Chance Observation Leads to Plant Breeding Breakthrough

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(PhysOrg.com) -- A reliable method for producing plants that carry genetic material from only one of their parents has been discovered by plant biologists at UC Davis. The technique, to be published March 25 in the journal *Nature,* could dramatically speed up the breeding of crop plants for desirable traits.

The discovery came out of a chance observation in the lab that could easily have been written off as an error.

"We were doing completely 'blue skies' research, and we discovered something that is immediately useful," said Simon Chan, assistant professor of plant biology at UC Davis and co-author on the paper.

Like most organisms that reproduce through sex, plants have paired chromosomes, with each parent contributing one chromosome to each pair. Plants and animals with paired chromosomes are called diploid. Their eggs and sperm are haploid, containing only one chromosome from each pair.

Plant breeders want to produce plants that are homozygous -- that carry the same trait on both chromosomes. When such plants are bred, they will pass the trait, such as pest resistance, fruit flavor or drought tolerance, to all of their offspring. But to achieve this, plants usually have to be inbred for several generations to make a plant that will "breed true."

The idea of making a haploid plant with chromosomes from only one parent has been around for decades, Chan said. Haploid plants are immediately homozygous, because they contain only one version of every gene. This produces true-breeding lines instantly, cutting out generations of inbreeding.

Existing techniques to make haploid plants are complicated, require expensive tissue culture and finicky growing conditions for different varieties, and only work with some crop species or varieties. The new method discovered by Chan and postdoctoral scholar Ravi Maruthachalam should work in any plant and does not require tissue culture.

Ravi and Chan were studying a protein called CENH3 in the laboratory plant *Arabidopsis thaliana*. CENH3 belongs to a group of proteins called histones, which package DNA into chromosomes. Among the histones, CENH3 is found only in the centromere, the part of the chromosome that controls how it is passed to the next generation.

When cells divide, microscopic fibers spread from each end of the cell and attach at the centromeres, then pull the chromosomes apart into new cells. That makes CENH3 essential for life.

Ravi had prepared a modified version of CENH3 tagged with a fluorescent protein, and was trying to breed the genetically modified plants with regular Arabidopsis. According to theory, the cross should have produced offspring containing one mutant gene (from the mother) and one normal gene (from the father). Instead, he got only plants with the normal gene.

"At first we threw them away," Chan said. Then it happened again.

Ravi, who has a master's degree in plant breeding, looked at the plants again and realized that the offspring had only five chromosomes instead of 10, and all from the same parent.

The plants appear to have gone through a process called genome elimination, Chan said. When plants from two different but related species are bred, chromosomes from one of the parents are sometimes eliminated.

Genome elimination is already used to make haploid plants in a few species such as maize and barley. But the new method should be much more widely applicable, Ravi said, because unlike the process for maize and barley, its molecular basis is firmly understood.

"We should be able to create haploid-inducing lines in any crop plant," Ravi said. Once the haploid-inducing lines are created, the technique is easy to use and requires no tissue culture -- breeders could start with seeds. The method would also be useful for scientists trying to study genes in plants, by making it faster to breed genetically pure lines.

After eliminating half the chromosomes, Chan and Ravi had to stimulate the plants to double their remaining chromosomes so that they would have the correct diploid number. Plants with the haploid number of chromosomes are sterile.

The research also casts some interesting light on how species form in plants. CENH3 plays the same crucial role in cell division in all plants and animals. Usually, such important genes are highly conserved -- their DNA is very similar from yeast to whales. But instead, CENH3 is among the fastest-evolving sequences in the genome.

"It may be that centromere differences create barriers to breeding between species," Chan said. Ravi and Chan plan to test this idea by crossing closely-related species.

Chan, who arrived UC Davis in 2006 in his first academic position, described the result as a "game changer" for his laboratory, opening up new research areas, funding sources and recognition.

Provided by University of California - Davis

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