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New rice plant may feed the hungry with less water and land

ITHACA, N.Y. -- Scientists at BTI and across the globe hope to feed the hungry with an ambitious project - engineering a more efficient type of photosynthesis into rice.

With water becoming scarce, synthetic fertilizers falling out of favor, and half the world's population depending on rice as a staple crop, the time has come for a more efficient type of rice - one that can grow better in hot dry climates like Africa, and that can weather droughts in China and elsewhere, producing more grain than before with just a fraction of the water.

A new $11 million grant from the Bill and Melinda Gates Foundation will bring that dream a little closer to reality, as researchers across the globe embark on several projects aimed at breaking down the basics of C4 photosynthesis, the system used by hot-climate plants like maize (corn) and other grasses, and figuring out how rice can follow their example.

Photosynthesis is the way plants turn sunlight and carbon dioxide into food for themselves and us. Rice uses an ancient type of photosynthesis called C3, but some plants have evolved a different scheme called C4, where the process is divided between two types of cells.

This division of labor keeps oxygen away from Rubisco, an enzyme that catalyzes the first step in turning carbon dioxide into sugar. When Rubisco reacts with oxygen, a process called photorespiration, the plant loses energy. In C3 plants, up to 30% of the photosynthetic capacity may be lost this way, but in C4 plants, the losses are minimal. The result: more energy goes into the plant. An additional benefit of C4 is that plants use less water, and utilize nitrogen more efficiently.

"Nitrogen comes at a huge expense for farmers and our environment," says Tom Brutnell, a BTI scientist who is coordinating the BTI and Cornell portion of the project. "We make most of our fertilizer from natural gas and from coal," he says. The price of grain follows energy prices, in part because of the need for synthetic fertilizers. "Currently, the cost of nitrogen contributes relatively little to rice production. However, as we look to expand the range of where rice is grown to feed our exploding population, we need to keep water and nitrogen in mind. If we are to develop truly sustainable agricultural systems, something has to change," says Brutnell. "We cannot continue to dump unlimited amounts of nitrogen on our fields"

John Sheehy, a scientist at the International Rice Research Institute in the Phillipenes, estimates that in addition to conserving water and fertilizer, C4 rice plants could produce up to 50% more food. "The benefits of such an improvement in the face of increasing world population, increasing food prices, and decreasing natural resources would be immense," he says.

Changing the way plants make their food is an ambitious project, but new technologies are making photosynthesis easier to study. "Many C3 plants have the necessary enzymes already, so we don't need to start from scratch," says Brutnell. A few tweaks to important pathways may be all that's needed, but first researchers must learn more about C4 plants and where the essential changes would be needed.

At BTI and Cornell, scientists are already working to identify stages in cells' development where the C4 system is formed, with support from the National Science Foundation. Bob Turgeon, at Cornell, is using electron microscopy to identify crucial points in leaf cells' development, while Tim Nelson at Yale (the NSF team leader) is using a laser to dissect individual leaf cells for study. Tom Brutnell, at BTI, is profiling gene expression from these cells to gain a dynamic picture of what genes are expressed as the cells are developing while Klaas van Wijk at Cornell studies the proteins present in the cells. These researchers are joined by others who focus on data analysis: Qi Sun at Cornell for high throughput sequence analysis, and Peng Liu at Iowa State with statistic analysis. The funding from the Gates foundation will enable the group to expand their bioinformatics component of the project and has attracted the attention of Chris Myers. Chris Myers at Cornell's Theory Center will be developing new methods and tools for mining the tremendous amount of data that is being generated through this project with the goal of engineering C4 rice.