Plants grow bigger and more vigorously through changes in their internal clocks

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The hybrid Arabidopsis (center) is larger than its parents (left and right), an example of hybrid vigor. Credit: Jeff Chen/Nature

Hybrid plants, like corn, grow bigger and better than their parents because many of their genes for photosynthesis and starch metabolism are more active during the day, report researchers from The University of Texas at Austin in a new study published in the journal *Nature*.

Their research has relevance in many areas of agriculture, and could result in new methods to increase biomass for biofuels and seed production for animal feedstock and human consumption.

It has long been known that hybrid plants such as hybrid corn are more vigorous than their parents. They are larger and have more biomass and bigger seeds. The same is true for plants that are polyploid, meaning that they have two or more sets of chromosomes. Over 70 percent of all flowering plants, including many important agricultural crops such as

wheat, cotton, canola, sugarcane and banana, are naturally polyploid.

Until now, the molecular mechanisms for hybrid and polyploid vigor have largely been unknown.

"Before this discovery, no one really knew how hybridization and polyploidy led to increased vigor," says lead author Dr. Jeffrey Chen, the D. J. Sibley Centennial Professor of Plant Molecular Genetics. "This is certainly not the only mechanism behind this phenomenon, but it is a big step forward."

The key, Chen and his colleagues studying Arabidopsis plants found, is the increased expression of genes involved in photosynthesis and starch metabolism in hybrids and polyploids. These genes were expressed at high levels during the day, several-fold increases over their parents.

The hybrids and polyploids exhibited increased photosynthesis, higher amounts of chlorophyll and greater starch accumulation than their parents, all of which led to their growing larger.

Also, growth vigor was higher in allotetraploid plants (polyploids formed by combining two different Arabidopsis species) than standard hybrids (formed through combining the same species).

The research team discovered a direct connection between circadian clock regulators and growth vigor in both hybrids and polyploids. Circadian clocks control growth, metabolism and fitness in plants and animals.

They found that some of these regulators, known as transcriptional repressors, were more repressed during the day in the hybrids and polyploids, leading to increases in their photosynthesis and starch accumulation.

"This connection was a bit of surprise, but it makes a lot of sense," says Chen.

With this knowledge, Chen says they can now develop genomic and biotechnological tools to find and make better hybrids and polyploids.

"We can think about screening parent plants for these genes and selecting the ones to make the best hybrids," says Chen. "This could all be done through traditional breeding techniques and could have a huge impact on generating higher biomass crops for biofuels and increasing yield in many food crops."

The hybrid vigor or "heterosis" phenomenon was first observed by Charles Darwin in 1876, and was extensively studied in corn in the early 1900s. All corn in the U.S. is hybrid.

Many of the important polyploid crops, such as wheat and cotton, are known as allopolyploids, because they are formed from two or more different species. Chen and his colleagues study standard hybrid and allopolyploid Arabidopsis, cotton and corn.

Source: University of Texas at Austin