inflorescence. These findings suggest that, in the monoecious plant maize, BRs have been coopted to perform a sex determination function not found in plants with bisexual flowers.

Provided by Purdue University